PROCEEDINGS

OF

INTERNATIONAL CONFERENCE & 34TH ANNUAL GENERAL MEETING

OF

THE NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE)

THEME:

AGRICULTURAL MECHANIZATION: A VERITABLE COMPONENT OF AGRICULTURAL TRANSFORMATION AGENDA

SUB-THEME:

- **Operation and Maintenance of Farm Machinery for Sustainable Agricultural Mechanization.**
- **Mechanization Policy for Objective Goal Attainment of Agricultural Transformation Agenda.**
- **Soil and Water Engineering for Environmental Sustainability.**
- **Agro-Food Process and Storage Technology for Value Chain Addition and Food Security.**
- **Innovation and Entrepreneurship as Keys to Value Delivery and Sustainable Food Production**
- **Farm Structures and Electrification for Enhanced Rural Life and Productivity.**
- **Emerging Technologies for Sustainable Agricultural and Food Production.**

VENUE: AKWA IBOM STATE E-LIBRARY, IBB AVENUE, UYO, AKWA IBOM STATE.

DATE: OCTOBER 21 – 24, 2013.

PROC, NIAE: VOLUME 34, 2013
© NIAE, 2013

ISSN: 0794 - 8387

PREFACE

The vision of the Agricultural Transformation Agenda is to grow N i g e r i a ' s Agricultural sector by making Nigeria an Agriculturally Industrialized Economy.The role the Agricultural Mechanization which is aimed at replacing human muscle with mechanical system for Agricultural operations with the purpose of reducing human drudgery, improve timeliness and efficiency of various farm operations, increase size of land under cultivation, preserve the quality of agricultural products, products, provide better rural living conditions and advance the economic growth of the rural sector could play in actualizing this vision can not be over emphasized.

The theme for the International Conference and the 34th Annual General Meeting of the Nigerian Institution of Agricultural Engineers is " Agricultural Mechanization: A Veritable Component of Agricultural Transformation Agenda" atempt to proffer solutions to the challenges being experienced in Agricultural Mechanization and provide a road map for the actualization of the Agricultural Transformation Agenda. Therefore, the conference provides opportunities for Agricultural Engineers and Policy makers from Government and Private Organizations all over the World to meet and rub minds, exchange ideas and experiences on technological innovations, research methods and findings, opportunities, challenges and constraints in their various fields of specialization and practice.

In this year's conference a keynote address, six lead papers and over one hundred technical papers which covered most aspects of Agricultural Engineering were reviewed and accepted for presentation and publication in the conference proceedings.

We appreciate the excellent contributions of all the Authors, Paper reviewers and Members of the Technical Sub-committee in ensuring that the papers were made available on time for publication in the proceedings before the conference. Thank you.



Engr. Professor Victor I. O. Ndirika, FNIAE
Chairman, Technical Sub-Committee
Dept. Of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture Umudike

October, 2013.

WELCOME ADDRESS

On behalf of my colleagues, members of the organizing committee, I want to welcome you for participation in the international conference on Agricultural Engineering of the Nigerian Institution of Agricultural Engineers (NIAE) holding in University of Uyo, Uyo, Akwa Ibom State, Nigeria on 21-24th October 2013. This is the second time in the history of NIAE when the conference will hold in South-South Region of Nigeria. The first time was in Yenagoa, Balyesa State in January 2006. This is however the first time that the conference will be holding in Akwa Ibom State of Nigeria

The Conference was initially scheduled to hold at the University of Uyo had to be shifted to the Akwa Ibom State E-Library. The University was established October 1, 1991 by the Federal Government of Nigeria, The University inherited students, staff, academic programmes and the entire facilities of erstwhile University of Cross River established by the then Cross River State Government in 1983. Academic activities commenced in 1991/92 session. The permanent site where the conference will be holding is located about 25 km from the Ibom International Airport, Uyo, Akwa Ibom State of Nigeria.

The main aim of this International Conference to provide a forum for engineers and associated professionals for sharing of information and knowledge on current research developments, achievements and practical applications in all disciplines related to Agricultural, Food and Bioresources Engineering.

The theme of the programme is "Agricultural Mechanization: A veritable component of agricultural transformation agenda". We are in a time as a state and nation when transformation is our main thrust. Agriculture will also play a major role in this national transformation. It is of note that agricultural production cannot be without appropriate agricultural engineering systems in place. The challenge now is to sustain the available technologies and improve them for national transformation. We welcome you to make your contributions through presentations at this conference.

The keynote and lead papers' speakers are well experienced and exposed in their chosen area. They are active members of International Commission of Agricultural Engineering (CIGR), European Federation of Food Science & Technology (EFFoST), American Society of Agricultural and Biological Engineers (ASABE), Canadian Society of Bio Engineering, Nigerian Society of Engineers. There is no doubt that the conference will be enriched by the presentations from these experts. Opportunities will also be opened for comprehensive discussion on specific fields of interest and for initiation of joint activities, collaborations and developing ideas for innovations.

The conference will consist of invited papers, oral presentations, technical and social events. English will be the official language in this International Conference. Accepted papers will be published in the proceedings for the conference. You are most welcome to one of the fastest developing city and state in Nigeria – Akwa Abasi Ibom State. Emedio o o o.



Dr. A. Folarin Alonge
Chairman, Local Organizing Committee

NATIONAL EXECUTIVE COUNCIL

	Name	Position	E-mail Address
1	Engr. Prof. B.A. Adewumi	National Chairman	adewumiba@unaab.edu.ng
2	Engr. Dr. Shuaibu M Musa	National Vice Chairman	shbmusa@yahoo.com
3	Engr. (Dr.) M.A. Enaboifo	National Secretary	m_aireloena@yahoo.com, michael.enaboifo@uniben.edu
4	Engr. (Dr) J.C. Adama	Assistant National Secretary	adamajoseph@yahoo.com,
5	Engr. Bala Gambo Jahun	National Financial Secretary	bgjahun@yahoo.com
6	Engr. (Mrs) C.A. Adamade	National Treasurer	Adamadechristiana@yahoo.com
7	Engr. Dr. M.K. Othman	Publication Secretary.	mkothman@yahoo.co.uk
8	Engr. Sabiu Bello	National PRO	Sabiubello64@yahoo.com or bellosabiu10@gmail.com
9	Engr. Dr. Shehu Adamu Iya	North East Reg. Chairman	Us5iya@yahoo.com
10	Engr. Prof. S.Z. Abubakar	Immed. Past Chairman	Szabubakar@yahoo.co.uk
11	Engr Dr L.A.O. Ogunjimi	South-West Reg. Chairman	laogunjimi@yahoo.com
12	Engr. A. A. Akintola	North-Central Reg. Chairman	toye_akintola@yahoo.com
13	Engr. A. L. Ijasan	South-South Reg. Chairman	ijasanal@yahoo.com
14	Engr. Clinton C. Emekoma	South East Reg. Chairman	mekuga24@yahoo.com, engrace2020@gmail.com
15	Engr. J. O. Daudu	North West Reg. Chairman	jodaudu@hotmail.com
16	Engr. Y. K. Dalha	Ex. Officio	ydalha@yahoo.com
17	Engr. (Mrs) Nneka.I. Nwagugu	Ex.Officio	nnenwagugu@gmail.com
18	Engr. Ike Azogu	Executive Director NCAM	ikechukwuazogu@yahoo.com
19	Eng. M.Y. Kasali	Business Manager	yommekasali@yahoo.com
20	Engr. Dr. Folarin Alonge	National Auditor 1	falonge6@yahoo.com
21	Engr. (Mrs) R. S. Samaila	National Auditor 2	roysformi@yahoo.com
22	Engr. Prof. A. P. Onwualu	Editor-in-Chief, JAET	ponwualu@yahoo.com

LOCAL ORGANISING COMMITTEE (LOC)

MAIN LOCAL ORGANIZING COMMITTEE (LOC)

NIAE South- South Regional Chairman

1. Dr. A. Folarin Alonge – LOC Chairman
2. Engr. Richard Ekpe – Vice Chairman
3. Engr. Elijah Ikrang - Secretary
4. Prof. V. I. O. Ndirika
5. Prof. Francis Okokon
6. Dr. O. E. Essien
7. Dr. E. U. U. Ituen
8. Engr. Augustine Ubong
9. Engr. Ikpe Udom
10. Engr. Francis Ubitt

INTERNATIONAL SCIENTIFIC COMMITTEE AND ADVISERS

1. Prof . E. U. Nwa – University of Uyo, Nigeria/Adviser
2. Prof. P. O. Ngoddy - University of Uyo, Nigeria/Adviser
3. Dr. Oladiran Fasina – Auburn University, Alabama, USA
4. Dr. Michael Ngadi – McGill University, Montreal, Canada
5. Dr. Israel Dunmade – Mount Royal University, Calgary, Canada
6. Dr. Klein Ileleji – Purdue University, Indiana, USA
7. Prof. Linus Opara – Stellenbosch University, South Africa
8. Prof. Babatunde Adewumi – UNAB, Nigeria/NIAE Chairman
9. Prof. K. C. Oni - University of Ilorin, Nigeria
10. Prof. Frank Idike – Ebonyi State University, Nigeria
11. Prof. M. O. Faborode – CVC, Abuja, Nigeria
12. Prof. John Ohu, University of Maiduguri, Nigeria.
13. Prof. A. P Onwualu - RMRDC, Abuja, Nigeria
14. Prof. S. Z. Abubakar, ABU, Zaria, Nigeria/Immediate Past Chair of NIAE
15. Prof. E. A. Ajav – University of Ibadan, Nigeria
16. Dr. A. Folarin Alonge – University of Uyo, Nigeria/Chair, LOC Uyo 2013/ASABE Rep
17. ASABE Executive Director of Programmes

SUBCOMMITTEES

1) Technical Sub-Committee

a) Prof. V. I. O. Ndirika - Chairman
b) Prof. F. B. Okokon
c) Dr. Obot Essien
d) Dr. Kayode Simonyan
e) Dr. A. Folarin Alonge
f) Dr. A. B. Eke
g) Mr. David Onwe
h) Mr. Ayobami Oladejo
i) Mr. Johnson Esua
j) Engr. Christopher Augustine Ubong
k) Mr. Femi Alege
l) Mr. Esua Johnson
m) Mr. Daniel Onwude

2) Fund Raising/Finance Sub-Committee

a) Engr. Richard Ekpe - Chairman
b) Engr. A. L. Ijasan – Regional Chairman, South-South
c) Dr. Folarin Alonge
d) Dr. M. A. Enaboifo
e) Engr. Francis Ubit
f) Prof. M. J. Ayotamuno
g) Engr. Moses Olatunji
h) Engr. Chinatu Nwaukwa
i) Miss Idaresit Ekaette
j) Engr. Israel Ahuchaogu
k) Chairmen of Subcommittees

3) Welfare/Protocol Sub-Committee

a) Dr. E. U. U. Ituen - Chairman
b) Mr. Orua Antia
c) Mrs Blessing Andrew
d) Engr. M. S. Obot
e) Engr. Udom Eyiekere
f) Mr. Isaac Akpan
g) Mr. Idongesit A. John
h) Mr. S. M. Ibanga
i) Miss Idaresit Ekaette
j) Juliet Udoh
k) Agnes Morgan
l) Miss Judith Ebegbulem

4) Exhibition Sub-Committee

a. Dr. O. E. Essien - Chairman
b. Mr. Christian Briggs
c. Mr. James Ibanga
d. Mr. Michael Ojelade
e. Mr. Nnamntefon Etuk
f. Mr. Paul Okoko

5) Registration Sub-Committee

a. Prof. F. B. Okokon - Chairman
b. Mr. Ime Etim
c. Mr. Esua Johnson
d. Mr. Uduak Edet
e. Mrs. Rhoda Banjo
f. Mr. Ayo Oladejo
g. Promise Chuckwu
h. MaryJane Umego
i. Archibong Donald
j. Archibong Edinyanga
k. Kingsley Umani
l. Godwin Akpan
k. Uduak Akpan
l. Mbaba, Uyobong

6) Transportation Sub-Committee

a) Engr. Ikpe Udom - Chairman
b) Mr. Michael Ojelade
c) Mr. Enobong Umoh
d) Mr. Inemesit Ekop
e) Mr. Joseph Okoko
f) Esua Johnson

7) Excursion Committee

a) Engr. Francis Ubit - Chairman
b) Engr. Udom Eyiekere
c) Mr. Ekere Ikpe Obot
d) Engr. Williams Olosunde
e) Mr. Ime Etim
f) Mr. Femi Alege

8) Media and Publicity Sub-committee

a) Engr. Ubong, Augustine - Chairman
b) Mr. Fakayode, Olugbenga
c) Mr. Promise Etim
d) Mr. Babatunde Olatunbosun
e) Mr. Daniel Onwude
f) Mr. Alege, Femi
g) Mr. Edet, Uduak
h) Engr. Mfrekemfon, Obot

9) ICT Sub-Committee

a) Dr. Folarin Alonge - Chairman
b) Mr. Daniel Onwude
c) Mr. Uduak Essien
d) Mr. Ayobami Oladejo
e) Mr. Bunmi Aregbe

10) Accommodation Sub-Committee

a) Engr. Israel Ahuchaogu – Chairman
b) Promise Etim
c) Sam Okon Emmanuel
d) Isaac John

11) Security Sub-Committee
a) Mr. David Onwe – Chairman
b) Joseph Okoko

PAPER REVIEWERS

Prof. V. I. O. Ndirika
Prof. F. B. Okokon
Prof. S. N. Asoegwu
Prof. L. A. S. Agbetoye
Prof. A. O. Raji
Dr. A. F. Alonge
Dr. E. U. U. Ituen
Dr. O. E. Essien
Dr. A.B. Eke
Dr. K. J. Simonyan
Dr. H. E. Igbadun
Dr. M. K. Othman
Prof. O. Chukwu
Prof. B. A. Alabadan
Prof. W. I. Okonkwo

TABLE OF CONTENTS

PREFACE - - i

WELCOME MESSAGE - - ii

NEC LIST - - iii

LOC MEMBERS - - iv

PAPER REVIEWERS - vi

TABLE OF CONTENTS - - vii

KEY NOTE SPEAKERS

DEVELOPING AUTHENTIC TECHNOLOGIES TO LEVERAGE AFRICAN AGRICULTURAL TRANSFORMATION.
Rev. Prof. Godfrey Nzamujo O.p. - - **1**

SPEECH DELIVERED BY THE HONOURABLE MINISTER OF AGRICULTURE, DR. AKINWUMI ADESINA, CON, AT THE UYO 2013 NIAE INTERNATIONAL CONFERENCE, ON THE 21ST OF OCTOBER, 2013 - - 16

LEAD PAPER SPEAKERS

MECHANIZATION POLICY FOR OBJECTIVE GOAL ATTAINMENT OF AGRICULTURAL TRANSFORMATION AGENDA
Professor Isaac N. Itodo, (FNSE, FSESN, FNIAE) - 21

BIOREMEDIATION OF PETROLEUM-HYDROCARBON CONTAMINATED AGRICULTURAL SOILS, SLUDGE AND DRILL CUTTINGS IN THE NIGER DELTA
Professor Josiah Miebaka Ayotamuno - 27

FARM STRUCTURES AND ELECTRIFICATION FOR ENHANCED RURAL LIFE AND PRODUCTIVITY" BASED ON ECONOMIC AND SUSTAINABLE ENVIRONMENT
Professor Abdullahi El-Okene - - 37

AGRO FOOD PROCESS AND STORAGE TECHNOLOGY FOR VALUE ADDITION AND FOOD SECURITY
Engr. Prof. Zinash Delebo Osunde - - 40

OPERATION AND MAINTENANCE OF FARM MACHINERY FOR SUSTAINABLE AGRICULTURAL MECHANISATION
Engr. M.A. Ladeinde - - 49

INNOVATION AND ENTREPRENEURSHIP AS KEYS TO VALUE DELIVERY AND SUSTAINABLE FOOD PRODUCTION IN AFRICA
Dr. Augustine Ehimen Okoruwa *(CFS MNIFST MIPAN)* 56

SECTION I:
POWER AND MACHINERY

DESIGN, CONSTRUCTION, AND TESTING OF A MANUALLY OPERATED MAIZE SHELLER
Edet, U. , Ituen, E.U and Alonge, A.F. - - 65

PERFORMANCE EVALUATION OF SOME SELECTED TILLAGE IMPLEMENTS
N.A Sale, M. A Gwarzo, O. G Felix and S.I Idris - 71

DESIGN OF INDUCTION FURNACE FOR HEAT TREATMENT OF AGRICULTURAL TOOLS
Ilori, Abolaji Okikiade, Jimo, Kabiru Adekunle, Akangbe, Oluseyi Emmanuel, Gbopa, Akeem Rotimi, Balogun, Lawal Adedamola and Ogunsina, Omotayo Ayoade - - 78

ASSEMBLY AND PERFORMANCE EVALUATION OF THE INSTRUMENTATION SYSTEM OF A SOIL BIN FOR TILLAGE STUDY
Ale, M.O, Ademosun, O.C., Manuwa, S.I., Agbetoye, L.A.S., Adesina, A, and Ewetumo, T. - - 84

ASSESSMENT OF TRACTOR HIRING SERVICES IN KADUNA STATE
Dalha I. B., M. A. Gwarzo, and O. E. Olayinka - 92

DEVELOPMENT OF A ROTARY POWER WEEDER FOR SMALL AND MEDIUM SCALE FARMERS.
Muhammed, U. S., M. Abdulsalam and A. Abdullahi - 97

SOME CHALLENGES IN THE MECHANISATION OF MANGO HARVESTING IN NIGERIA
E.O. Atanda, P.A Imanogor and R.O. Akinbamowo - 107

DESIGN, CONSTRUCTION AND TESTING OF MANUAL ROW WEEDER
Sam, E. O.; Okokon, F. B. - - 113

DEVELOPMENT OF NRCRI CASSAVA ROOTS HARVESTING AID
Ikejiofor, M.C. and Okwesa, C.O - 124

SECTION II
SOIL AND WATER CONSERVATION PAPERS

EFFECT OF RUNOFF AND HAULAGE VEHICLE TRAFFIC ON GULLY GROWTH ON ROADSIDE SLOPES OF UNPAVED SANDQUARRY ROAD, UYO.
Obot Ekpo Essien - 129

QUALITY ASSESSMENT OF A SPRING FOR DOMESTIC WATER SUPPLY
Ogwuche, Emmanuel Udeh, Bashiri, Istifanus Malami and Eleke, Patience Nkemjika. - 137

ENVIRONMENTAL SUSTAINABILITY: IMPROVEMENT OF WATER DISTRIBUTION NETWORK FOR THE FEDERAL POLYTECHNIC BAUCHI, NIGERIA.
Udusuyi, O. Felix and Ahuchaogu, I. Israel - 143

ESTIMATION OF THE VOLUME OF SOIL DISTURBED IN THE CASSAVA TUBER ZONE IN LOAMY SOIL DURING CASSAVA HARVESTING
Ogunjirin, O. A., L. A. S. Agbetoye and O. C. Ademosun - 154

COMPARISON OF SOME FILTER MEDIA FOR WATER FILTRATION TREATMENT
Tolubanwo, S. E., Ogbuagu, A. E and Kadurumba, C. H. - 161

DEVELOPMENTS OF SELF PURIFYING CASSAVA PRODUCTION SYSTEM IN THE IMPROVEMENT OF WATER BUDGETING PRACTICES IN NIGERIA
EWEMOJE Temitayo Abayomi and OMOTOSHO Olayinka Akinola - 170

TREATMENT OF WASTE WATER FOR IRRIGATION PURPOSES (A CASE STUDY OF NIGERIAN BREWERIES PLC AMAEKE NGWO, ENUGU)
P. C. Eze, H. U. Offiah And C. N. Eze - 180

WATER INTAKE CHARACTERISTICS OF SOILS IN JAMILA VILLA FARM, MINNA, NORTHERN NIGERIA
Popoola, A. S and A. A. Balami - 188

TREATMENT OF WASTEWATER TREATMENT USING MORINGA OLEIFERA SEED SOLUTION IN MAIDUGURI, NIGERIA
A.Y. Arku, S. M. Musa and I. I. Ahuchaogu - 194

WATER QUALITY ANALYSIS OF A RECIRCULATORY AQUACULTURE SYSTEM
Ogunlela A.O and Ala A.I - 208

ASSESSING THE SODICITY AND SALINITY STATUS OF THE DAM OF AGRICULTURAL SERVICES AND TRAINING CENTRE PLATEAU STATE- NIGERIA
Oiganji Ezekiel, B.C Falemara, S. H. Kwarams, A. A Stanley - 215

WATER QUALITY OF BOREHOLES IN FEDERAL POLYTECHNIC, BAUCHI.
Ahuchaogu, I. Israel and Udusuyi, O. Felix - 224

WATER RESOURCES MANAGEMENT IN SMALLHOLDER FARMS: CASE STUDY OF MINISTRY OF AGRICULTURE AND NATURAL RESOURCES, SOKOTO STATE, NIGERIA.
Ewemoje Temitayo Abayomi and Abimbola Olufemi Peter - 233

SOIL AND WATER ENGINEERING FOR ENVIRONMENTAL SUSTAINABILITY CASE STUDY OF SUMBU GULLY EROSION CONTROL PROJECT
Engr Matthew Boniface Kamai. - 243

INFILTRATION CAPACITY OF SOILS IN FEDERAL COLLEGE OF EDUCATION (TECHNICAL) OMOKU, RIVERS STATE
Ahiakwo, A. A and Nnah - 251

DETERMINATION OF COMPACTED SOIL PROPERTIES USING A BELOW FLOOR LEVEL SOIL BIN
Olutayo, L.A and Agbetoye, L.A.S - 257

DESIGN OF TERRACE STRUCTURE FOR SOIL CONSERVATION ON DISSECTED GULLIED STEEP UPLAND OF USE SUB CATCHMENT
Obot Ekpo Essien - 262

FEASIBILITY OF RAINWATER HARVESTING SYSTEMS FOR POULTRY PRODUCTION AND WATER CONSERVATION IN NORTHERN AKWA IBOM STATE, NIGERIA.
Ikpe J. Udom and Christopher B. Afangideh - 271

INFILTRATION RATE DETERMINATION USING PRESSURE HEAD DIFFERENTIAL APPROACH IN DRY SEASON
Othman M. K, N.A Sale and Jonah J - 281

IRRIGATION PRACTICES IN TARABA STATE: PROBLEMS AND PROSPECTS
Istifanus, A. B., Nsukka and Chukwuma, G.o. -
299

EFFECTS OF SALINE WATER ON PHYSICO-CHEMICAL PROPERTIES OF SOIL,GROWTH AND YIELD OF PEPPER (*Capsium Spp*) VARIETIES
A. Ibrahim I. A. Udo and S. Ibrahim - 298

EVALUATION OF WATER AND SOIL QUALITY UNDER SMALL SCALE IRRIGATION AT OBUFA ESUK IN CALABAR, CROSS RIVER STATE
A. Ibrahim S. Ibrahim A. Y. Gambo E. A Obio - 307

VARIATIONS IN QUALITY OF AGRICULTURAL SERVICES AND TRAINING CENTRE'S DAM PLATEAU STATE –NIGERIA
Oiganji Ezekiel, O.E Nwafor S. H. Kwarams, A.A Ahmed - 316

SECTION III
FARM STRUCTURES AND ENVIRONMENTAL CONTROL PAPERS

TECHNICALITIES OF SOLAR PHOTOVOLTAIC CROP IRRIGATION WATER PUMPING
Nwoke , O.A., Okonkwo, W, I., Ugwuishiwu, B. O., Chukwuma, E.C., Ezenne, G. I.,Ohagwu,C.J - 324

DEVELOPMENT OF AN APPROPRIATE ONION STORAGE STRUCTURE FOR HUMID TROPICAL ENVIRONMENT
Falayi F.R. and J. Isa - 335

EFFECTS OF PARTICLE SIZE AND TIME OF SLURRY STORAGE ON SOME PHYSICAL PROPERTIES OF COW DUNG.
Nwoke O. A. , Ugwuishiwu,B.O., Asoiro,F.U - 345

SECTION IV
PROCESSING, STORAGE AND FOOD ENGINEERING PAPERS

FLOW PROPERTIES OF CASSAVA AND YAM STARCHGLYCEROL RESINS USEFUL IN THE DESIGN OF SCREW EXTRUDER FOR FILM MAKING
Adeshina Fadeyibi, Zinash Delebo Osunde, Gbagbo Agidi and
Egwim Chidi Evans - 352

DESIGN AND DEVELOPMENT OF A MOTORIZED SCREWED BRIQUETTING MACHINE
Onyenwoke C.A. and Simonyan K.J. - 362

MODELING OF WATER ABSORPTION RATE OF DOUM PALM FRUIT
O.K. Fadele and A.K. Aremu - 370

CARROT PRESERVATION BY VACUUM PACKAGING TECHNIQUE
S. L. Ezeoha, F. U. Asoiro and A. Ikejiofor - 375

ENGINEERING PROPERTIES OF AFRICAN MAHOGANY (*KHAYA SENEGALENSIS)* SEEDS RELEVANT TO PROCESSING
Usman, D. D, Ibrahim, M. E. , Yakubu, I. T. and Adanu, E. O. 383

DEVELOPMENT OF A REFLECTIVE SOLAR COOKER
S. L. Ezeoha, F. U. Asoiro And I. G. Tobias - 490

DESIGN OF A ROASTER/FRYER FOR HIGHER EFFICIENCY AND ENERGY SAVING IN TRADITIONAL GROUNDNUT OIL PROCESSING
M. A. Ali and A. Shitu - 402

DEVELOPMENT OF INDIGENOUS PSYCHROMETER FOR ESTIMATING PSYCHROMETRIC PROPERTIES DURING PRESERVATION OF VEGETABLES IN EVAPORATIVE COOLER IN AKURE, NIGERIA
Simon O. Odey, Seth I. Manuwa and Raphael S. Bello - 412

CONSUMPTIVE WATER USE OF EVAPORATIVE COOLING PAD DURING PRESERVATION OF VEGETABLES
Simon O. Odey, Seth I. Manuwa and Raphael S. Bello - 420

MECHANIZATION OF VEGETABLE PRODUCTION FOR SUSTAINABLE AGRICULTURAL PRODUCTION IN JABA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA
Makarau, Shehu Bako, Shebi, GojeJoshua, Garba, Ogilvie Anna. Paul, Wamagi Ishaku Thomas and Ayuba Damina - 427

DETERMINATION OF SOME PHYSICAL PROPERTIES OF PHASEOLA SPECIES
A.O. Ojomo and A. T. B. Aderibigbe - 435

PEELING OF CASSAVA (Manihot esculenta crantz) USING CHEMICAL AND MECHANICAL METHODS
Judith Ebegbulem, P. O. Ngoddy and A. F. Alonge - 442

EFFECT OF RELATIVE HUMIDITY ON FUNGAL LOADS OF POST- HARVEST TOMATO FRUITS IN BAUCHI METROPOLIS
Atanu, O.S., Ohanwe, C.N and Saleh J.Y - 457

SURVEY OF RICE PARBOILING PRACTICES IN KURA AREA KANO STATE, OF NIGERIA
N. A. Sale, N. D. Dangora, M. K. Othman and A. O Lawal - 462

DEVELOPMENT AND PERFORMANCE EVALUATION OF A MOTORIZED GARI SIFTER
Ologunagba, F. O., M. O. and Lawson, O. S - 471

SORGHUM THRESHING VIS-À-VIS WOMEN PARTICIPATION IN KANO STATE
M. A. Ali, M. M. Bello - 477

DEVELOPMENT AND PERFORMANCE EVALUATION OF AN ORANGE JUICE EXTRACTOR - 484

DESIGN OF A MANUALLY OPERATED DESKINNING/WINNOWING MACHINE FOR ENHANCED PRODUCTION CAPACITY OF THE TRADITIONAL GROUNDNUT OIL PROCESSORS
M. A. Ali and B. A. Ayuba - 492

DESIGN AND DEVELOPMENT OF AN EFFICIENT FISH SMOKING KILN FOR SMALL SCALE FARMERS
Lawal, A.O., M. Abdulsalam, T. Andefiki, and N. A. Sale - 501

REVIEW OF HOUSEHOLD PALM OIL PROCESSING AND STORAGE IN THE SOUTH EASTERN NIGERIA
Onyenwoke C.A., M.C. Ndukwu, A.U. Ezenta - 513

ASSESSMENT OF RICE PROCESSING OPERATIONS IN EKITI STATE, NIGERIA
Okunola, A.A. and Adekanye, T.A - 520

PHYSICOMECHANICAL AND CHEMICAL PROPERTIES OF TWO PALM FRUITS VARIETIES
Fati Astapawa Adamu; Muhammad Hamisu Muhammad;
Barbara Ndidi Acquaye - 529

EFFECT OF DRYING METHODS ON SOME PHYSICOCHEMICAL PROPERTIES OF SOME SELECTED VARIETIES OF CASSAVA STARCH
A. A. Adesola, D. Lasisi, L. A. Balogun, A.R. Nasirudeen, F.O. Ogunsola, and T.A. Adeyeye - 536

EFFECT OF FEEDING METHODS ON GROWTH RATE OF CATFISH (CLARAS GARIEPINUS)
Ogunlela, A. O. and A. A. Adebayo - 544

AN INVESTIGATION INTO THE LOCAL TECHNOLOGY OF THE PRODUCTION OF SUGARCANE BASED SWEETENER (MAZARKWAILA) IN NORTHERN NIGERIA
Mohammed Abubakar and R.F.Jahun - 549

ENGINEERING PROPERTIES OF THEVETIA PERUVIANA KERNEL FOR THE DEVELOPMENT OF PROCESSING MACHINES FOR BIO-DIESEL PRODUCTION
Nasirudeen A.R., Balogun L.A., Jimo K..A., Akangbe O.E, Lasisi D., Ilori A. O. - 558

DETERMINATION OF SOME ENGINEERING PROPERTIES OF MORINGA SEEDS, GROWN IN KANO STATE, NIGERIA
Mohammed Abubakar and Faruq, Z.A - 570

COMPARATIVE STUDY OF EFFECTS OF DRYING METHODS ON THE QUALITY OF COCOA BEANS
D. Lasisi, L. A. Balogun, A. R. Nasirudeen, F. O. Ogunsola, A. A. Adesola and T. A. Adeyeye - 579

DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF A CABINET DRYER
Oladimeji A.O, Abisuwa F.T, Olajide O.G, Akintade A.A, and Fasoyin S.A - 584

DEVELOPMENT OF SOFTWARE FOR MONITORING PERFORMANCE EVAPORATIVE COOLING SYSTEM FOR STORAGE OF FRUITS AND VEGETABLES
W. A. Olosunde, A. K. Aremu and D. I. Onwude - 591

DESIGN AND CONSTRUCTION OF DOMESTIC SOLAR WATER HEATER
Abdulsalam M., M. L. Suleiman, I. B. Dalha and D. O. Emmanuel - 607

DETERMINATION OF SELECTED PHYSICAL AND MECHANICAL PROPERTIES OF CEREALS AND LEGUMES AND THEIR EFFECT WITH MOISTURE CONTENT
Isa, J. and Oladele, S.O. - 614

EFFECTS OF PROCESSING METHODS ON THE BRABENDER AMYLOGRAPH PASTING PROPERTIES OF FALSE YAM (*Icacinatrichantha*) FLOUR
Umoh, EnobongOkon - 622

DEVELOPMENT OF AN IMPROVED MULTIPURPOSE COWPEA DEHULLER: A VALUE CHAIN ADDITION IN FOOD PROCESSING AND SECURITY.
Aniyi, O. S. - 627

PROXIMATE ANALYSIS OF TOMATO (Syria variety) UNDER COMMON PREPARATIONS
Oiganji Ezekiel , Emefiene Mercy, A.H Makama, A.A Stanley 638

INVESTIGATION OF EFFECT OF PRE-STORAGE THERMAL PROCESSING TEMPERATURE AND EXPOSURE TIME ON STORAGE STABILITY OF BLACK-EYED COWPEA (Vignaunguiculata)
Ohanwe, C.N., Ogunlowo, A.S., Agbetoye, L.A.S., and Sule, S. 642

DESIGN AND CONSTRUCTION OF A MELON DRYER
O.E. Akangbe, K.A. Jimo, A.O. Ilori, A.J. Adesope, S.O. Timothy and O.A. Ogunsina 651

PERFORMANCE EVALUATION OF A 50 - LITRE COLD STORAGE FACILITY FOR FRUITS AND VEGETABLES FOR SMALL SCALE TRADERS IN JOS, NORTHERN NIGERIA.
Omoniyi O.I., A. S. Popoola, 1S. M. Joshua, Y. M. Sani, A. R. Ojo and D. B.Gwong. 659

PHYSICAL PROPERTIES OF FRESH TURMERIC RHIZOMES RELEVANT TO POSTHARVEST PROCESSES
Ikejiofor, M.C 664

SECTION V
EMERGING TECHNOLOGIES AND ENGINEERING EDUCATION

DESIGN AND CONSTRUCTION OF *Thevetia peruviana* SEED DEHULLER FOR BIO-DIESEL PRODUCTION IN NIGERIA
Jimo, K. A, Nasirudeen, A. R, Balogun, L.A, Oladebo, M.A and Gbopa, A.R 673

EFFECT OF UV-IRRADIATION ON MICROBIAL LOAD OF DRIED TOMATO SAMPLES
Atanu, S. O., V. A. Abodenyi and K. W. Leddi 679

DESIGN AND PERFORMANCE OF HEFINC840 MICRO-CONTROLLER BASED INCUBATOR
A. Mohammad; M. J. Musa; K. Ahmad; S. Garba and M.D. Almustapha

FLOWERING RATE OF SNAKE TOMATOES AS AFFECTED BY DAY-LENGTH
ohanyere, S. O., C. O. Akubuo, And S. N. Asoegwu 693

TOWARDS TAKING AGRICULTURAL ENGINEERING IN NIGERIA TO THE NEXT LEVEL: THE ROLE OF COMPUTERBASED SIMULATION MODELS
Henry E. Igbadun 699

DESIGN AND DEVELOPMENT OF AUTOMATIC MICROCONTROLLER BASED ELECTRONIC GARDEN DRIP IRRIGATION SYSTEM
K. Ahmad, M. M. Jibrin; Y. A. Shaaban, A.M.S Tekanyi, A. Muhhamad 712

COMPARATIVE EVALUATION OF PRODUCTIVITY AND PROFITABILITY OF RICE-FISH CULTURE AND RICE MONO CULTURE IN AKWA IBOM STATE, NIGERIA.
Augustine, C. Ubong and C.C. Mbajiorgu 720

SUBSURFACE DRAINAGE SYSTEM DESIGN USING FUZZY CONTROL
A.M. Adewara, I.I. Ahuchaogu and A.O. Ogunlela 733

SYSTEM DEVELOPMENT OF LOW CARBON BIOPROCESS TECHNOLOGIES FOR ECONOMIC TRANFORMATION IN NIGERIA
Oladipo Ajayi, Olugbemide A.D, Adebayo A.A, and Atanda E.O 743

PERCEIVED CONSTRAINTS IN AGRICULTURAL ENGINEERING COURSES IN OUR HIGHER INSTITUTION
Kayode A.K, Adedire O, Amusa T, Duro K.O, Ojo M 752

CONTROL AND MONITORING OF GREEN HOUSE ENVIRONMENT MICROCONTROLLER-BASED APPROACH
M. J. Musa1, K. Ahmad, I. Umar, M. A. Aminu and A. Ahmed 757

INFLUENCE OF EDUCATIONAL BACKGROUND ON THE ADOPTION OF MECHANISED PRACTICES IN AGRICULTURE IN AKWA IBOM STATE
Ikpe J. Udom; Alexis M. Roberts and Noamy I. Udom 764

COMMUNIQUÉ OF THE INTERNATIONAL CONFERENCE AND 34TH ANNUAL GENERAL MEETING OF THE NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE) HELD AT THE IBOM E-LIBRARY, UYO, AKWA IBOM STATE FROM 21ST-24TH OCTOBER, 2013. 774

KEYNOTE ADDRESS

SUMMARY OF REV. Prof. GODFREY NZAMUJO O.P.

Developing authentic Technologies to leverage African Agricultural Transformation.

International conference on Agricultural Engineering, Uyo, October 21st, 2013

Never before today has our planet faced the multiple challenges it is experiencing today. It is not just one or two crises scattered here and there. This is a multifaceted and global crisis. Interestingly however, all of them are connected. This suggests that our present day crisis is **fundamentally a systemic one** that requires a holistic approach.

Unfortunately most of the solutions we have seen so far seem to be piecemeal and symptomatic therapies that hardly work. In the best cases, these solutions are simply band aid endeavors. In most cases they end up creating more problems.

But today, more and more people are realizing that we have hit a point in history that calls for dynamics that are deeper than any "revolution" we have heard about. It requires a radical shift not just in our vision of the world or our mentality and how we think, but in every sphere of our lives - from the way we see ourselves and relate to each other, from our relationship with the environment to our scientific and technical orientations, from our production systems to the ways we exchange and consume our products and services.

Instead of shallow and piecemeal solutions we are used to, **we must see the urgent need to embark on the road of doing the hard work of growing up. Business as usual is no longer acceptable.**

It should be new win in a new win skin

The disheartening socio-economic and environmental situation today, I think will continue and will definitely get worse if we continue to navigate with the same "old map". Our compass is not pointing to the "True North". This "wrong map" developed and adopted slowly since the fifteenth century has brought us very close to a deep cliff.

Once again, it is getting clearer that the solutions to our problems can no longer be found in the present day logic. We must therefore develop new mental and operational frameworks based on what we now know about how our planet works. Modern sciences including the neurosciences are providing us with a fundamentally different and refreshing framework on our human dynamics and that of our planet.

From these sources, **a new paradigm that is called BIO-MIMICRY** has emerged with a completely new and different technological orientation. This paradigm challenges us and engages us to learn from the basic principles of the workings of our planet for more than three billion years. We believe that from seeing our planet from this world view, we will be in a better position to design and re-engineer our way out of these crises. This new paradigm has to be appropriated and deployed if we are really committed to creating, designing and inventing organizations, industries, economic activities that would solve our present day problems.

Some of these principles are:

- ***Synergy,***
- ***Symbiosis***
- ***Complementarity***, **Collaboration** and
- ***Suplementarity.***

One of the fundamental elements in these principles is the concept of life as a web or network of relationships and energy flow in this web of life. The key ideas are:

1. The interdependent relationship among all living things.

2. The flow of energy permeating this web of Life.

3 The concentration of energy at nodes (to create biological, economic and social entities like agriculture, green enterprises and human settlements)

4. The cyclical displacement of elements and nodes within this web.

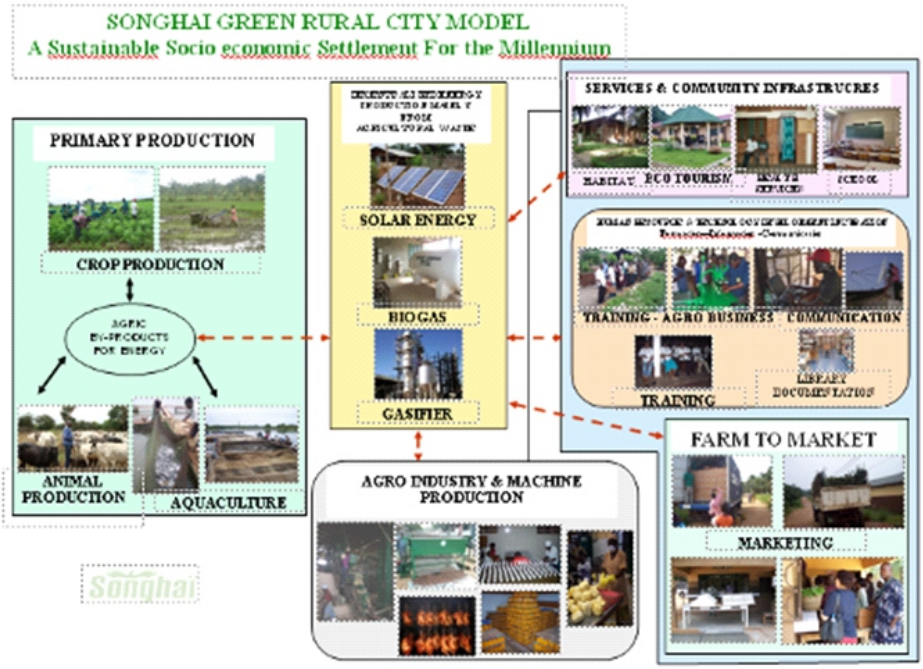
The notion of waste disappears as all gets recycled. Hence the ZERI (zero emission research initiative) concept

And that is not all; we now know that we have three space dimensions and the time dimension as our real playing field in this new paradigm. This new vision calls for a closed system that holds its resources within to service all available sub-systems. In this space, organisms, life cycles and processes, nodes and sub-nodes don't have to compete for space and resources. They don't have to grow at the expense of each other.

Our space-time can be filled up more thickly and more efficiently with life cycles of different sizes that occupy different space-times. This is exactly what organisms in a naturally biodiverse ecosystems do to maximize the reciprocal, symbiotic, complementary, supplementary and synergetic relationships that enhance the performance of all.

The Songhai initiative is basically the harnessing of these principles to invent and develop new and appropriate technological and developmental trajectories. It is an integrated development system that organically creates dynamic linkages and synergy between Agriculture, Industry and services.

Putting it in another way, **Songhai is a new and innovative development organization, an entrepreneurial space, a community developed by a new breed of entrepreneurs (practicing –creators "Travaileurs-Createurs") by harnessing the possibility sets around us with an integrative approach (Clusters of activities). It is designed to create synergy as we tackle the multifaceted challenges (Agriculture/Food Security, Demographic (particularly Youth), Environmental, and Energy) we are facing today.**

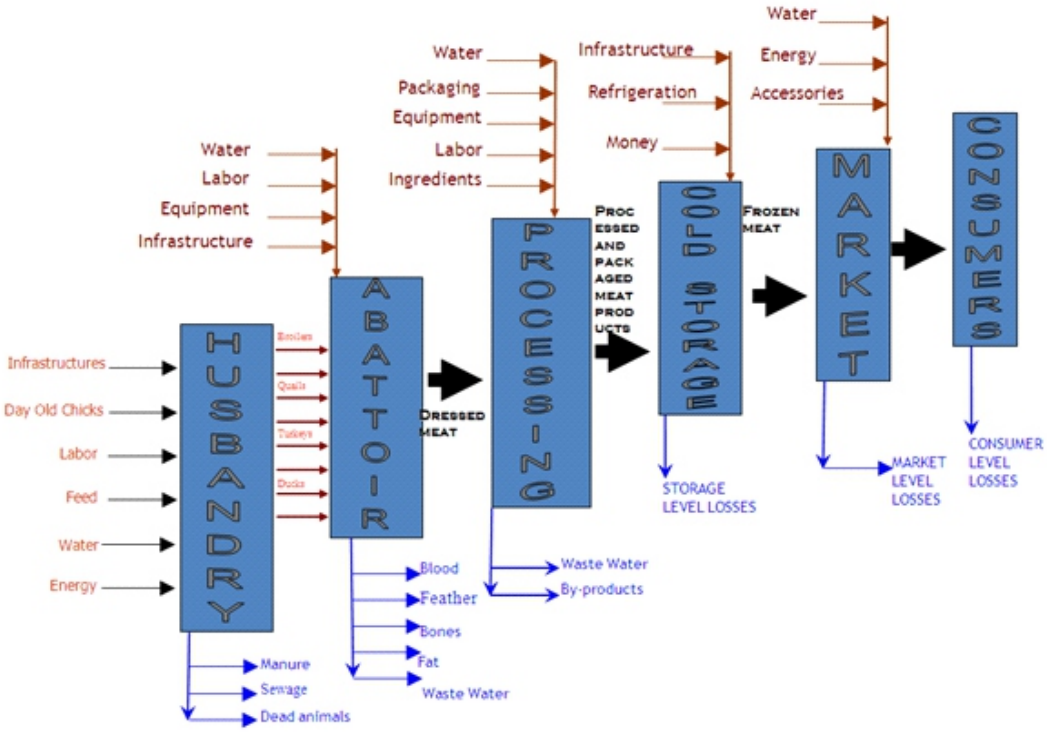


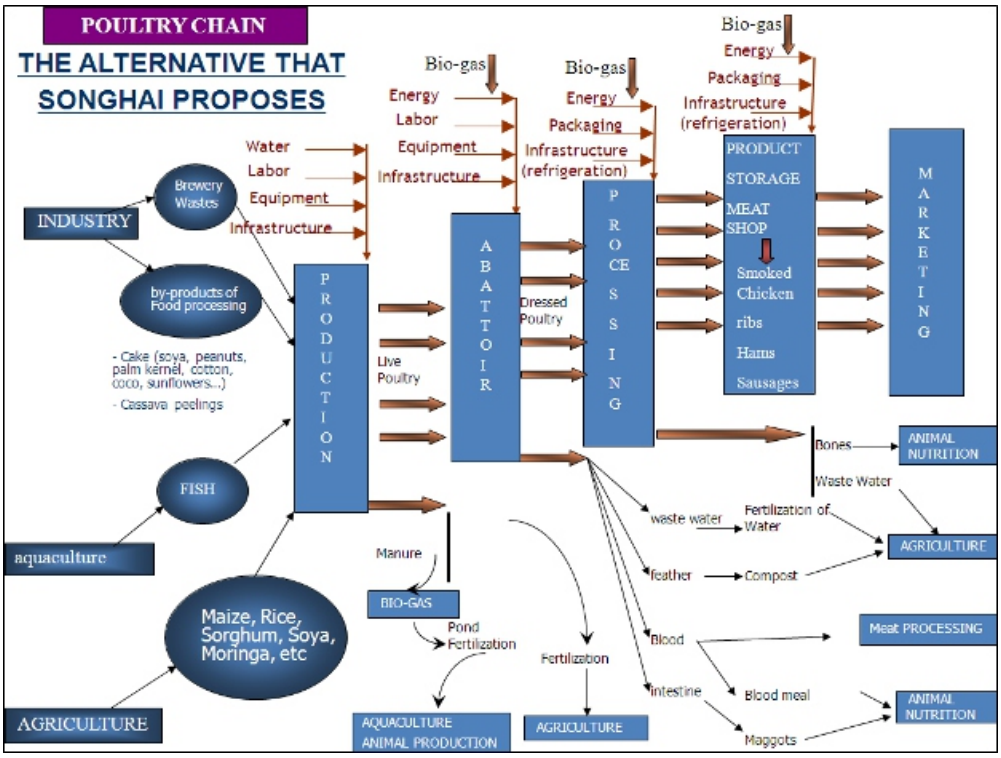
A new Millennium settlement model that is aligned with the new principles

agriculture is practiced. From the way we view the soil and its fertility, through the way we maintain, nourish and protect our plants and animals to the way we condition and market them.

The technological packages here include among other techniques, renewable energy generation, natural soil regeneration, genetic recombination of seeds ***NOT*** GMOs, Integrated pest management, deployment of **Indigenous Micro-Organisms (IMO)** etc.

CONVENTIONAL POULTRY PRODUCTION CHAIN





It is within this new mental framework **(aligned with nature and authentic and fundamental human needs)** that our techniques, production system, social organizations and new human settlements are developed.

The concrete expression of this movement is **the "Green Rural City" model – In this new human settlement model, the over arching policy is that:**

1- All the technologies, production system and social organizations deployed must be aligned to the new vision - Bio-Mimicry. We call these sustainable **technologies "Authentic Technologies".**

2- The movement is animated by a new breed of individuals, the Songhai core group or socio-economic leaders. **The Songhai Leadership Academy** is the platform for raising a critical mass of young men and women with a new and different set of values and equipping them with new management skills and technologies that are in line with the new paradigm. These **"travaileurs-createurs" or "practicing-creators"** are key to the success of this initiative. The Songhai Initiative is an expression of a "regenerative social economy"- **("Une Economie de communion"-in French)**. This initiative, while strongly reaffirming and reactivating the central position of solidarity and altruism in social constructions, goes steps further to ensure the sustainability of this human value, giving it a "self-sustaining" base.

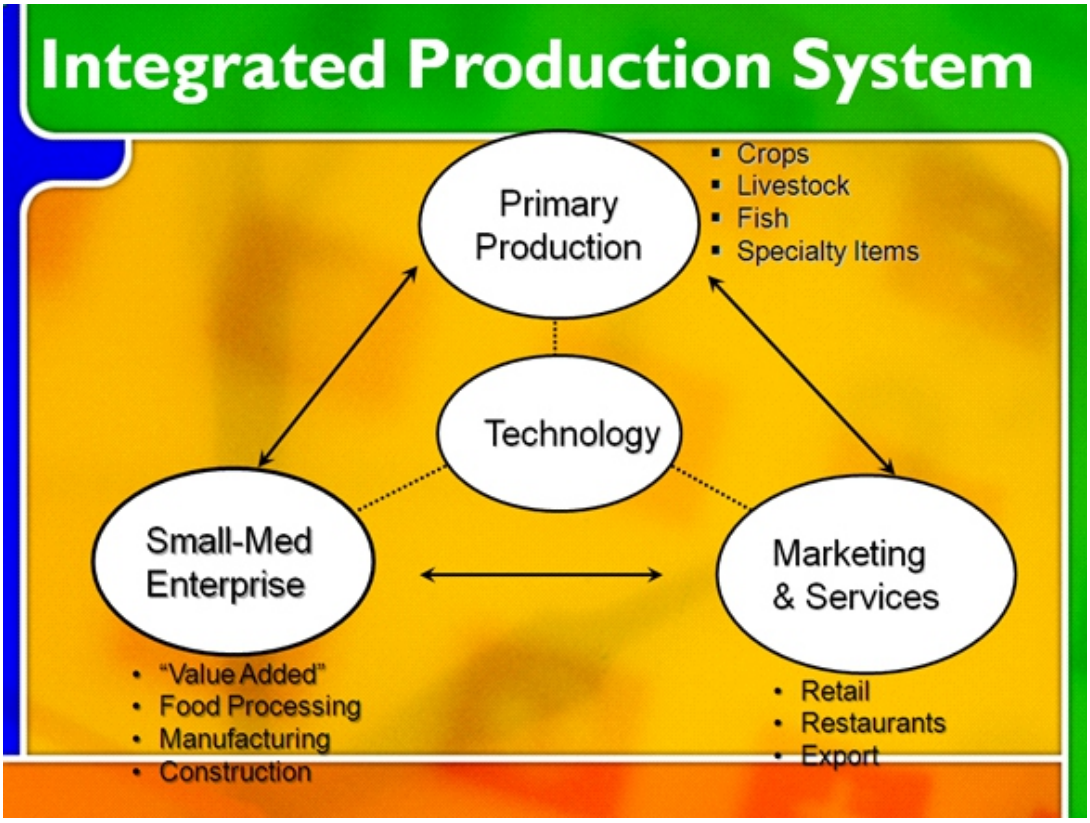
3- The sustainability of our communities is inbuilt in our basic structure.
Thanks to the authentic technologies (syntropic/synergetic systems) deployed, and the orientation and quality of the human resource involved, **the Songhai initiative is a commitment to an active and generative use of resources**. All resources must be made to circulate within the social fabric of communities to make them reproduce themselves. This initiative is therefore designed to have a snowball and not a trickledown effect. It revitalizes work as the basic structure of modern economy – **the human centered enterprise**. Here this new type of enterprise becomes the focal point where resources are oriented for the continuous creation of social, environmental, spiritual and economic wealth.

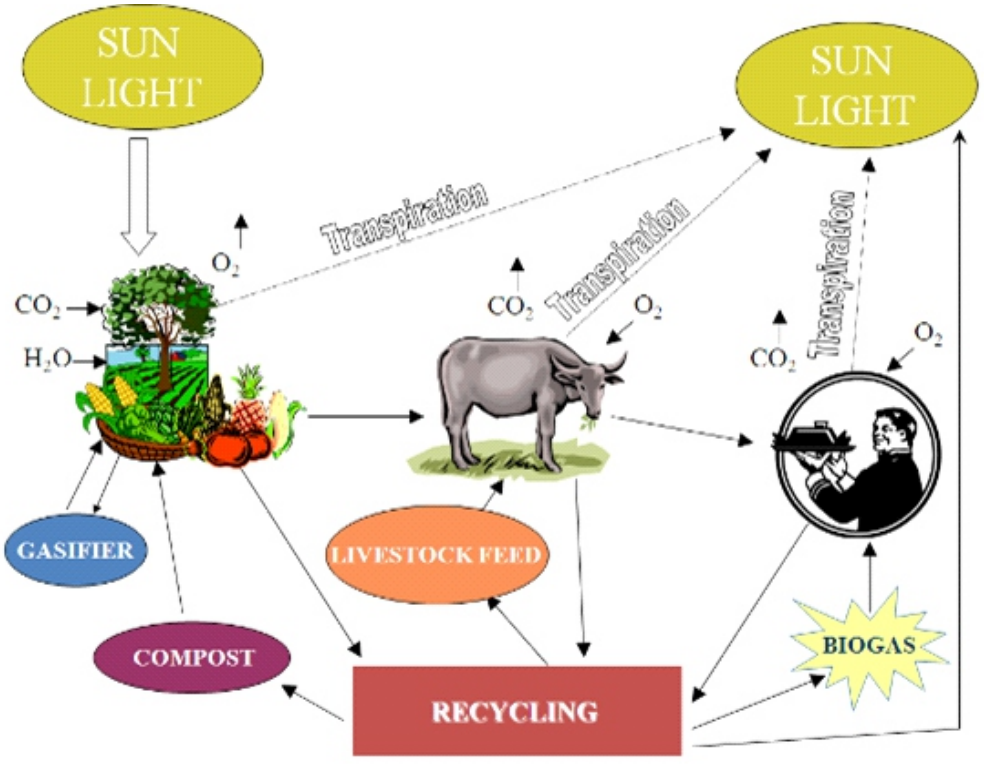
- It must be noted however, that solidarity in this initiative is detached from the usual practice of social welfare that is characterized by perpetual-handouts, as seen in many development programs in Africa and many developing economies.
- In the emerging third generation economy, four (4) billion people at the bottom of the pyramid will be considered an enormous potential market.
- It is because we imposed the pre-existing industrial boundaries (like known product lines as they exist in the industrialized nations today), that we failed to see business opportunities of potentially vast proportions in these so called poor nations- We are under the spell of a of a one-size-fits-all mentality.

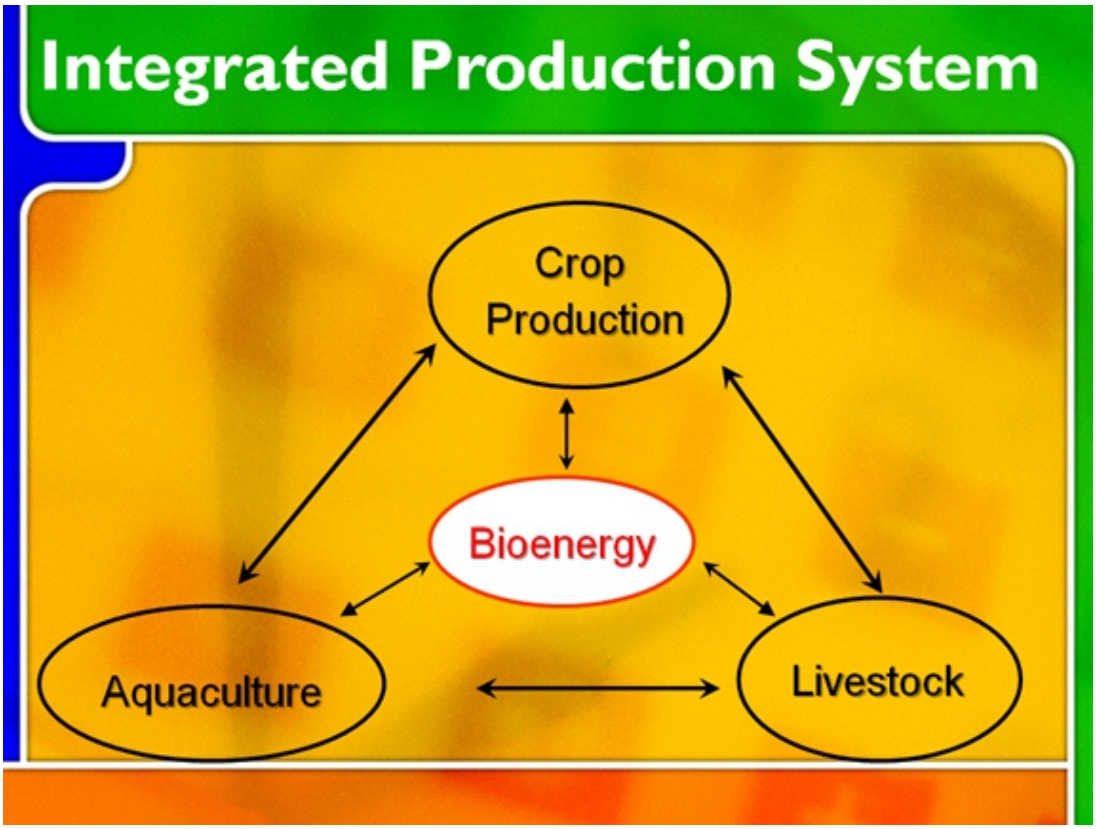
The take-off point in this initiative is the Agricultural sector. It is here that we have made the biggest mistakes. The way we grow our food determines who we are.

The technologies deployed are enabling our Agriculture to produce **MORE WITH LESS** because this is executed within an integrated system of production where the principles of synergy, complementarity, supplementarity and negative entropy or syntropy are in play.

This agriculture is not a primarily chemical process like the conventional Agriculture with heavy investment and heavy machinery, but largely a **biological process** - where our environmental and biological capitals like the effective Micro-organisms are being engaged and harnessed. At Songhai we are re-learning the way


Integrated Production System
Primary Production
Crops
Livestock
Fish
Specialty Items
Technology
Small-Med Enterprise
Marketing & Services
"Value Added"
Food Processing
Manufacturing
Construction
Retail
Restaurants
Export


SUN LIGHT
SUN LIGHT
Transpiration
Transpiration
Transpiration
O_2
CO_2
H_2O
CO_2
O_2
CO_2
O_2
GASIFIER
LIVESTOCK FEED
BIOGAS
COMPOST
RECYCLING


Integrated Production System
Crop Production
Bioenergy
Aquaculture
Livestock













USE OF WATER HYACINTH/AQUATIC PLANTS FOR WATER PURIFICATION – RECYCLED WATER USED FOR FISH FARMING




CENTRE SONGHAI
SON-GAZ
MADE IN BENIN


















Sonqbai


Purée de tomate
Songhaï
Tomato Puree



















SPEECH DELIVERED BY THE HONOURABLE MINISTER OF AGRICULTURE, DR. AKINWUMI ADESINA, CON, AT THE UYO 2013 NIAE INTERNATIONAL CONFERENCE, ON THE 21ST OF OCTOBER, 2013

I wish to start by thanking you for inviting me to the UYO 2013 NIAE International Conference tagged "Agricultural Mechanization: A Veritable Component of Agricultural Transformation Agenda". Your choice of this theme indicates your belief in the transformation agenda of the President of the Federal Republic of Nigeria, Dr. Goodluck Ebele Jonathan, GCON, and the critical relevance of agricultural mechanization in the realization of the objectives of my Ministry's Agricultural Transformation Agenda (ATA).

This speech will dwell on our efforts to transform Nigeria's agricultural sector in which we intend to build a new future for our country, a future that would depend less on oil and more on our drive to create jobs through overhauling our internal production mechanisms, especially in agriculture.

Let us project to year 2030 and imagine that we have transformed our 85 million hactares of land of which we currently cultivate about 40% and only 10% optimally. Imagine that our savannas are revived with large commercial farms coexisting side by side with small-holder commercial farms, the rail systems are working making it easier and cheaper to transport food from the north to the south and vis-virsa, translating to more food at cheaper prices, jobs are in abundance in rural areas and wages are higher as a result of agro-based industries located in those areas.

Imagine in 2030 that agricultural productivity has risen, inducing rapid gains from the adoption of total mechanization, improved seeds and fertilizers coupled with irrigation and modern water management systems. Imagine that Nigeria has more than doubled her output in all crops, especially rice, maize, soybean, sorghum, cassava etc. The savannas which were not different from the cerrados of Brazil, and had been so underutilized, have been transformed to become the breadbasket of the nation, boosting food production and driving competitiveness.

Staple Crop Processing Zones (SCPZ), which are vast areas with private sector food manufacturing companies, are established to make it easier for food manufacturing companies to buy agricultural commodities directly from farmers, process and add value to them at lower costs due to improved integrated infrastructure with power, roads, rail and water. Commercial farms are spreading as land and markets are developed, allowing farmers to lease land, sell land and those with freeholds are using them to secure greater financing for investments.

Imagine that a new generation of young commercial farmers account for some 45% of the farmers of the country – with mechanization and precision agriculture allowing them to compete with farmers in other parts of the world. Rural-urban migration has reduced as new farm cities have come up, with modern housing and farm service support centers.

In less than two decades, the agribusiness sector of Nigeria has fully emerged. The structural transformation of the sector is complete, as less than 25% of the population now engage in primary agriculture, with greater share in high valued agro-allied food manufacturing enterprises. Nigeria has now joined the league of agriculturally industrialized economies like Brazil, Argentina, Thailand and Malaysia.

Distinguished engineers, wouldn't this be wonderful if this is the story told about Nigeria by 2030. For Nigeria to get there, major institutional and policy reforms must be required. The habit of business as usual must be jettisoned for well thought-out and structured policies and implementation strategies. We must make sacrifices to ensure that we look inwards for our needs and export our surpluses. We cannot continue to depend on

other countries for our daily needs, especially food. The time for change is now.

Nigeria has immense agricultural potentials. We have 85 million hactares of arable land and only cultivate 40% with hoes and cutlasses. We have 263 billion cubic meters of water with two of the largest rivers in Africa. We have a population of 167 million people which confers on us the country with the highest market potentials in Africa. All these potentials point to the imperative and uncompromising fact that we must grow our own food, develop our markets and not be market for products from other countries, helping them to provide employment for their people at the detriment of unacceptable levels of unemployment in Nigeria. While we admit that we have great potentials, nobody eats potentials. We must unlock our agricultural potentials to once again drive the economy as was done in the 60s.

To realise Nigeria's potentials in agriculture, we have embarked on a major transformation of the agricultural sector. The President and Commander in chief of the Armed Forces of the Federation, Dr. Goodluck Ebele Jonathan, launched the Agricultural Transformation Agenda (ATA) in 2011. ATA looks at agriculture as a money making business and not a charitable development project, and operates through agricultural value chains. ATA aims at adding additional 20 million tonnes of food to the domestic food supply and in the process stimulate the creation of 3.5 million jobs along the agricultural value chains.

To achieve the objective of the transformation agenda, we are reforming/building institutions for greater performance and efficiency. The reforms of our policies and institutions that are expected to drive ATA are:

i. Input sector policy and institutional reforms
ii. Reforms of the agricultural research and development system and institutions
iii. Reforms of the agricultural extension system
iv. Land reforms
v. Market institutional reforms
vi. Developing new institutions to manage climate change
vii. Institutional reform of the Ministry of Agriculture
viii. Financial sector reforms to increase lending to agriculture
ix. Reforming university curriculums to address the needs of the agriculture sector.

The impact of the reforms have already started yielding the desired gains. Additional 9 million metric tonnes of food was produced in 2012/2013 cropping season, which is 80% higher than the 5 million metric tonnes target. Food imports declined by N857 billion by the end of 2012, a 144% achievement above the target of N350 billion. It is heart-warming to note that import bills on wheat, rice and sugar, declined by $3 billion in 2012. Agricultural exports expended by 822,000 metric tonnes in 2012, which was 144% higher than the target of 364,000 metric tonnes. Agricultural sectors contribution to non-oil exports expended by N759 billion – 83% above the target of N128 billion. Over 2.7 million farm jobs were created, which is 77% of the target of 3.5 million jobs by 2015.

To sustain these milestone achievements, the government of President Goodluck Ebele Jonathan is providing tremendous support to Agriculture through various interventions activities. We are working hard to ensure that millions of farmers get access to quality and affordable farm inputs. The Growth Enhancement Scheme (GES), where farmers get access to subsidized seeds and fertilizers via mobile phones, continues to show impressive results. So far in 2013, more than 3.4 million farmers have received their seeds and fertilizers via the E-wallets. We expect to reach 5 million farmers by the end of the growing season.

therefore being supported with guaranteed minimum prices and a buy-back program to assure them access to markets. Government has completed a total of 1.3 million MT of silos capacity, all across the country. We increased completed silos capacity from 260,000 MT to 1.3 million MT within one year – an increase of 400%.

We should be self sufficient in rice production, and become a net exporter of rice to our neighbouring countries. After all, West Africa is the region with the fastest growing consumption of rice. With our proximity, Nigeria can produce and compete in rice better than Thailand, Vietnam and India. To achieve this, we have set for ourselves the target of becoming self sufficient in rice by 2015.

We are focused on achieving this target by accelerating the production of local paddy rice. In November 2012, President Jonathan supported the first ever policy for dry season rice production. We focused on ten states of northern Nigeria, i.e. Kebbi, Kogi, Niger, Zamfara, Sokoto, Kano, Jigawa, Bauchi, Kastina and Gombe. Over 267,000 farmers were reached via the Electronic Wallet and received high yielding varieties of rice and three bags of fertilizer subsidized by the Federal Government. Instead of relying on massive irrigation, farmers were provided with pumps, wash bores and tube wells. The result was dramatic. Farmers produced 1.1 million tons of rice paddy; unleashing a rice revolution. To support the rice production effort, 100 large-scale integrated rice processing mills with a total capacity of 2 million metric tonnes of milled rice per year will be installed.

A lot more strategic effort is needed to raise the productivity of other crops, and this is being done. The productivity of sorghum is being improved. In 2012, high yielding seeds of sorghum were distributed and cultivated on 50,000 ha. Our expectation was to reach 100,000 ha with improved sorghum seeds by 2013. With the commercialization of the newly developed hybrid sorghum, it will be possible to reach 2 million ha under new varieties within the next three years.

What is unknown to many Nigerians is another silent revolution on wheat just about to be unleashed across the northern states of Nigeria. Nigeria has the potential to produce wheat across ten states in the north with an estimated 600,000 ha suitable for wheat production. Dry land wheat can also be grown in the high lands of Plateau, Mambilla in Taraba State and Obudu in Cross Rivers state.

Through investments in research and development over the past two years, we have now introduced and tested well-adapted tropical wheat varieties into Nigeria. The varieties are heat tolerant and give yields of 5-6 tons per ha, which is 500-600% of the yields obtained previously. Work is underway to rapidly multiply these wheat varieties at the Lake Chad Research Institute, Maiduguri. My ministry has embarked on the development of a wheat value chain to take advantage of the new varieties. Over the next two years, 450,000 ha will be planted with the new wheat varieties across the wheat growing belt of northern Nigeria. We expect to produce at least 2.5 million MT of wheat, which will reduce wheat imports by 50% by 2015.

Making further in-roads into agricultural development to achieve our 2030 dream would require robust attention to agricultural mechanization interventions which account for 60% - 70% of the investment cost in farm business. Most developed countries have moved from total reliance on human power to using tractors and implements to varying degrees. Over the years, modest changes have occurred within each power source in terms of the quality and diversity of the tools and implements in use. There is no doubt that mechanization is a compulsory requirement for boosting agricultural production in developing countries and unavoidably, a key to the realization of the food security policy in Nigeria. Consequently, tractorization, which is a major component of agricultural mechanization, requires appropriate attention.

The internationally accepted national tractorization intensity is put at 1.5hp/ha (FAO). The estimated number of tractors in Nigeria is 40,000, and only about 20,000 are functional. This number of tractors translates to a tractorization intensity of 0.04hp/ha. To achieve the recommended intensity of 1.5hp/ha, the country will require between 1.5 million to 2.0 million tractors, depending on the tractor engine capacity. The current available tractors translate to only about 2.7% of the number required to achieve full tractorization in the country. Urgent steps, therefore, need to be taken to address this unacceptable short-fall.

Before the inception of this administration, tractors were imported by government with no provisions made for their repairs and maintenance. The provision of after sales services, including availability of fast moving parts by the tractor importers were poor with the tractors breaking down shortly after they are delivered. Tractors requiring critical parts for repairs would sit for months before ordered parts are supplied. Most times, the parts never arrive and the tractors are cannibalised to keep others running. This must stop. We are now encouraging investors to set up tractor and implement assembly plants that would transform to manufacturing plants within a few years. Currently, we would need about 60,000 tractors a year and 300 tractors in the next five years. We are already discussing with investors to achieve these targets.

My ministry has started addressing the issues that will remove the bottlenecks in providing efficient and cost effective mechanization services to the farmers. We are establishing the Agricultural Equipment Hiring Enterprise (AEHE) to provide value added agricultural mechanization services that include leasing/hiring out of various kinds of agricultural equipment for land preparation, harvesting and post-harvest activities, repair and maintenance services etc. AEHE would also act as a training platform for youths on agricultural mechanization development. AEHE will bring together owners/investors, end-users, technical support personnel, agric extension officers and rural finance agents, all in one location for the purpose of sustainable agricultural mechanization.

The volume of agricultural produce losses in Nigeria currently range from 15% to about 40% depending on the crop. These levels of losses are unacceptable and we are doing something about it. We are developing Agricultural Investment Clusters through the establishment of Staple Crop Processing Zones (SCPZ) throughout the country. The SCPZ will attract private investors into areas of high food production to set up food processing plants. They would link farmers in clusters to food processing plants, create jobs and drive rapid rural economic growth and above all, lead to the establishment of roads, power supply, storage facilities etc within the rural communities. The SCPZ will target commodity value chains within the six geo-political zone of Nigeria and selection of the sites will be dictated by the crops production comparative advantage.

Another notable intervention will be the procurement and installation of 18 large-scale industrial processing plants for the production of High Quality Cassava Flour (HQCF) with a total capacity of 1.3 million metric tonnes per year. These plants would be owned and run by the private sector. The mills will support massive structural shift in the flour milling and bakery industry towards greater use of cassava flour in bread etc. These mills would lead to massive expansion in mechanized cassava production by medium and large-scale cassava farmers. When the plants are completed, they would save Nigeria $2 billion annually, create markets for 1.6 million metric tonnes of HQCF and 6.4 million metric tonnes of cassava roots, and thousands of jobs.

I went on a learning trip to Brazil in April of this year with some of my Technical Advisers and Directors of the Ministry to understudy the Brazilian agricultural transformation. We were amazed at what we saw. Through effective research and

development innovations on critical crop production in-puts and technologies, appropriate policies and legislations, Brazil was able to transform the Cerrados, a waste land worse than the northern guinea savannas, into a productive cluster of commercial farms that have catapulted Brazil from a food import dependent country to a leading exporter in most of the agricultural produce/products. I, must admit the agricultural mechanization formed the major platform upon which this miracle was achieved. We are currently discussing with Brazil to initiate technical exchange between Brazil and Nigeria, which will lay the solid foundation for the transformation of the savannahs of northern Nigeria.

The President and distinguished members of the Nigerian Institution of Agricultural Engineers, you would agree with me that the realisation of our plan to transform Nigerian agriculture requires a strong commitment by agricultural engineers who form the care of your membership. I have a sizable number of agric engineers in my Ministry, most of them located at the National Centre for Agricultural Mechanization (NCAM), Ilorin, where they are doing a great job for the country. I challenge all of you, especially those of you carrying out research in the various universities and polytechnics to engage in contemporary research that will be relevant to our farmers needs. NCAM is already running an agricultural equipment commercialisation programme whose primary aim is to move research technologies to the field for adoption and commercialization. I seek your support for this programme by collaborating with NCAM to ensure that your research efforts get to the farmers.

It is my hope that your deliberations will be targeted at adding value to my Agricultural Transformation Agenda and I look forward to receiving your recommendations at the end of this conference.

Thanks and God Bless.

Dr. Akinwumi Adesina (CON)
Honourable Minister of Agriculture.

MECHANIZATION POLICY FOR OBJECTIVE GOAL ATTAINMENT OF AGRICULTURAL TRANSFORMATION AGENDA

Professor Isaac N. Itodo, FNSE, FSESN, FNIAE
Department of Agricultural and Environmental Engineering
University of Agriculture
P. M. B. 2373, Makurdi, Nigeria
E-mail: dritodo@yahoo.com
Tel: +2348054621424

1.0 INTRODUCTION

Agriculture in recent time has become known and appreciated as 'green economy' and remains the hope of the Nigerian economy. Mechanization remains the key to unlocking this green economy for the wellbeing of Nigerians. There is a decline in output from our smallholder farms as reflected in the regular and steady increases in the prices of food and malnutrition of the population. The mechanization of Nigeria's smallholder farms is beset with high cost of imported machinery and inappropriate government policy amongst others. This paper examines mechanization practices in Nigerian agriculture and proposes new course of actions to attaining the much talked about 'transformation agenda'.

2.0 OUTLOOK OF WORLD'S AGRICULTURAL MECHANIZATION

2.1 New Thinking

In recent times agriculture is being discussed in the context of climate change, food security, poverty and gender inequality. It is generally believed that is the problem and the solution to climate change. The issue on the agenda now is how to produce food without adding more greenhouse gases to the atmosphere. Although agriculture holds tremendous promise for mitigating climate change it is generally acknowledged that up to 50% of emissions from land use change and deforestation are due to agriculture and food – related transport, processing, storage and consumption (Mae-Wan Ho, 2013). This has called to question the current practice of agricultural mechanization. It is estimated that inappropriate mechanization of agriculture has over the years caused the collapse of small family farms particularly in developed countries. Also, the failure of agricultural mechanization in developing countries has left some1.4 billion people undernourished and poor, 70 – 80% living in rural areas, who can no longer afford to buy enough food, even when food is available.

2.2 The Verdict

The verdict now is that the inter-related problems of agriculture could be solved by a paradigm shift away from the current industrial agriculture and globalized food system to a conglomerate of small, bio - diverse, ecological farms around the world and a localized food system that promotes consumption of regional produce (Mae-Wan Ho, 2013). Current mechanization practice must, therefore, support this verdict.

3.0 PROFILE OF NIGERIA'S AGRICULTURE

3.1 A Snapshot At Some Nigerian Agricultural Facts

The employment in crop farming by gender and category of workers in Nigeria as at 2009 (NBS, 2012) shows that Kaduna state has the highest farmer population of 1,433,702 farmers followed by Jigawa state with a farmer population of

1,024,169. Bayelsa state has the least farmer population of 113,354. The survey (Table 1) shows that there were 16,636,279 farmers in Nigeria of which 3,356,589 (20.2%) of them are women. Kaduna state also has the highest population (384,248) of women farmers while the Federal Capital Territory has the least population of women farmers of 1,109.

Kano State and Bayelsa state has the highest and least unpaid family farmer population of 1,805,828 and 114,738 respectively. The unpaid family farmer population of Nigeria is 23,131,403 of which 9,378,150 (41%) are women. There are more unpaid family farmers than men in Abia, Akwa Ibom, Anambra, Baylesa, Benue, Borno, Delta, Edo, Ekiti, Enugu, Imo, Lagos, Ondo, Osun, Oyo, Plateau and Rivers states. Kano state also has the highest population of paid employed farmers of 1,494,456 followed by Katsina state and Plateau state with 1,359,314 and 1,278,181 respectively.

Table 1: Employment in Crop Farming by Gender and Category of Workers in Nigeria, 2009

STATE	FARMERS		UNPAID FAMILY		PAID EMPLOYEES	
MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	
Abia	176,802	130,347	237,642	275,956	261,820	254,466
Adamawa	386,092	52,659	308,448	204,673	175,255	38,813
Akwa Ibom	223,318	107,434	127,331	171,136	33,448	42,851
Anambra	341,406	282,738	273,941	275,125	257,413	174,002
Bauchi	790,207	4,381	657,081	153,125	392,683	30,049
Bayelsa	72,220	41,134	54,912	59,826	96,708	35,107
Benue	322,025	125,581	499,381	511,520	190,879	236,577
Borno	426,039	11,238	275,376	289,509	207,637	103,995
Cross River	280,025	124,126	363,484	335,175	299,183	276,154
Delta	294,924	145,247	179,021	212,038	237,516	59,482
Ebonyi	395,283	264,962	449,742	436,744	479,463	390,672
Edo	247,599	104,579	191,831	225,347	213,180	46,195
Ekiti	117,791	16,848	57,866	67,106	159,001	17,423
Enugu	203,996	115,628	87,536	139,908	49,754	56,836
Gombe	368,973	88,052	436,431	200,684	461,243	377,090
Imo	511,638	122,647	304,985	526,812	100,357	307,188
Jigawa	1,021,184	2,985	498,425	129,920	278,185	36,873
Kaduna	1,049,454	384,248	949,563	540,881	676,828	343,426
Kano	415,553	234,465	1,223,889	581,939	1,119,608	374,848
Katsina	227,862	131,043	1,030,020	247,927	1,050,565	308,728
Kebbi	205,696	109,183	544,950	213,450	401,147	124,674
Kogi	134,423	352,307	60,242	325,355	127,396	
Kwara	285,961	17,591	191,272	132,841	146,640	34,422
Lagos	456,961	27,250	121,038	125,281	139,127	67,955
Nassarawa	285,594	35,019	223,303	169,599	115,985	50,141
Niger	456,961	3,279	563,022	385,006	360,661	289,363
Ogun	200,226	54,933	181,091	175,636	314,359	26,103
Ondo	237,416	47,806	212,503	239,374	307,488	265,083
Osun	322,331	31,130	189,191	271,585	309,500	205,870
Oyo	338,531	62,534	167,470	287,719	789,131	146,499
Plateau	307,229	35,180	374,203	380,698	1,145,386	132,795
Rivers	284,053	160,190	362,450	460,124	394,052	545,915
Sokoto	467,777	11,785	563,839	150,260	547,071	175,214
Taraba	325,709	15,083	389,355	238,167	243,550	108,895
Yobe	493,462	20,392	542,055	83,035	131,015	38,297
Zamfara	482,270	233,783	454,731	311,129	552,969	599,071
FCT	119,699	1,109	113,568	108,653	123,262	42,542
Nigeria	13,276,690	3,356,589	13,753,253	9,378,150	13,087,424	6,491,010

SOURCE: NBS/CBN SOCIO- ECONOMIC SURVEY ON NIGERIA, 2010.

There are 18,176,082 crop farms in Nigeria; 15,623,709 (86%) of these farms are owned by males while 2,546,371 (14%) are owned by females. The age group of 30-49 has the highest number of farms (9,873,229 representing 54.3% of the total number of farms) followed by the age group of 50-64, which has 5,376,031 (29.6%). The age group of 15-29 owned the least number of farms of 1,034,510 (6%) followed by the age group of 65 and above that owned 1,892,314 (10%) farms (NBS/FMARD).

These statistics shows that the farmer population of 16,636,279 represents about 10.4% of the estimated Nigeria population of 160 million. The states of Jigawa, Kaduna, Kano, katsina and Plateau have a substantial number of their population involved in crop farming. Nigeria is made up of 98.32 million hectares of land

and of this available land, 74.036 million hectares (75.3%) may be regarded as arable (Olayide, 1985). Therefore, the arable land available to a farmer in Nigeria is about 4.5 hectares.

3.2 Agricultural Mechanization in Nigeria

Table 2 is agricultural machinery, 4-W tractors per 100 square km of arable land in Nigeria compared to some countries from 2003 to 2006 (World Bank, 2012). The table shows that Nigeria has an average of 7 tractors for every 100 square km (10,000 ha) of arable land compared to 100, 1,900 and 64,000 tractors for Algeria, Ghana and South Africa respectively. In Nigeria, where 'tractorization' has been misconstrued for mechanization, this table has clearly shown that agricultural mechanization is relatively zero. The 4-W drive tractor with plough and harrow implements remains the flagship of Nigeria's agricultural mechanization. The other machinery that should augment the tractor complete the cycle of crop mechanization are almost non-existent. The Nigeria agricultural system lacks such machinery as cultivators, boom sprayers, land planes, chisel ploughs and harvesters.

The lack of electrical power to drive prime movers on postharvest machines such as rice threshers, maize shellers, grain grinders etc. has also eliminated their use on farms in remote rural locations. Alternative sources of power must be employed on these machines in order to mechanize these postharvest activities. In truth the mechanization of postharvest activities is also almost zero. In all, the mechanization of Nigerian agriculture is still substantially dominated by manual power and the hoe-cutlass technology.

Table 2: Agricultural Machinery, Tractors per 100 km^2 of Arable Land

Country	2003	2004	2005	2006
Nigeria	6.9	7.0	6.6	6.8
Algeria	97,800	97,809	100,128	102,636
Ghana	1,920	1,912	1,803	-
South Africa	65,475	63,200	-	-

Source: World Development Indicators

4.0 A NEW COURSE OF ACTION?

4.1 Training of Agricultural Engineers

There is a great need to step up the training of Agricultural Engineers and this can only be achieved by affecting the Agricultural Engineering curriculum. The revised curriculum should correct the present inadequacies of Agricultural Engineering students, which they graduate with and become lowly rated professionals.

Inadequacies in the curriculum can be found in the inability of students to design, draw and fabricate prototype machines. This explains why projects in machine development has continued to dwindle in our universities. Students' attention should be drawn to challenging areas of tuber crop and indigenous cereal crop machines that don't exist. The curriculum should, however, be flexible allowing students focus and pursue their prejudices.

The curriculum should also take cognizance of location-specific courses; e.g. why should the Department of Agricultural Engineering in Rivers State University of Science and Technology, Port Harcourt not have more courses on drainage, saline water, aquaculture and Fadama agriculture? Why should the

Department in Makurdi, Minna, Awka and Nsukka not do more on the mechanization of tuber crops and gully erosion remediation? Why should the Department in Maiduguri, Kano and Bauchi not do more on desertification and wind erosion control? Why should the Department in Abeokuta, Ibadan, Ife, Akure and Agowoye not do more on the mechanization of plantation agriculture? This will enable the Departments grow to become 'Centers of Excellence' in specific national agricultural goals.

The inability to venture into machine design, from my 28 years as a Lecturer, derives from the students' poor background in technical drawing, lack of teaching facilities for the interactive teaching of drawing using software such as Autocad and the lack of it in the present curriculum and the absence of such courses as Mechanics of Machines. The curriculum must, therefore, step up above the minimum standard and accommodate these courses.

4.2 Energy in Agriculture

All agricultural machines require a source of energy to work. Existing postharvest machines, irrigation pumps cannot be used on farms in remote rural locations because of the unavailability of electricity to power the electrical motors that drive them. This has made the mechanization of primary processing of cereal crops almost zero in Nigeria.

The mandate of Agricultural Engineers, particularly those specialized in Farm Power and Machinery is to provide a source of power for agricultural machines for their use anywhere. Moreover, this option of the profession requires distinctive pre-requisite competence in energy use and application on one hand and a deep knowledge of developing and using agricultural machines on the other hand. Surely, the energy for the remote rural locations are the inexhaustible renewable energy (RE) of solar, wind and biofuels. The in-depth teaching and demonstration of the use of these REs in powering, say a rice threshing machine, is a mandatory knowledge for the Agricultural Engineer in this century.

4.3 Promotion of Mechanization of Smallholder Farms

The Institute of Science in Society report by Mae-Wan Ho (2013) stated that small farms (less than 2 hectares dominate the world today. 800 million hectares of the 1.6 billion hectares of global croplands are smallholder farms cultivated by 99% of the world's 2.6 billion farmers, producing 70% consumed. 70% of these farmers are women. These small farms are known to be 2 to 10 times as productive as large industrial farms, and much more profitable, a position that was supported by Olayide (1985) many years ago.

The American Society of Agricultural and Biological Engineers (ASABE) still encourages the mechanization of smallholder farms by instituting prizes for ¼ tractor design competitions and 2-W power machines that support small family farms. The smallholder machines are largely responsible for the high output of food from the South East Asian countries. These machines are also the numerous small family farms in Nigeria.

4.4 Machinery Mix in Our Agriculture

Inappropriate machinery mix has been a long standing problem in the mechanization of Nigeria agriculture. The vogue in government is to purchase 4-W drive tractors to signify interest in agriculture. Tractors have been bought year after year yet the mechanization of our smallholder farms has remained

dominated by the hoe-cutlass technology. Why is this so? The reason is that these smallholder farmers have not found it profitable to increase the size of their holdings using these tractors. What sense does it make to increase the size of area ploughed when there are no planters, boom sprayers and harvesters for the subsequent operations to guarantee timeliness of operation in a rain-fed agriculture? Increasing the size of ploughed fields without the capacity to hire the required workers to plant, weed and harvest on time has resulted in unforgivable losses to the farmers.

The mechanization of our smallholder farms will thrive if government provides a mix of farm machinery to famers. The farm size will increase with a commensurate increase in output.

5.0 CONCLUSION

A paradigm shift in the agricultural mechanization policy is required to transform Nigeria's agriculture, which should improve the socio-economic indicators of the population. This paper has analyzed and proposed the new policy direction for attaining this goal. It is concluded that:

1. The Nigerian Institution of Agricultural Engineers (NIAE) as a learned society set up a standing Curriculum Advisory Committee to timely advice on the review of the agricultural engineering curriculum in line with world trend and best practices taking into account the expected role of the profession in the Nigerian economy.
2. The agricultural engineering curriculum should go above the NUC Minimum Academic Standard.
3. Agricultural Engineering professionals should begin emphasize the use of renewable energy sources such as solar PV, wind and biofuels to power agricultural machines/technologies for on-farm postharvest agricultural activities in remote rural locations.
4. Government and organizations should consider the mix of agricultural machinery procured in the various Tractor Hiring Units so as to enable the farmers mechanize all the unit operations of their farming activities. Indeed, these Tractor Hiring Units should be Machinery Hiring Units.
5. In line with current thinking of increasing output from family rather than industrial farms, the 2-W single axle tractors should be emphasized in Nigerian agriculture.

REFERENCES

Mae-Wan Ho, 2013. *Paradigm Shift Urgently Needed in Agriculture*. The Institute for Science in Society. http;//www.i-sis.org.uk. Assessed on September 17, 2013.

NBS. 2012. *Social Statistics in Nigeria 2012 – Part III (Health, Employment, Public Safety, Population and Vital Registration).* National Bureau of Statistics, Abuja. Pp. 39.

NBS/FMARD. 2012. Collaborative Survey on National Agriculture Sample Survey 2010/2011. National Bureau of Statistics and Federal Ministry of Agriculture and Rural Development, Abuja. Pp. 14-17

Olayide, S. O. 1985. *Characteristics, Problems and Significance of Farmers*. In: Nigerian Small Farmers: Problems and Prospects in Integrated Rural Development. University of Ibadan Press, Ibadan.

World Bank, 2012. *World Development Indicators*. World Bank, Washington DC, USA

BIOREMEDIATION OF PETROLEUM-HYDROCARBON CONTAMINATED AGRICULTURAL SOILS, SLUDGE AND DRILL CUTTINGS IN THE NIGER DELTA

Professor Josiah Miebaka Ayotamuno
Department of Agricultural and Environmental Engineering
Rivers State University of Science and Technology
Portharcourt, Nigeria
Tel: +234 803 3403 998) / Email add: mjayotamuno@hotmail.com

ABSTRACT

Bioremediation of petroleum-hydrocarbon impacted soils, sludge and drill cuttings was carried in one of the Agricultural sites in the Niger Delta region of Nigeria using remediation by Enhanced Natural Attenuation (RENA) or Land farming. The remediation operations basically involved systematic tilling of the impacted soils through ploughing, homogenisation and construction of a series of windrows, coupled with the addition of nutrient amendments and effective drainage of the site for storm water management. These were carried out in a biocell divided into four compartments corresponding to different levels of contamination of the impacted soils, sludge and drill cuttings. Samples were collected from the treated area at set periods and monitored for contaminant attenuation to reasonable limits. All operations were carried out following good quality assurance / quality control measures alongside strict compliance with standard HSE procedures. At close out, the soil, sludge and drill cuttings in the treatment biocell were observed to have been remediated to target limits as defined by the Environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN) remediation intervention levels.

1.0 INTRODUCTION

Bioremediation is the use of biological agents, such as bacteria, fungi, or green plants, to remove or neutralize contaminants, as in polluted soil or water. Bacteria and fungi generally work by breaking down contaminants such as petroleum hydrocarbons into less harmful substances. Plants can be used to aerate polluted soil and stimulate microbial action. They can also absorb contaminants such as salts and metals into their tissues, which are then harvested and disposed of. Bioremediation is the use of any organism metabolism to remove pollutants.

Bioremediation can be generally classified as in situ or ex situ. *In situ* bioremediation involves treating the contaminated material at the site, while *ex situ* involves the removal of the contaminated material to be treated elsewhere. Some examples of bioremediation related technologies are phytoremediation, bioventing, bioleaching, landfarming, bioreactor, composting, bioaugmentation, rhizofiltration, and biostimulation.

Phytoremediation describes the treatment of environmental problems through the use of plants that mitigate the environmental problem without the need to excavate the contaminant material and dispose of it elsewhere. While landfarming is a bioremediation treatment process that is performed in the upper soil zone or in biotreatment cells. Contaminated soils, sediments, or sludges are incorporated into the soil surface and periodically turned over (tilled) to aerate the mixture (Ayotamuno et. al., 2008). This technique has been successfully used for years in the management and disposal of oily sludge and other petroleum refinery wastes. Bioaugmentation, on the other hand, is the addition of necessary nutrients required to speed up the rate of degradation of a

stimulate existing bacteria capable of bioremediation. This is done by addition of various forms of rate limiting nutrients and electron acceptors, such as phosphorus, nitrogen, oxygen, or carbon (e.g. in the form of molasses).

1.1 Crude Oil Pollution of Agricultural Soils

Agricultural soils are simply defined as natural bodies of loose unconsolidated materials; several centimeters deep that forms a thin layer of the earth's surface (Brady and weil, 1999). They are rich in organic matter and soil nutrients, which ranges from carbon, nitrogen, phosphorus, potassium, calcium, sodium, magnesium, iron etc. These provide favourable conditions for the growth of plants and microorganisms when they are in the proper balance. It is the effect of soil microbes that facilitates the working of the soil nutrients into the soil for the utilization of the plants. Hence the introduction of toxic materials into the soil will affect the balance of nutrients that favours the effective survival of plant life and microbial activity within the soil. From the above premise, crude oil pollution of agricultural soils adversely affects the biota of the soil due to the creation of an imbalance in soil nutrients and chemical composition which in turn becomes deleterious to the survival of the soil biota.

Jobson et al. (1974) noted that crude oil is essentially a mixture of carbon and hydrogen, and thus spills will result in an imbalance in the carbon-nitrogen ratio at the spill site. For bacteria to grow efficiently they require about 10 parts carbon to 1 part nitrogen. If the ratio is greater, e.g. 100:1 or 1000: 1, the growth of bacteria and utilization of carbon source(s) will be retarded. In addition to there being a nitrogen deficiency in oil soaked soil, other nutrients such as phosphorus may become growth-rate limiting. It was on the basis of the imbalance in nutrient ratio caused by petroleum pollution that the researchers decided to use the application of urea-phosphate to correct both deficiencies in one application.

Molnaa and Grubbs (1989) noted that large amounts of biodegradable organics in the top layers of soils (this corresponds to the definition of agricultural soils) depletes oxygen reserves in the soil and slows down oxygen diffusion rates to the deeper layers. Sequel to this crude oil pollution persists until remediation measures are resorted to since oxygen is a limiting factor in all types of petroleum degradation. It is for this reason they noted that the addition of large quantities of hydrocarbons in a system usually creates a nutritional imbalance which needs to be corrected by the application of inorganic fertilizers containing nitrogen and phosphorus.

It was noted that in the aftermath of the pollution of a soil by crude oil, the biological treatment of such a soil could be affected by the hydrocarbon structure and by the weathering process, which decreases the hydrocarbon structure, and by the weathering process, which decreases the bioavailability of pollutants to microorganisms. All in all, the pollutant is mineralized to carbon dioxide and water. Weathering refers to the result of biological, chemical and physical processes that affect the type of hydrocarbons that remain in the soil. These processes enhance the sorption of hydrophobic organic contaminants (HOCs) to the soil matrix, decreasing the rate and extent of biodegradation. Moreover weathered oil-contaminated soil normally contains a recalcitrant fraction of compounds composed basically of high molecular weight hydrocarbons, which cannot be easily degraded by indigenous microorganisms. In contrast, a recently oil contaminated soil contains a higher amount of saturated and aliphatic compounds, which are the most susceptible to microbial degradation.

1.2 Microbial Degradation of the Contaminant

All agricultural soils in Nigeria contain a large variety of microorganisms able to degrade or chemically modify organic and inorganic molecules (Nester et al, 1998). Hence

different microorganisms are capable of growing in a wide variety of environments but each will grow best in those environments for which it is well adapted microbial degradation of the contaminant (i.e. Petroleum hydrocarbon) is based on the idea that all organisms remove substances from the environment to carry out growth and metabolism.

Bacteria, protista, and fungi are very good at degrading complex molecules and incorporation of the breakdown products into their metabolisms. The resultant metabolic wastes that they produce are generally safe and somehow recycled into other organisms. Fungi are especially good at digesting complex organic compounds that are normally not degraded by other organisms. The ability to degrade a pollutant is dependent on enzymes produced by the organism. Thus only bacteria with the abiity to produce enzymes that select petroleum as a substrate can degrade petroleum (Shmaefsky, 1999). Bacteria are usually the most important group of soil microbes in the breakdown of hydrocarbon compounds, such as gasoline and diesel fuel (Brady & Weil, 1999). Accordingly, a simple example of the degradation process for hydrocarbons involves the following:

- The microbes consume and convert the petroleum products.
- The converted petroleum product becomes a fatty acid.
- Microbes perish after all the petroleum products is consumed.
- The end products are: carbon, food for indigenous organisms, carbon dioxide and water.

The effectiveness of biodegradation is dependent upon a number of site-specific factors such as nutrient availability, the size and type of microbial population, aeration, pH of the soil, temperature, and ease of biodegradation in the substrate. For biodegradation to occur, bacteria must be involved. The dynamics of bacteria growth indicates that bacterial growth is measured by an increase in cell numbers, as opposed to the growth of most other organisms, which is measured by an increase in total size. The great majority of soil bacteria and fungi are heterotrophic.

1. 3 Nature of Petroleum Hydrocarbon Pollution of Agricultural Soil in the Niger Delta

In the Niger Delta region of Nigeria and particularly in the oil bearing communities of Rivers State , contaminated land resulting from crude oil spill is one of the greatest challenges as far as the environment is concerned. From the early stage of oil exploration, and until recently, most of the wells drilled have produced large quantities of spills and other drilling wastes including drill cuttings and sludge, which were hardly taken care of as a result of lack of proper waste control measures. Other times oil spill results from over aged and hence corroded pipelines, oil bunkering and indeed sabotage by aggrieved persons protesting for the equitable distribution of the oil wealth from their communities. Most times the spills were left un-attending to, in the surrounding areas of the immediate pipe or well locations, for many months and sometimes into decades.

In one of the contaminated farms sites worked on by the author in the Niger Delta Region (Figures 1 and 2), trials pits measuring about 3m by 4m by 2m were dug with an Excavator. The soils obtained of these pits were studied and the various samples were qualitatively analyzed revealing the physical characteristics (nature) of the contaminated soils. For ease of reference and description, the contaminated soils were classified as follows: Granular Caked Tar, Granular Caked Soil, Oily Caked Tar, Caked Stony Materials, Carbonized Burnt Soil, Oily Stained Soils (Light, Medium and Heavy), Light Sludge, Heavy Sludge, Free Phase Oil, Oily-Sludge Mix, Sludge-Clay Mix.

Agricultural soils using any of the methods of bioremediation earlier detailed in the article. For reasons of space and time, this article will only dwell on the method of landfarming whose equipment and operation are very close to agricultural engineering



Figure 1: Free Phase Oil Recovery Team



Figure 2: Heavy Sludge Excavation

practice in the farm. The other name for landfarming is Remediation by Enhanced Natural Attenuation process (RENA). The article is intended to give a typical example of how the RENA technique worked on a pilot project supervised by the author in one the sites in the Niger Delta region whose tropical climate is characterized by abundant sunshine, frequent rainfall and high-biotic habitats, which supports the remediation method.

Therefore, the main objectives of this article is to determine the capacity and limits of the application of Remediation by Enhanced Natural Attenuation process (RENA) for various concentrations of contaminations in soil, sludge and drill cuttings to the EGASPIN (DPR, 2002) remediation intervention levels.

2.0 MATERIALS AND METHODS

2.1 The Landfarming Transformation Technique

Landfarming or RENA is an integrated biological and physico-chemical process that works together to accelerate the natural processes of petroleum-hydrocarbon attenuation or reduction by means of human intervention to increase access to water, sunlight, oxygen and nutrients.

In practice, in a contaminated agricultural soil, the technology basically involves:

- Trenching and recovery of free phase oil where necessary.

- Systematic tilling of the impacted soil/sludge/drill cuttings through ploughing, homogenisation and construction of windrows.
- Addition of nutrient Amendments (such as phosphates and Nitrates, etc), water and sometimes top soil in appropriate quantities.

2.2 Description of Work, Preparation and Layout of Off-Site Treatment Area

The work plan was thoroughly designed to cover a period of twelve (12) weeks, including technical report writing of active work on site. The active work on the site included site preparation, continuous drainage for storm water management, construction of dykes, spreading of containments into the various cells, primary and secondary tilling and homogenization, manual and mechanical construction of windrows, and the split application of nutrient amendments to the various levels of contaminated soil / sludge / drill cuttings and indeed close out. The remediation was planned for completion after the appropriate risk based remediation targets have been reached on the basis of laboratory analysis of soil samples.

The off-site treatment area was made into an engineered High Density Poly-Ethylene (HDPE) lined and compartmentalized containment (other wise referred to as a Bio-cell) . A concrete lined leachate receptor was provided to collect leachate or effluent that was generated as a result of storm water effects. This was to prevent secondary pollution incident. The treatment area (bio-cell) was divided into 4 plots and initial hydrocarbon concentration results measured as follows:

- Plot 1, measuring 2, 240m^2, was allocated for about 1, 500m^3 of medium contaminated soil with a contaminant concentration of about 10, 000 ppm.
- Plot 2, measuring 320m^2, was allocated for drilling cuttings.
- Plot 3, measuring 1280m^2, was allocated for heavily contaminated soil with contaminant concentration greater than 10, 000 ppm.
- Plot 4, measuring 640m^2, was allocated for about 200m^3 of oily sludge with concentration ranging from 150,000 to 500,000 ppm.

The bio-cells allowed for easier filling and monitoring of the landfarm thus created. By dividing the land farm into cells rather than one large space, better aeration, degradation and nutrient amendment was achieved thereby enhancing the attenuation of contaminants.

2.3 Treatment Bed, Backfilling, Construction of Dykes and Spreading of Contaminants

A layer of 0.4 m of clean sand was placed over the HDPE liner to serve as the treatment bed. The plots were separated from one another by tarpaulin liners in order to prevent cross contamination .For reasons of aesthetics and accessibility to the various cells, the bio-cell was back filled with clean sand; this provided a gradient for the movement of storm water. It also gave the entire bio-cell a face lift such that operations on the site could be viewed from any position. Concrete sand bags were used to demarcate various cells in line with their respective dimensions. Prior to the construction of dykes, light density

polyethylene liners (LDPL) were laid on the sand bed of the bio-cell. The concrete sand bags were then placed on them. This was done to forestall the migration of contaminants from one cell to another. In the aftermath of the preparation of the treatment area, different levels of impacted soils, sludge and drill cuttings were transferred into their various compartments using a pay loader.

2.4 Drainage / Storm Water / Leachate Management

High rainfall and low sunshine characterized the terrain; hence storm water management became imperative in order to constantly reduce the storm water within the bio-cell for an effective RENA process. Storm water in the bio-cell was not discharged to the primary environment. Channels were constructed round the entire bio-cell and directed to a ditch from where they were discharged into a sump pit designed and situated close to the bio-cell, with the aid of a pumping machine manned with a suction and discharge hose. The channels were periodically cleaned to allow for an easy flow of



Figure 3 : Bulking Process Of 1:2 At The Sludge Cell

Water collected in the sump pit was first allowed to stand after which a suction pipe was lowered to the base of the sump pit through a vent and with the aid of the pumping machine the water was pumped out and sent to a reservoir / fast tank. The water thus discharged from the bio-cell was then sampled by staff and sent to the Laboratory for analysis of Chemicals of Concern (CoCs). Throughout the treatment period, leachate from the bio-cell was effectively managed such that there was hardly any overflow to the primary environment. Besides, leachate generated from the treatment operations were sampled and analysed accordingly, and based on the results of the analysis they were put back into the treatment area and remediated along with the soil.
?

2.5 Bulking, Primary, Secondary Tilling and Homogenization

Bulking was the treatment given to the sludge cell prior to the execution of the usual treatment operations (Fig. 3) . Clean sand and sludge were homogenised in the ratio of 1:2; while lumps were mechanically crushed to finer particles. This process is engineered to facilitate the reduction of the hydrocarbon content of sludge, as well as increase the surface area and hence its remediation process.

At the take off of the RENA process tillage machines were employed to break down and hence pulverise the impacted soil in order to make room for proper aeration (or



Figure 4: Primary and Secondary Tilling Operations and, Breaking Down of Biocells After Soil Amendment Homonization

of the soil matrix to oxygen supplies) and importantly allow for easy homogenisation during treatment (Fig. 3). This was important as the impacted soil was already undergoing weathering, a process which decreases the bioavailability of contaminants.

The secondary tilling further enhanced the process by breaking down the impacted soil to smaller particles thereby increasing the surface area and aeration for optimal microbial activities.

This was done using the tillage machinery to facilitate the proper mixing of applied nutrients and microbes with the contaminated soil matrix (Fig. 4). During these operations, the top soil and sub-soil layers are properly mixed, thereby giving way for the exposure of the latter and the reduction of the moisture content of the entire soil mass.

2.6 Construction of Windrows / Ridges and Application of Nutrient Amendments

Windows or Ridges were constructed both manually and mechanically. The combination of both methods of windrow construction led to a greater homogenisation, as the use of only mechanical method did not allow for much exposure of the deeper layers of the bio-cell. The windrows were allowed to stand for four (4) days before they were broken down; while a three day interval elapsed before a further series of windrows were constructed (Fig. 5). All in all, a total of twenty (20) windrows were constructed in all the cells during five series of construction on the four compartments of the bio-cell. About 75% of the windrows were manually constructed.

Nutrient amendments were delivered in 20 litre kegs. A bio-organic nutrient (also called Enzyme in the field) in liquid form was the nutrient source employed. The kegs containing the nutrients were stationed round the cells. The nutrients were then sprayed unto the contaminated soils, sludge and drill cuttings in the biocell, and also in the ditches and channels. After each application, windrows were re-constructed in order to give way for proper mixing of the nutrients within the contaminated soil matrix.

The bio-organic nutrients were supplied in four (4) split applications (rounds of nutrient amendments), such that two phases of application was carried out during each round of nutrient amendment. After the first phase of each application, there was thorough mechanical homogenization with sufficient time given for sorption and



Figure 5 : Construction of Windrows/Ridges

percolation of the liquid enzymes into the soil matrix before the second phase of application. Each split application took about seventy-five (75) kegs (similar to 1500 litres) of organic nutrients.

2.7 Sampling Protocol

Composite samples were collected (Fig. 6) in duplicates from plots 2, 3 and 4; while 2 composite samples were obtained from plot 1 and duplicated for chemical analysis, at set periods. Vertical profile samples were taken at five (5) different depths. This was repeated at nine (9) points within plots 1 and 3 at intervals of 10 m; and at three (3) and six (6)



Figure 6 : Sampling At The Drill Cuttings Cell

points in plots 2 and 4 respectively. The samples were pooled together to form composite samples which were representative of the treatment area. Thus, a total of 10 duplicate samples were collected for analysis, fortnightly, for a period of three (3) months.

3.0 RESULTS AND DISCUSSION

The results of the analyses are not included in this article, however, visible field indicators that points to the effectiveness of the land farming or RENA process include the following: in the aftermath of the second phase of nutrient amendment, no free surface oil was visible, and there was a great reduction in the hydrocarbon fumes that emanated during the treatment process as compared to the experience at project take-off.

Subsequent nutrient applications and homogenisation revealed treatment cells with soils highly pulverized; no hydrocarbon fumes were observed even during manual windrowing. These, coupled with a clear change in soil colour (compare Fig. 1&2 to Fig. 6) that was observed are visible signs of enormous contaminant attenuation.

4.0 CONCLUSION AND RECOMMENDATION

In the final analysis, it was clear from the observations made during the course of the pilot project that the land farming or RENA process is effective and suitable for remediation of petroleum-hydrocarbon impacted soils, sludge and drill cuttings within the Niger delta region of Nigeria, as the process is cost effective relative to other conventional methods of treatment; and environmentally friendly. All end products are benign and potentially utilised by the surrounding ecosystem. Hence, it was recommended that the RENA process be employed for future treatment of petroleum contaminated soils, sludges and drill cuttings within the project area and other affected areas.

REFERENCES

Ayotamuno M.J., A.J. Akor, and M. R. Daka (2008). Bioremediation of hydrocarbon sludge using different levels of nutrients. Unpublished Article.

Brady N. C and Weil R. R (1999). The nature and properties of soils. 12th ed., Prentice Hall Publishers pp. 1 – 9, 453-536, 727, 739-740.

Department of Petroleum Resources (DPR). Environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN). Ministry of Petroleum and Natural Resources, Abuja, Nigeria; 2002. 314pp

Jobson, A., Mclauglin, M., Cook, F. D. and Westlake, D. W. S. (1974). Effect of Amendments on the microbial utilization of oil applied to soil. App. Microbiology vol. 27, No 1. pp. 166-171.

Molnaa B. A. and Grubbs R.B. (1989). Using a microbial consortia as innoculum. A publication of Solmar Corporation U.S.A.

Nester, E.W., Gordon, M.P., Amasino, R.M. and Yanofsky, M.F. (1998). Microbiology: A human perspective, HC, 2nd Edition.

Shmaefsky, B. R. (1999). Bioremediation: Panacea or fad? Access Excellence. The National Health Museum.

A farmstead design must start by aiming at integrating all the resources available on the farmland, ranging from topography, climate and natural resources like waterways. Demarcation of all Activity Zones should be based on set of planning factors as follows.

a) Topographical Advantages: A contour map of the whole farmland should be obtained and profile developed to assist in using highlands and lowlands to advantages. All physical structures to be erected on the farm now and those envisaged in the future must first be listed. Such structures that need to be on highlands like water tanks should then be distinguished from those to be constructed on lowland areas like dams, water dugouts and septic tanks. Issues of the farm drainage should be kept in mind in locating roads and gutters.

b) Natural Resource Advantages: Natural resources on the farmland should be identified and indicated on the farmland map. This will include soil texture and profile, waterways, rivers, fadama or marshland and even rocks and peculiar hills. In living zones, effort should be made to grow shade-providing trees as this will give a good source of cooling and ventilation.

c) Climatic Advantages: Climatic factors like sun-directions, prevailing wind-directions during rain and dry seasons should be indicated on the map prior to planning the farmstead. Activities and Structures should be categorized into climatic-dependent or otherwise stating nature of dependence. For instance, activities that will generate pollution like dust, odour, and liquid waste should be listed for proper placement just as structures requiring heat; ventilation should be properly oriented to take advantage of the sun and wind.

d) Space and Distance: Space and Distance are very fundamental to the initial and the long term running cost of the farm. Initial cost of a farm will normally be affected by its size and distance from the town and highways. This initial cost if compromised without due consideration can result into high running costs in the long run. With regards size of Farmland, the intended production volume and envisaged expansion will dictate the minimum land space requirement.

In planning, activity zones must be demarcated in concentric circles of 30.0m minimum space in-between each zone with the cropping and major livestock zone located at outskirts. In locating specific structures and production buildings, it must be born in mind that distance between buildings will translate into cost of road building. The less the possible travel distance, the better. Distance will also come into play in addressing fire and security, generally flammable and chemical structures should be located close to water source and away from human activity area.

e) Water Requirement: This is one area that our Profession should play a major role in resolving. Water Sourcing, Storage, Usage and Management should be of utmost importance to the Agricultural Engineer particularly in Nigeria where we have enormous amount of rainfall, yet lack water in most location for most part of the season. In design, water requirement should be properly computed, requirement will include not just for human and livestock needs but also for processing buildings, orchards, and irrigation where applicable. Then all available sources should be considered to determine the best method of obtaining or sourcing the required amount. All possible sources ranging from harvesting with dugouts, rooftops, underground drainage collection as well as shallow-well and borehole should all be investigated to determine which is best in terms of portability and cost effectiveness.

f) Utilities and Services: Utilities will normally include Electrification, Gutters, Generator House, Water, Vacuum and Milk Lines, Roads etc. It should be noted that people are not normally cautious in selection of utility in planning. Serious checks and balances should be made to see which utility is necessary and in what form it is best. Most government projects fail when it get privatized because of the initial wasteful

FARM STRUCTURES AND ELECTRIFICATION FOR ENHANCED RURAL LIFE AND PRODUCTIVITY" BASED ON ECONOMIC AND SUSTAINABLE ENVIRONMENT

Professor Abdullahi El-Okene
Department of Agricultural Engineering
Ahmadu Bello University
Zaria, Nigeria

1.0 INTRODUCTION

This great profession of Agricultural Engineering has a unique role to play in keeping the Human Race at Peace and ensuring quality life full of happiness and satisfaction. We are in an era where the disparity across the different continent of the world in terms of industrialization and per-capita is so wide that problems of each continent or more specifically each country, must be looked at with the intention of achieving the basic goal of this noble profession of ours, which is the reduction of drudgery to the barest minimum. While it is true that seeking profit is part of every profession, it is however not a goal in isolation. Professional etiquette which is fast dwindling worldwide has reduced most professions to a goal of only profit seeking irrespective of quality of life and peace. This has meant that investments are directed more at companies with higher profit margins.

There is no need for the Agricultural Engineer to seek to reduce drudgery only to turn around to create unemployment or encourage cheap labour. Etiquette demands that we match the quest for profit with the realities of the specific locality in question. Therefore while large scale farming is the preferred and profitable option in highly industrialized and capitalist states, the case is different in a country of low industrialization and huge level of unemployment.

The usual small profit margin in Agricultural Production necessitates serious consideration of all parameters involved in running any farm enterprise. The most important of these parameters which is foundation to the efficient running of the farm is its Farm Structures and Electrification. The farmstead plan affects all activities to be carried out on the farm for its entire life and must therefore be given thorough and detail consideration. A bad farmstead plan will not only result in loss of useful land, it will equally result in waste of energy, time and resources. Therefore such factors as distance, topography, climate, recirculation etc. must be thoroughly examined and put into proper consideration.

Even though, several attempts have being made by Governments in actualizing National Agricultural Development through huge monetary interventions and several Agricultural Policies, corruption has always hindered the true implementation of any of these policies and intervention to date. This paper is therefore more of an advice based on experience, to Agricultural Engineers on ways of approaching Farmstead Planning and Rural Electrification for Sustainable Productivity in a Rural setup.

2.0 GENERAL DESIGN PRINCIPLES IN PLANNING AND LOCATING ACTIVITY ZONES

The main key here is to aim at a well Integrated and Nature Friendly Design with functionality in mind. Activity Zones are determined by grouping all activities expected to be carried out on the farm in groups depending on their similarity. The number and type of activity zones will generally depend on the nature of the farm, example; is the farm livestock based or is it a cereals farm, orchard farm, fish farm, or an integration of all. Other activities may include limited or extensive animal-product or grain processing and storage operations likely to take place on the farm and the size and kind of personnel expected to be living on the farm etc.

nature of the design that seem to believe everything can be provided for. Decisions should be made not just by considering the ideal but the realities and possibilities on ground. Effort should be made to reduce distance of supply lines as much as possible.

g) Fire and Security: Proper design with respect to electrification, distance between buildings, proper storage location and good housekeeping in terms of lawn management will go a long way in preventing fire. Where possible, fire resistant building materials should be used. Generally, minimum gap of 15.0m should be maintained between all buildings and for barns, garages, chemical storage and processing buildings this should be increased to 20.0m.

3.0 EFFECTIVE USE OF NATURAL COOLING AND DRYING POTENTIALITIES

a) Building Materials: Possibility of using materials on site for the construction of Production Buildings must be investigated seriously. Stabilized Earth Blocks for Production Buildings will not only be cost effective but equally functional with respect to thermal resistance. In selection of building materials for any of the structures, desirable properties like strength, durability and low cost of maintenance is as important as the availability of local skill to use such materials.

b) Building Shape: Shape and orientation of building must take into consideration sun and wind-directions. For production buildings requiring heat like the poultry brooding house, the longer side of the building should face the sun. Where stabilized earth blocks are used, roof-overhangs should be provided. Roof-Overhangs apart from protecting building walls help to both create shadow and fit the building into the landscape.

c) Shelter Belts: Trees used as shelter belt will help in providing cost effective shade to animals, particularly in hot dry areas. Emphasis should be on economic and early maturing trees that provide good amount of shade like mangos, eucalyptus, while ornamental trees should be avoided.

d) On Farm Construction: On farm construction should be explored where the experience exist. Functional workshop even of a small size should be established with minimum tools and appliances to assist in fabrication of basic tools and construction.

4.0 ENERGY MANAGEMENT

Proper Harnessing and Coordination of all Potential Energy Sources on the farm should be considered from the initial stage. Renewable energy is abundant and easily harnessed in most part of the country if there is the will. Therefore attention should be put in designing Manure pits, to enhance its generation of biogas.

Choice of electrical appliances should be made with having in mind that cost of electrical consumption could outweigh the initial economical advantage. Choice of type of some appliances like air-conditioners should be selected having in mind the need to use their residual output of heat for drying. Energies normally available on the farm include:

a) Solar Energy: Solar energy can be used directly for limited cooking, water heating, refrigeration and drying of grains. Photovoltaic Cells can be employed for electrical generation.

b) Wind Energy: Natural wind is effective in carrying away odour and removal of dust if properly harnessed. Simple wind mills can also be used to generate electricity and pump water from wells.

c) Biomass and Briquette from waste: The possibility of using this source as an alternative to conventional energy sources should be seriously explored.

d) Residual heats: Residual heat of cooking stove and heat sources in processing buildings are good sources of heat available for drying. It should not be forgotten that

air-conditioners are heat pumps and the exits heat is excellent for quality drying if properly harnessed.

5.0 OFF-FARM FACTORS

While in developed countries, off-farm factors has more to do with the local legal laws concerning the setting-up and running of a farm enterprise, in Nigeria, additional factors of importance will include community well being and behavior.

a) Community Involvement: In Nigeria, one of the issues will be how to assist the rural community of the farmstead area through employment generation by rural development that encourages small machineries for better management.

If cropping fields and production buildings can be in smaller unit and kept under the management of individual managers, not only will efficiency of land management be enhanced; employment opportunity will be created for the community. The type of production to be engaged in could be better with some communities than others. The community may be welcoming to a particular production because of traditional interest or know how while yet some animal production type could be offensive to the community.

b) Avoiding Industrial Waste, Pollution and Cultural Abuse: Type of livestock, crop, processing to be done of the farm should take into consideration the possibility of attracting the hatred of the community if the activities of the farm will generate waste and cause abuse to the culture of the area in question.

6.0 GOVERNMENT POLICY

Government policy can go a long way in encouraging young people to take-up farmstead living by its kind of land reform and marketing policies. Offering of professional and functional financial assistance would ease the initial capital intensive nature of a typical farmstead. In almost all Federal Government Programmes, little has being done to address farmstead development issues. It is recommended that current Agricultural Policy be reviewed to provide for Farmstead Development in Nigeria. The Department of Agriculture should develop Standard Agricultural Building Designs that takes into consideration geographical zones, climate peculiarity and culture. There should also be a combined effort by the Research Institutes, Raw Materials Development Council and Agricultural Engineers to specify Functional Building Materials for the different geographical zones of the country.

AGRO FOOD PROCESS AND STORAGE TECHNOLOGY FOR VALUE ADDITION AND FOOD SECURITY

Engr. Prof. Zinash Delebo Osunde
Professor of Agricultural Engineering
Department of Agricultural and Bioresources Engineering
Federal University of Technology, P. M. B. 65, Minna

ABSTRACT
Appropriate Agro-Food Process and Storage Technology is an essential component of a vibrant agricultural sector. Too often, even when the yields are high, producers lose income due to poor post-harvest practices. One of the causes of food insecurity especially in developing countries is high post-harvest losses due to lack of appropriate food processing and storage facility. Food processing in addition to improving food security also improves the diet of the population, generate wealth to the farmer or processor and reduce import dependence of the country. This paper reviews the state of food security in Nigeria, look into different ways of adding value in agricultural products, discuss the role of food processing and storage technology in achieving food security, the present situation of food processing and storage technology in Nigeria and make some recommendations on the way forward.

INTRODUCTION
According to ILO (1999) Agriculture is the cultivation of plants and fungi, rearing of animals and other life forms for food, fiber, bio-fuel and other products used to sustain life. It is also simply defined as: A large or small scale farming enterprise: practice of cultivating the land and raising livestock or business of people engaged in growing food and fiber.

Agriculture worldwide has been recognised as an important sector of the economy as it is expected to achieve the following roles or objectives:

- provide food for the teaming population,
- Provide employment for the labour force,
- Generate foreign exchange for the country and
- Provide raw materials for the industry.

However, for the sector to realise these objectives a robust agro-food process and storage technology must be in place Igbeka (2003). Agriculture in Nigeria is a major branch of the economy, providing 70% of employment for the population. However the question is, does agriculture in Nigeria provide sufficient food for the teaming population? Does it provide sufficient raw material for the industry? Or does it generate sufficient foreign exchange for the country? Obviously the answer is no. According to the Food and Agriculture Organization of the United Nations (FAO, 2010) there is much room for improvement in Nigerian agriculture. The area of land under cultivation in Nigeria could be increased by as much as 100 per cent. However, increasing the area of cultivation or even increasing the production level on its own may not assure food security, as large proportion of the produce may not reach the consumer. Even at present level of production large amount of agricultural produce is lost due to various causes of postharvest loss (Osunde and Fadeyibi 2011). Table 1 shows the estimated annual postharvest losses of various agricultural commodities in Nigeria in the year 2010. The table show estimated loss of 20 – 30 % for cereals, 10 – 80% for tubers, 10 – 50 % for legumes and oil seeds and 10 – 100% for fruits and vegetables. Thus to achieve food security there is the need to develop and make use of appropriate processing, preservation and storage facility for the excess produce that will be produced.

Commodity		Estimated Loss
Cereals	Maize, millet, sorghum	20 – 30 %
Tubers	Cassava	10 – 25%
	Yam	20 – 67%
	Cocoyam	10 – 40%
	Sweet potato	50 – 80%
Legumes and oil seeds	Soybean, cowpea, bambara nut, ground nut	30 - 40 %
	Beni seed	20 – 50%
	Melon	10 – 30%
	Palm nut	10 – 15%
Fruits and vegetables	citrus	20 – 95%
	mangos	20 – 80%
	Garden eggs	40 – 100%
	Okra	30 – 70%
	Pepper	10 – 20 %
	Tomatoes	20 – 50%

Table 1. Estimated Percentage Loss of Agricultural Commodity in Nigeria
Adopted from Gernah *et al*., 2013

FOOD SECURITY AND THE NIGERIAN SITUATION

Food security is defined as the availability of food and ones access to it (Wikipedia, 2013). A house hold is considered food secured when its occupants do not live in hunger or fear of starvation. Food security situation in a community or a country exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The World Health Organization (WHO) defines three facets of food security WHO (2013). These are food availability, food access and food use. Food availability is having available sufficient quantities of food on a constant basis. Food access is having sufficient resources both economic and physical to obtain appropriate foods for a nutritious diet. Food use is the appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation. FAO (2012) add a fourth dimension that is the stability of the first three facets of food. The stages of food security range from food secure situations to full-scale famine. "Famine and hunger are both rooted in food insecurity. Food insecurity can be categorized as either chronic or transitory. Chronic food insecurity translates into a high degree of vulnerability to famine and hunger; ensuring food security presupposes elimination of that vulnerability.

Raghavan (2003) identified different levels of food security. These are household food security, Village level food security and national level food security. At house hold level food is grown by individual farmers mostly for sale and partly for consumption by themselves. Moving up, the problem appears at the village level, where community action becomes necessary to tackle the challenges. The next dimension involves densely populated urban centers linked with rural production areas for their food supply. And at the top, the problems appears at the national level where the solutions are linked to government policies and macroeconomic factors.

Worldwide, around 925 million people are chronically hungry due to extreme poverty, while up to 2 billion people lack food security intermittently due to varying degrees of poverty (FAO, 2010). The paradox is that the highest quartile of the food insecure live in rural areas where food is produced, yet they are net food buyers rather than food sellers.

Abubakar (2012) describes the Nigerian food situation as follows

- Domestic food production is increasing, but at a lower rate than the population growth, resulting in excess of national food demand over supply or food deficit.
- Food import is increasing steadily
- There is no stability of food supply.
- Due to the inefficient harvesting, processing and storage techniques usually deployed, post harvest losses are between 20 to 80% resulting in unstable supply and food insecurity.

In Nigeria access to adequate and nutritious food is generally limited by low income and poverty, largely because nutritious foods are usually expensive. Nigeria is a large food importer, importing foods such as wheat, rice, sugar, fish and vegetable oil. Imported foods are far from the reach of the low income earners. Food utilization is yet another important index of food security. Food in-take and nutritional well-being of many households in Nigeria are of relatively low quality, which is usually as a result of their low economic status. About 61% Nigerians are malnourished and deficiency diseases such as Fe deficiency, which affects physical capacity, and in severe cases leads to death and susceptibility to infections and *protein-energy malnutrition* (PEM), which causes growth failure in children, and weight loss in adults are very common Abubakar (2012). The food security situation is further compounded by human induced climate change.

Nigeria ranked 20th out of 42 African countries studied on the 2006 Global Hunger Index (GHI). It improved to 18th position on the 2009 GHI and 46th out of the 84 developing countries captured globally for the study in 2009 Abubakar (2012).

FOOD PROCESSING, STORAGE AND VALUE ADDITION

Food processing aims to make food more digestible, nutritious and extend the shelf life. Due to the seasonal variations high levels of wastage or shortages can arise if adequate measures are not taken to preserve and store the foods. Food processing covers all the processes that food items go through from the farm to the time it arrives on the consumer's plate. It includes basic cleaning, sorting, grading and packaging of agricultural products and also alteration of the raw material by size reduction, extraction, heat treatment and make it ready-to eat food like bakery products, instant foods, flavored and health drinks.

At all the steps of processing and storage value is added to the commodity thereby creating value to the consumer. Value addition in to agricultural product can be achieved in different ways Osunde, 2013. These are:

- Form value
- Location value
- Time value
- Information value

Form value: In this case the form of the commodity is changed in to a desired product which can be consumed or has a longer shelf life. A raw material is converted into finished or semi-finished products. Changing the form usually:

Increases the usability of the product
Maintaining or improve product quality
Extend the shelf life
Reduce the size
Increase availability of nutrient

Here processing of agricultural products plays a big role. Unit operations in agricultural processing such as size reduction, heat processing, drying, dehydration, cooking, malting, concentration, filtration, mixing etc all changes the form of the product and add value to it. A typical examples of form value addition are wheat to flour and to

bread, Cattle to meat, cassava to garri etc

Location value: in this value creation the agricultural commodity is brought closer to the consumer. Agricultural products are transported from the farm to markets, supermarkets, department stores etc. This provides the commodity or the product in the desired place, it also increase assortment and access to exotic products. Agricultural product in raw, finished or semi finished form is transported by road, by air or by sea to bring it close to consumer.

Time value: In this value creation agricultural product are provided at the desired time in spite of its seasonality. This is achieved by storage and preservation. Some agricultural products are available for consumption throughout the year in spite of their short production period. This is achieved by the use of appropriate preservation and storage facilities, such as silos, cold storage, controlled atmosphere storage and Modified atmosphere storage.
Information value: Value is added here by informing and educating the consumer about the product he is purchasing and consuming. This is often done through marketing functions, advertising, promotion, packaging & labeling.

THE ROLE OF FOOD PROCESSING AND STORAGE IN COMBATING FOOD INSECURITY AND WEALTH CREATION

Board (2003) stated that Agro processing is the most promising and sunrise sector of the economy in developing countries, in view of its large potential for growth and likely socio economic impact specifically on employment and income generation. The agro industry is an important and vital part of the manufacturing sector in developing countries and the means for building industrial capacities. The food processing sector is a highly fragmented industry, it has the potential to be the driver of economic growth and enhance rural incomes. It has several segments like dairy, grain processing, packaging and storage, fruits and vegetable processing, fisheries, consumer foods include packaged foods, meat & poultry processing, beverages and packaged drinking & water.

Food processing offers an opportunity for the creation of sustainable livelihoods and economic development for rural communities. Food processing has come a long way in the last few decades. The ever changing lifestyles, food habits and tastes of cosumers globally have altered the dynamics of the industry. The world food production and consumption patterns are evolving with a change in the needs of the customer. Increasing demand for exotic and different foods from customers across the world has redefined the market for food processors across the world. With these changes, producers, processors, retailers and suppliers of food, world over, are reorienting their business plans to meet the new demands of the customers. Food processing storage benefits all the sections of the society. It helps:
Farmers - get higher yield, better revenues and lower the risks drastically,
Consumers - have access to a greater variety, better prices and new products,
The economy - gets benefitted with new business opportunities for the entrepreneurs and
The work force - gets employment.

According to Potter and Hotchkins (1996) Processing of agricultural materials is very beneficial in several ways and generally ensures food security in the following ways:

- Preservation of agro – raw materials, thus reducing wastage
- Increases economic gains of those involved in the food supply chain
- Guarantees long term availability of food products

- Extension of shelf life of agro – raw materials
- Reduces import dumping and capital flight in the country
- Increases food quality through transformation of different food products
- Improving the diet of the population by improving the nutritional value of the product

Developing countries, Nigeria inclusive need to establish a strong and dynamic food processing and storage sector which can play a vital role in diversifying the agricultural sector, improving value addition opportunities and creating surplus food for the teaming population, raw material for the industry and wealth creation. As a matter of fact unprocessed foods are very much susceptible to spoilage on storage. The agro industry mainly comprises of the post-harvest activities of processing, preservation and storage of agricultural products for intermediate or final consumption. The right post harvest practices such as good processing techniques, and proper packaging, transportation and storage (of even processed foods) can play a significant role in reducing spoilage and extending shelf life thus assuring food security.

FOOD PROCESSING AND STORAGE TECHNOLOGY IN NIGERIA

The need for appropriate equipment and technology in achieving a well developed food processing and storage sector cannot be overemphasized. Various processing equipment have been designed and developed in various higher institutions and research organizations in Nigeria Alonge (2011). However, at farm level producers and processors still use age-old traditional methods to process and store their agricultural products.

Babatunde (2006) listed a range of agro processing technologies promoted and popularised by agricultural extension agencies in Nigeria. This was based on the study of the Agricultural Machinery Industrial system in Nigeria under the auspices of UNIDO. These technologies include grain milling technology, cassava processing technology, palm, groundnut and soya bean oil processing technology, fruit juice extraction technology and so on. Various agricultural equipments are also being manufactured locally. Babatunde, 2006 listed over a hundred indigenously manufactured agricultural equipment in Nigeria. More than half out of these are processing technologies. However in spite of all these the Nigerian agro-food industry is not the sunrise sector of the economy. Its impact on job creation, wealth generation and enhancing economic growth is yet to be felt. This is also the case in other Sub Saharan African Countries.

Table 2 shows the share of agriculture and agribusiness (which is the complete process of processing, storage, packaging, transportation and marketing of agricultural products) in national GDP of some selected countries. In developed and emerging economies agribusiness contributes immensely to the Gross Domestic Product (GDP) of the economy. It is interesting to note that in the United State of America (USA) and other emerging economies the share of agribusiness to the GDP is much higher than that of agriculture. While in Sub Saharan African Countries (SSA) except South Africa the reverse is the case. This shows the low level of development of the agribusiness sector of the economy. According to Jaffee *et al*., 2003 agribusiness activity constitutes between 15 and 30 percent of the GDP for most SSA countries, this in spite of most industries in this countries are food or agro related. Jaffee *et al*. (2003) estimated that,

Table 2. Share and Size of Agribusiness in National GDP of Selected Countries

Source: Jaffee *et al*., 2003

excluding South Africa, agro industry accounts for some 49% of manufacturing value

added in South Saharan African countries, while some 43% of the region's services value-added is food /agro-related (i.e., food transport and distribution).

Country	Agriculture's Share of GDP	Agribusiness' Share of GDP*	Combined Agriculture and Agribusiness Share of GDP	Agribusiness GDP ($ Billion)
S. Africa	4	16	20	14.9
Nigeria	42	16	58	5.7
Côte d'Ivoire	28	26	54	3.1
Ethiopia	56	30	86	2.9
Uganda	41	23	64	2.7
Kenya	26	23	49	2.4
Zimbabwe	18	21	39	1.9
Cameroon	40	17	57	1.7
Ghana	44	19	63	1.4
Tanzania	44	19	63	0.9
All SSA	32	21	53	67.0
For Comparison				
U. S.	1	13	14	1007
Brazil	8	30	38	236
Argentina	11	29	40	94
Mexico	9	27	36	91
Indonesia	20	33	53	71
Thailand	11	43	54	68
Chile	9	34	43	25

The Federal Government of Nigeria has begun the development of Staple Crop Processing Zones [SCPZ] across the country intended to attract the private sector to set up food manufacturing plants in areas of high production, for import substitution (Daily independent, 2013). This is a welcome development, however it is also important to encourage small scale food processing industries in rural and semi urban areas and develop indigenous technology which will be used by this industry.

Crop storage in Nigeria is generally achieved by the traditional method. The traditional methods usually made from mud and thatch roof cannot guarantee protection against major storage pests of staple food crops like maize, leading to 20–30% grain losses, particularly due to post-harvest insect pests and grain pathogens. As a result, smallholder farmers end up selling their grain soon after harvest, only to buy it back at an expensive price just a few months after harvest, falling in a poverty trap, The Strategic Grains Reserve Department of the Federal Ministry of Agriculture and Rural Development manages and operates 33 grain storage silo across the country. The storage capacity of the silo complexes range from 11,000 to 100,000 metric tons with combined total storage capacity of 1.3 million metric tones. However, presently only 13 silo facilities are in operation, 6 new ones have been completed awaiting commissioning while 14 are at different stages of completion This day (2013). The silos are used to store grains such as paddy rice, maize, millet, sorghum, and gari and soybean in some cases Okolo, 2013. Presently the silos are used by the Federal Government, the Federal Government purchases the excess grain during harvest store it in the silos and disposes it during periods of scarcity or to areas affected by any natural or manmade disaster. Other storage technology such as cold storage, control atmosphere storage and modified atmosphere storage are beyond the reach of the small scale farmers and processors.

Household metallic silo for grains and the triple bagging system for cowpeas which is been successfully used by small scale farmers in other developing countries is yet to be adopted by farmers in Nigeria. The household metallic silo is a key post-harvest technology in the fight against hunger and for food security. It is a simple structure that

allows grains to be kept for long periods and prevents attack from pests such as rodents, insects and birds. If the grains have been properly dried (<14 percent moisture in the case of cereals and <10 percent in the case of pulses and oilseeds) and the household metal silo is kept under shade, there are no problems of moisture condensation in it's inside FAO (2008). Household metal silos generally hold between 100 and 3 000 kilos of grain. A household metal silo with a capacity of 1 000 kilos can conserve the grain needed to feed a family of five for one year. A small or medium farmer with more than one silo can store surpluses for off-season sale when prices are more attractive, thus increasing household income and food security SPORE, 2011.

The triple bagging system for cowpea which is also known as the Purdue Improved Cowpea Storage (PICS) is a non chemical storage technology, which cuts off the supply of air to insects and stores it hermetically. It has been successfully used to extend the shelf life of cowpeas SPORE, 2011. However this simple technologies are yet to be adopted by the small scale farmers in Nigeria

CONCLUSION

In Nigeria today more than half of the food produced is lost, wasted or discarded as a result of inefficiency in the post– harvest management of the food chain. This loss is mainly due to lack of appropriate processing and storage facilities. Dependence on imported solutions by governments cannot guarantee sustainable food security instead it slows the agribusiness and agri enterprise activity and economic development of the country. One of the best ways to address food security challenges is therefore through the development and improvement of indigenous processing and storage technologies which can be adopted by small scale producers. In line with this the following recommendations are given as the way forward.

RECOMMENDATIONS

- Research and Development techniques are inevitable tools in improving the food and agro processing and storage technology in the country.
- Synergy between Universities and research institutes will go a long way in improving postharvest technology and other areas of agricultural engineering also assure adoption of this technology by the end users.
- In any research and development the end users in this case small scale producers and processors should be carried along and encouraged to adopt the developed technology.
- Linkage of relevant stakeholders of all the value chains to appropriate technologies is critical to achieving increased productivity, job creation, economic empowerment, poverty alleviation & attainment of national food security & safety.

- Training and education of end users of developed technology is very essential
- Agripreneurs (entrepreneurs in agricultural sectors, this include, processors, processing equipment fabricators etc) should be encouraged and also empowered.
- Establishment of collection centers for perishable crops with appropriate technology will go a long way in reducing heavy loss being experienced.

REFERENCES

Abubakar B. Y. (2012) Research and development: a panacea for food security, job

creation and poverty alleviation. Lecture delivered at the Nigerian universities research and development fair, 2012, Held at the federal university of technology, Minna, 10th October, 2012.

Alonge A. F. (2011). Food Processing, Preservation and Storage For Economic Development In Nigeria. A lead paper presented at the 11th International Conference and 32nd Annual General Meeting of the Nigerian Institution of Agricultural Engineers. (NIAE Ilorin October 17 – 20, 2011, Ilorin, Nigeria) ISBN: 978-036-578-8

Babatunde O. O (2006). Crop Processing for Food Security and Poverty Alleviation in Nigeria. A lead paper presented at the 7th International Conference and 28th Annual General Meeting of the Nigerian Institution of Agricultural Engineers (NIAE) held in Ahmadu Bello University, Zaria, Nigeria, November 6-10, 2006.

Board, Niir (2003) Modern Technology Of Food Processing & Agro Based Industries (2nd Edn.). Published by the National Institute of Industrial Research, India.

Daily Independent (2013) Federal government to Develop 14 Staple Crop Processing Zones Across Nigeria; Daily Independent News Paper, July 7 2013. Pp 6

FAO (2012) Food Security Agricultural and Development Economics Division (June 2006). Food Security Retrieved June 8, 2012

FAO (2008) Agricultural and Food Engineering Technologies Service, household metal silos, key allies in FAO's fight against hunger, Food and Agriculture Organization of the United Nations. Viale delle Terme di Caracalla, 00153 Rome (Italy) E-mail: AGS-registry@fao.org

FAO (2010) FAO Practical Guide : Basic Concept of Food Security. Food and Agriculture Organization of the United Nations. Viale delle Terme di Caracalla, 00153 Rome (Italy) E-mail: AGS-registry@fao.org

Gernah D.I, Ukeyima M.T, Ikya J.K, Ode, F.K And Ogunbande B.J (2013) Addressing food security challenges through agro – raw materials processing; Agricultural Science Research Journals Vol. 3(1), pp. 6-13, January 2013, Available online at http://www.resjournals.com/ARJ. ISSN-L:2026-6073 ©2013 International Research Journals

ILO (1999) Decent employment for agricultural and rural development and poverty reduction; http//www.fao-ilo.org/ilo-dec-employ/en/

Igbeka J. C. (2003)Review and appraisal of the Agricultural Policy for Nigeria in relation to Post harvest technology, Paper presented at the forth International Conference of NIAE at Damaturu Yobe State 8th – 12 September, 2003

Jaffee Steven, Ron Kopicki, Patrick Labaste, Ian Christie, (2003) Modernizing Africa's Agro-Food Systems: Analytical Framework and Implications for Operations. World Bank, Africa Region Working Paper Series No. 44.

Okolo, 2013 personal communication, Strategic Grains Reserve, Minna

Osunde Z. D. (2012), Agricultural Product Value Addition: Panacea for Rural Economic

Development. A paper presented at the NIAE, Kaduna Branch Annual Public Lecture, 2012.

Osunde Z. D. and A. Fadeyibi (2011) Storage Methods and Some uses of Cassava in Nigeria

Continental J. Agricultural Science 5 (2): *ISSN: 2141 – 4203; http://www.wiloludjournal.com*

Potter N. N, Hotchkins J. H (1996) Food Science, 5th ed. CBS Publishers and Distributors, New Delhi.

Raghavan G. S. V (2003) Appropriate Postharvest Handling of Agri-Products for Food Sufficiency in Developing Economies A lead paper presented at the 4th International Conference of the Nigerian Institution of Agricultural Engineers, Damaturu, 2003.

SPORE 2011 Postharvest Management Adding Value to Crops. The magazine for Agricultural and Rural Development in ACP Countries April-May, 2011.

Thisday (2013) Ministry of Agriculture and Rural Development (FMA&RD) This day news paper, Monday September 9 2013 pp 46

Wikipedia (20013) en.wikipdia.org/wiki/food set

WHO (2013) trade diplomacy and health Glossary of globalization, trade and health terms. http://www.who.int/trade/glossary/story/en/

OPERATION AND MAINTENANCE OF FARM MACHINERY FOR SUSTAINABLE AGRICULTURAL MECHANISATION

Engr. M.A. Ladeinde
Head of Centre, Agricultural Mechanics and Machinery Operator's Training Centre (AMMOTRAC) P.M.B. 636, Akure, Ondo State, Nigeria.
mabayojeladeinde @yahoo.com. 08035637321.

ABSTRACT
This paper discusses the needs of training tractor operators and mechanics on maintenance of farm machinery and the ways of ensuring sustainable Agricultural Mechanization Development in Nigeria. It also discusses AMMOTRAC'S intervention and its rationale towards agricultural mechanization development; a veritable component of Agricultural Transformation Agenda. In the paper is AMMOTRAC Objectives, training programmes, training scope and approach to trainings. Its achievements as a mechanization training institution, as well as the challenges of training of agricultural machinery operators and mechanics in Nigeria and appropriate solutions to problems being encountered are also discussed.The centre has so far trained six thousand seven hundred and twenty four (6,724) agricultural machinery operators (5930) and mechanics (381), engineers (68), technical officers (90) workshop managers (45), farm managers (57), farmers (115), and sales representatives (38).

1.0 INTRODUCTION

For over three decades, National, State and local governments have made different efforts to achieve food sufficiency with little success. Agricultural labour has remained scarce, due to the drudgery of manual farm work. This has resulted in loss of cropping opportunities; most farmers which are small scale in size cannot find labour for land clearing, land preparation and more importantly for planting, weeding and harvesting. These farmers cannot afford the high labour costs and they lack the incentives or tools to perform the high quality work needed to improve their productivity (Propcom and Mai- Karfi-2013).

Past governments have made efforts to promote and possibly privatise mechanized farming. Thousands of tractors and implements were procured and sold at subsidized prices. State and Local Government also established tractor – Hiring Units which have not been profit oriented and most of them have folded up as of today (Ademiluyi et al., 2004).

Nigeria with an estimated tractor population of about 30,000 tractors, out of which about 50% are functional. This is low mechanization rates of 0.021 hp/ha as against the 1.5hp/ha recommended by FAO. If we consider the 70million hectares of arable land available in Nigeria demanding mechanization activities (Ahmed et al-2013). Nigeria will need nothing less than One million tractors.

It is also observed, that the high tractors and implements breakdown are due to various reasons such as wrong selection and matching of tractors with implements, lack of spare parts, and insufficient knowledge on how to operate and maintain tractors, inadequate experienced mechanics especially in the rural areas. Lack of planned and preventive maintenance culture.

This is further compounded by the technological changes in the agricultural equipment that were imported into the country in the past three decades. Most operators find it difficult to calibrate and adjust gadgets on modern agricultural equipment, simply because they are not well informed and or a failure to follow the manual's instructions as well as a lack of repair facilities. (Ladeinde, 1996).

The unit of functional tractors is too low and cannot meet the need of the present government Agricultural Transformation Agenda as to promote agriculture as a business. The private vendors and private service providers are being encouraged by the Federal

government to take over the tractor Hiring/Leasing programme and this will create great potential for mechanization market. This is a job opportunity for young agricultural engineers and technologists to explore.

It is important to guard against premature failure or early breakdown right from the time of planning for equipment purchase to the time of usage and storage (Odusanya - 1996).

Against this backdrop therefore, it becomes necessary for personnel in operation, maintenance and repair to continue to upgrade their knowledge of agricultural machinery trends and innovation through training courses.

2.0 NEED FOR TRAINING AS A WAY OF ENSURING SUSTANABALE AGRICULTURAL DEVELOPMENT

Human resources are one of the greatest assets in any endeavour. Thus, the development of human resources is vital. In a rapidly changing technological environment, new models of equipment are placed in the market, at times, old ones are rendered obsolete without spare parts to maintain them. Training will assist operators to know how to reduce breakdown and alternatives available to keep the equipment functional and extend the service life span.

2.1 AMMOTRAC'S Intervention

Increase in mechanization activities without due consideration of spending up to 5% for training personnel to cater for the upkeep and maintenance of such huge investments were leading to huge losses and wastage (Junk Yard Syndrome). This promoted the idea of establishing AMMOTRAC in 1988. This move was aimed at achieving maximum profitability of the machinery and realizing their full service life span.

In August 1992, a station of AMMOTRAC was established at Misau in Bauchi state to take care of trainees from the northern states including the Federal Capital Territory, while AMMOTRAC station at Akure handles the training programme for trainees from the southern states including Kwara and Kogi States.

2.2 Objectives Of AMMOTRAC

AMMOTRAC mission is to identify and analyse training problems, needs of agricultural machinery operators and mechanics and develop appropriate interventions for improving agricultural equipment management for sustainable agriculture. Our vision is to be a Centre of Excellence for Agricultural Machinery Management.

Some of the objectives of the centre are as follows:

Train agricultural machinery mechanics and operators on the techniques of operation, maintenance and repair of agricultural machines and equipment.

*Train personnel on the techniques of operation and maintenance of animal traction equipment as well as management of work animals.

*Train agricultural machinery mechanics and operators on the techniques of operation, maintenance and repair of agricultural land development and bush clearing equipment.

*Train personnel on the installation, operation, maintenance and repair of agro processing machinery.

*Train personnel on the operation and maintenance of irrigation equipment.

2.3 Training Programmes

AMMOTRAC realizes the above listed objectives through the following training programmes:

***Short term training programme:**

This is usually within one to four weeks duration. The one week training as a refresher course for old operators while four weeks training for those wanting to become tractor operators.

***On-the-spot training programme:**

This training is usually carried out on the field of operation through the use of well-equipped mobile workshop manned by skilled technical personnel. Conducting on the spot training and correcting common mistakes that might be observed during the training. This type of training is requested for by big mechanization farms (i.e Michelin Rubber Plantation, Araromi Obu)

***Train the trainers' training programmes:**

This programme is for the trainers from other training institutions and machinery marketers to acquire new skills and refresh their knowledge. They also are able to transfer same skills and knowledge to trainees and personnel in their various places of work. AMMOTRAC through phone do communicate with the trainees and sponsors to find out impacts of our trainings, if there is noticeable improvements. We have conducted such trainings for staff of higher institutions, Tractor Operators Owners Association of Nigeria (TOOAN) and Agro-Nigeria Venture Limited, Ekiti state.

***Long term training programme**

This is a long duration training programme that will take about 1 to 2 years to train highly efficient operators and mechanics. Though it is yet to commence but in the planning stage.

2.4 Training Scope

Some of the centre's training programmes and courses cover the following major topics namely:

* Basic Tractors' Training
* Intermediate Agricultural Machinery Training
* Advance Agricultural Machinery Training
* Repair and Maintenance of Farm Machinery
* Operation of Power Tiller and its implements.
* Hydraulic and Transmission Systems.
* Economic Management and Operation of Farm Machinery.
* Training on Irrigation pump operation, maintenance and repair.
* Cassava mechanization training.
* Rice Mechanization training.

2.5 Recent Achievements

As part of AMMOTRAC contribution to the success of Agricultural Transformation Agenda, the centre has developed training curriculum for different levels of operators considering their level of education and language. For the year 2012, AMMOTRAC developed a 4-WEEK extensive operators training programme for youth Empowerment in Agricultural Programme (YEAP). By teaching on how to drive tractors, hitching of various implements and there field adjustments and operations. Participants were also trained on maintenance/servicing, trouble shooting and how to rectify technical faults as well as train participants on machinery management. We put emphasis on

preventive (daily and periodic) maintenance. Safety precautions, basic soil and tillage management, principles and agronomic practices of production of some selected ATA crops were also taught. We have interactive section on work ethics.

This training curriculum has been tested on 128 Youths of Akwa Ibom State and 100 Youths of Ondo State. From the test run, we discovered that the youths within 4-WEEKs have become efficient in operating tractor and implement (Ladeinde, 2013).

3.0 CHALLENGES AFFECTING THE PROGRESS OF TRACTOR OPERATION MAINTENANCE AND REPAIR

From our various training interactions and observations, we are able to discover the following problems as major bottlenecks to the progress of tractor operation, maintenance and Repair (Ladeinde-et al- 2009):-

1 Insufficient technical knowledge of private importers and in-correct selection and matching of tractors with implements.

2 Importation of technically faulty tractors and implements being sold to ignorant users who find it difficult to rectify the manufacturer's defects.

3. Poor land clearing methods that causes breakdown of vital parts.

4. Use of untrained personnel. (i.e. Taxi drivers converted to tractor operators without proper training. Many states are guilty of this).

5. Poor maintenance culture by not following the maintenance schedule.

6. Operating equipment under difficult conditions (bad terrain, poor weather) thereby using tractor as tree clearing equipment (bulldozer), breaking parts of equipment and risking life of operators.

7. Dishonest practices between operators and the supervisors through diversion of tractors.

8. High degree of abuse of machinery by operators and managers through overworking of tractors in order to cut corners for illegal gains.

9. Changing honest operators as a result of non-delivery of additional fund or non-compliance to corrupt practices.

10. Poor incentives to the operators of Farm Machinery.

11. Lack of sufficient sales service centres by private distributors/vendors to cater for the customers.

12. Lack of knowledgeable mechanics in the rural areas and delay in rectifying fault.

13. Lack of spare parts and funds to carry out preventive maintenance and repair of broken down tractors due to too many makes of tractors in the market.

14. Agricultural Machinery not kept under shed as to prevent rust.

15. Non promotion of staff for many years and pegging of tractor operators on Grade level 07 in some state Ministries of Agriculture and Local government tractor hiring centres. Tertiary institutions are also guilty of this and this demoralises the operators.

16. Use of wrong professionals to supervise the use of tractor operation thereby causing misunderstanding and mistrust.

17. Poor record keeping of operations, maintenance activities and the amount made or being spent on the machinery to determine economic viability.

18. Some trainees are illiterates making it extremely difficult to impact knowledge and skills. They slow down the training activities. We have to interpret in local languages.

19. Many officers of governments are interested in the procurement of

tractors and implements but never appreciate the importance of training and the after effects of their actions.

20 From experience, trainings conducted by tractor marketers/ vendors are too short in duration and most times not effective because they are not related to agronomic requirement in the country.

21. Inconsistency in the 3-tier of government policy on agricultural mechanization as it relates to tractorization. This is due to frequent changes of leadership in the ministries and often each leader starting a new programme.

22. Many private owners believe that government alone must sponsor training.

3.1 Suggested Solutions to the Findings/ Hindrances.

1. The possession of JSS Certificate as the requirement for future training will ensure better service delivery.
2. Avoid use of untrained personnel to operate tractors. It takes time to train a good operator.
3. Change of attitude by government officials by encouraging training of personnel (operators, mechanics and relevant supervisors). Need to upgrade tractor operators beyond the present Grade level 07 through training.
4. Ensure agricultural machinery is stored under shed to avoid rust.
5. Need for continuous training and retraining of operators of various categories of tractor operators, mechanics and supervisors (Ladeinde and Appolo -2013).
6. Enforce that tractor marketers/vendors mandatorily establish after sales service centres. Need for agreement between Nigerian government and the vendors/marketers.
7. Ensure continuous supply of spare parts of different models/ make of tractors in the country at affordable cost. Need for agreement between Nigerian government and the vendors/marketers.
8. Ensure proper land clearing operation to extend tractor life span. Avoid using tractor in bad terrains. Put emphasis on safety of operators and equipment.
9. Supervisors of tractor operators are to ensure that the maintenance schedule charts are strictly followed. Encourage preventive maintenance.
10 Ensure discipline by operators, mechanics and supervisors.
11. Introduce incentives to tractor operators to reduce corrupt practices.
12. Need for AMMOTRAC staff to make frequent field visit to monitor the performance of trainees (impact assessment).
13. Urgent need to hold a national stakeholders workshop for owners, managers and supervisors of tractor Hiring Units in the nation to discuss on the way forward.
14. Tractor operation is a profession and it needs competent and well trained personnel to handle and to supervise the operators and mechanics.
15. Need to conduct management training for the supervisors and managers of agricultural machinery operation and maintenance.
16. Conduct training on proper agricultural land clearing operations to avoid destroying the top soil by using the right equipment.
17. Emphasize the need for training the trainers on other agricultural equipment outside tillage equipment.
18. Encourage proper record keeping of daily operations, maintenance, repairs as well as the amount generated and spent on each tractor or implement to

determine its viability. This will reduce corruption and encourage better management.

19. Ensure that various tractor models being marketed in Nigeria are first tested by National Centre for Agricultural Mechanization (NCAM), Ilorin and National standard organisation (NSO). Test to confirm performance and issue a certificate of approval to marketers.
20. Standardization of machinery fleet in order to reduce cost of maintenance, to enable interchangeability of parts when absolutely necessary.
21. Need for the State and Federal governments and the private individuals to establish more centres like AMMOTRAC so as to bring mechanisation training closer to the farmers and operators.
22 Need to install Agricultural Machinery Tracking System on tractors to monitor machine location of operators.
22. The Federal and State government need to sponsor the survey of existing numbers of functional tractors and other machinery in Nigeria and continue to upgrade the data every five years.
23. Important for tertiary institutions involve in training agricultural mechanisation experts to devote more efforts on practical trainings on agricultural machineries (i.e. tractor and its maintenance).
24. Acceptance and need for continuity of mechanisation policy/ programme with little modification when necessary.

4.0 CONCLUSION AND RECOMMENDATION

This paper has identified low competence level of several agricultural machinery operators, mechanics and tractor marketers as the major constraint to successful mechanization practice in Nigeria. It is recommended that farmer's, operators, mechanics, tractor owners, marketers, government /private organizations, hiring /leasing companies, educational institutions and other stakeholders involved in mechanization practices in Nigeria should avail themselves of the various training opportunities available at AMMOTRAC for their overall training needs which we often communicate through State Governments and various Farmers Associations and TOOAN . There is need for the Federal Government to improve the capacity of AMMOTRAC staff through trainings on PowerPoint , on Hydraulics and Injection systems as well as the infrastructural/technical development of the centre. It is also important for the release of adequate funds to conduct numerous trainings for operators and mechanics of tractors and farm machineries .It is OVERDUE for AMMOTRAC to become a full fledge institution like National Centre for Agricultural Mechanisation. Nigerian Institute of Agricultural Engineers (N.I.A.E) should play a leading role in advising government on all issues of mechanisation.

These recommendations will greatly influence the development of mechanization in Nigeria which is a vital tool for driving Agricultural Transformation Agenda of government.

REFERENCES

Ademiluyi, Ladeinde and Oni – 2004 Nationwide survey of Draught Animal Power, paper present at NIAE conference 22nd-26th October, 2004.

Ahmed, Abubakar and Ladeinde – 2012 - Enhancing Contract Tractors, A Mechanization report presented at a Technical Consultative Workshop for Youth Empowerment in Agricultural Program, held at Sheraton hotel, Abuja from19th-21st

September,2012 .

Ladeinde - 1996- Animal Traction as an Alternative source of power for Agriculture Development Paper presented at the National Workshop on Appropriate Agricultural Mechanization for Skill Development held at NCAM, Ilorin from 26th-28th,1996, Page188.

Ladeinde, Ageh and Atanda- 2009- Agricultural Machinery Operators and Mechanics training in Nigeria: An overview of contributions. Journal of Agricultural Engineering and Technology.(JAET) Vol. 17, no.2.

Ladeinde and Apollo- 2012 –Status of Agricultural Mechanization Development in Nigeria. A country paper presented at a Training Workshop held at Agricultural Mechanization Management Institute at Beijing, China from 22nd August-4thSeptember, 2012.

Ladeinde-2013 – A Mechanization Intervention paper by AMMOTRAC on Youth Empowerment in Agricultural Programme (YEAP) presented to the Honourable Minister for Agriculture on the 29th June, 2013 .

Odusanya - 1996 – Care, Maintenance and Repair of Source of Power used in Agriculture. Paper presented at the National Workshop on Appropriate Agricultural Mechanization for Skill Development held at NCAM, Ilorin from 26th-28th, 1996,Page235.

Propcom and Mai- Karfi 2013 - Tractor intervention: Profile Strategy and Plans. A paper presented at the Technical Consultative Workshop for Youth Empowerment in Agricultural Programme (YEAP) at Abuja.

INNOVATION AND ENTREPRENEURSHIP AS KEYS TO VALUE DELIVERY AND SUSTAINABLE FOOD PRODUCTION IN AFRICA

Dr. Augustine Ehimen Okoruwa *CFS MNIFST MIPAN*
Technical Manager-Africa, GlaxoSmithKline Consumer Nigeria Plc,
1, Industrial Avenue, Ilupeju, Lagos, Nigeria

INTRODUCTION

Agriculture is an important sector of the economy in most developing countries and it continues to be a fundamental instrument for sustainable development, poverty reduction and economic empowerment. Many countries have slowly reformed their agricultural policies and this has contributed to increased trade and a greater role for the private sector in agriculture vis-à-vis the state. In addition to basic commodities, the demand for high-value crops and processed products has increased due to the rapidly expanding world market, along with increasing urbanization, advances in technology, increasing foreign investments and liberalized trade.

THE GLOBAL AGRI-FOOD SECTOR

The agri-food sector is undergoing changes that is influencing new models of production and marketing involving a focus on:

- demand rather than on producer-defined agricultural goods
- a global, liberalized and fragmented marketplace with little seasonality and high product diversity
- Food safety and traceability requirements
- higher quality standards in conjunction with the enforcement of basic environmental regulations.
- The ongoing evolution requires a better understanding of the whole set of transactions within each value chain and that of the agricultural sector within which it operates.
- Integrated chains are able to do this most effectively. This information is important for making financial decisions by stakeholders in the value-chain.
- Value chains require constant innovation and technology inputs to become and remain competitive.

GLOBAL AGRICULTURAL TRANSFORMATION: IMPERATIVES

Increasing population, income, and urbanization, which are changing diets along with the use of food crops for non-food uses such as bio-fuels have contributed to increased food prices. As consumer demands related to safety, quality, convenience, organic and processed foods increase, the gap between farm and consumer prices is widening. Collectively, these changes contribute to a paradigm shift in the way food is produced, processed and sold. Increased demand for safe, higher value and differentiated agricultural products has created opportunities for farmers and agribusiness entrepreneurs to transform commodities into products that are demanded by consumers.

This change in food retailing has led to greater involvement of the private sector in agriculture and a focus on developing and improving agriculture value chains (AVCs) in terms of quality, productivity, efficiency and depth. Thus, Innovation and Entrepreneurship is vital to value delivery and sustainable food production.

GLOBAL AGRICULTURAL TRANSFORMATION: FINANCING CHALLENGES IN AFRICA

Despite the global changes in agriculture and agribusiness, the typical offer for financial products and services for agricultural and rural food production has been deficient and not particularly innovative. Financial service providers and intermediaries still lack much depth in rural areas. Producers and processors, especially smallholders, are still grossly underserved.

INNOVATION DEFINED

Innovation is the process of translating an idea or invention into a good or service that creates value or for which customers will pay. To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves deliberate application of information, imagination and initiative in deriving greater or different values from resources, and includes all processes by which new ideas are generated and converted into useful products. In business, innovation often results when ideas are applied by the company in order to further satisfy the needs and expectations of the customers

CHARACTERISTICS OF INNOVATION

Innovation is synonymous with risk-taking and Entrepreneurs/Organizations that create revolutionary products or technologies take on the greatest risk because they create new markets. Evolutionary innovations (also called continuous or dynamic evolutionary innovation) are brought about by many incremental advances in technology and/ or processes. On the other hand, Revolutionary innovations (also called discontinuous innovations) are often disruptive and entirely new.

ENTREPRENEURSHIP DEFINED

The capacity and willingness to develop, organize and manage a business venture along with any of its risks in order to make a profit. The most obvious example of entrepreneurship is the starting up of new businesses. Entrepreneurial spirit is characterized by innovation and risk-taking and is essential to succeed in the ever changing and increasingly competitive global marketplace

WHO IS AN ENTREPRENEUR?

An entrepreneur can be defined as follows: 1) anenterprising individual who builds capital through risk and/or innovation; 2) One who is willing to help launch a new enterprise and accept full responsibility for the outcome and 3) One who undertakes an enterprise, especially a contractor, acting as intermediary between capital and labour.

CHARACTERISTICS OF ENTREPRENEURS

- Capabilities of innovating, introducing new technologies, increasing efficiency and productivity, or generating new products or services.
- Management skill, financial prudence and strong team building abilities.
- High creativity with tendency to imagine new solutions by finding opportunities for profit or reward.
- Risk takers, self motivated, visionary, passionate and uncompromised core values but flexible to seek assistance when needed from others.

KEY ATTRIBUTES OF INNOVATION AND ENTREPRENEURSHIP

Innovation and Entrepreneurship that would deliver value and enhance sustainable food production must be:

- Appropriate – scale, meet consumer/customer needs met.
- Technically feasible.
- Economically viable and feasible.
- Process/product &service quality enhancing.
- Environmentally safe/sustainable.
- Socially responsible.

INNOVATION AND ENTREPRENEURSHIP: APPROPRIATE TECHNOLOGY REQUIREMENTS FOR THE AGRI-FOOD SECTOR.

- Production practices-agronomic practices, cultivation, seeds, weed control, pest control, harvesting, etc.
- Postharvest handling-packaging, transportation and storage facilities
- Processing/value addition – farm gate, primary and secondary processing.
- Processing Equipment for farm-gate, household, cottage and SME applications
- Food safety-GMP/Hygiene practices, pesticides and herbicides, chemical preservatives applications
- Ergonomics-Equipment design
- Raw Material/Finished Product Quality Standards.

BENEFITS OF INNOVATION AND ENTREPRENEURSHIP IN THE AGRICULTURE VALUE CHAIN.

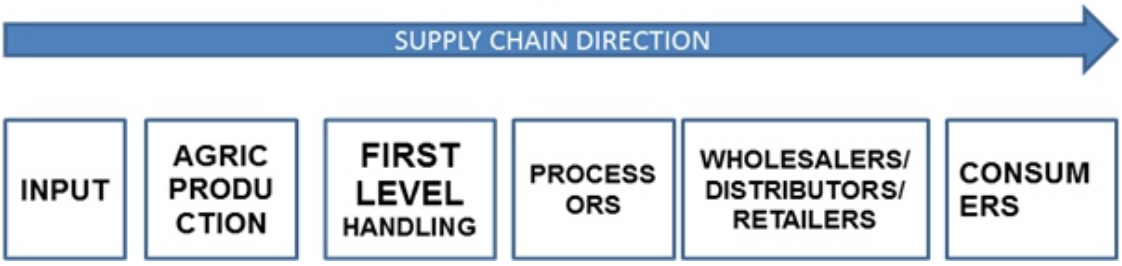
- Significant reduction in postharvest losses, thereby increasing food availability and security
- Economic empowerment of rural farmers, SMEs and industrial processors, marketers, service providers, etc.
- Diversified utilization and recycling of natural resources
- Competitive pricing of agricultural commodities, intermediate and finished products

- Demand-driven production of food and cash crops/livestock, creating greater market linkages and opportunities.
- Improved national/household food security, nutrition and health.
- Expansion and development of the food and agro-allied industries, especially SMEs.
- Increase in employment generation along the entire agri-food value chain, thereby reducing the burden of unemployment and its associated risk factors for the family, society and national economy.

VALUE CHAINS IN THE AGRI-FOOD SECTOR

Value chains are organized linkages between groups of producers, traders, processors, and service providers (including nongovernment organizations) that join together to improve productivity and the value added from their activities. In a well managed value chain, the value of the end-product is often greater than the sum of individual value additions. By joining together, the participants in a value chain increase competitiveness and are better able to maintain competitiveness through innovation.

A typical agri-food value chain is shown below.



IMPORTANCE OF THE VALUE CHAIN CONCEPT IN THE AGRI-FOOD SECTOR.

The value chain can help you answer questions regarding:

- How the products you produce reach the final consumer.
- The structure (economic relationships) between players in the chain.
- How this structure is likely to change over time.
- The key threats to the entire value chain.
- The key determinants of your share of the profits created by your chain

(Source: Report of the Vision 2020 NWTG on SMEs, July 2009 page 10)

S/N	SIZE CATEGORY	EMPLOYEE NO	ASSETS (Naira excluding land & building)	ESTIMATED No OF MSMEs (2004)	% OF TOTAL
1	MICRO	10	<5m	6.7m	80
2	SMALL	10-49	5m to <50m	1.2m	15
3	MEDIUM	50-199	50m to <500m	0.42m	5

CONTRIBUTIONS OF SMEs IN SELECTED ASIAN ECONOMIES (%)

Industrial Characteristics	Malaysia (1985)	Singapore (1990)	Rep. of Korea (1991)	India (1994)
Contribution to total number of industrial establishments	92.1	88	97	94
Contribution to total industrial employment	49.4	40	63.5	31
Contribution to total industrial production	46.7	26	44.5	40
Contribution to total industrial value addition	30	23	45.8	35

(***Source: Confederation of Asia Pacific Chamber of Commerce and Industry-Journal oCommerce and Industry. Volume 11, 1994: pages 6-18)***

NURTURING INNOVATION AND ENTREPRENEURSHIP THROUGH SMEs

- Create and expand access to capital markets for agriculture continuously
- Widen conventional and novel market-linkages that open up business opportunities & markets for Agribusiness
- Pay attention to small-scale technologies that are both efficient and produce quality products, and/or link small-scale producers to industrial scale processors.

KEY REQUIREMENTS TO DRIVE INNOVATION AND ENTREPRENEURHIP VIA SMEs IN AFRICA

- Adequate infrastructure.
- Supportive trade policies for agribusiness.
- Robust Agribusiness financing options.
- Technical know-how: appropriate production and post-harvest technologies.
- Market Research information on consumer/customer needs, preferences, expectations, changing habits/global trends.
- Regulatory standards and enforcement

SOME FOOD PRODUCTS FROM INNOVATION AND ENTREPRENEURSHIP-NIGERIA









25

INNOVATION AND ENTREPRENEURSHIP OPORTUNITIES FOR AGRIC ENGINEERS IN THE AGRI-FOOD VALUE CHAIN

- Crop and Livestock Production
- Postharvest technologies-farm gate technologies, dryers etc
- Food processing and Preservation
- Transportation
- Packaging systems
- Storage-Silos etc
- Machinery design fabrication-planters, harvesters, grinders, dryers, etc
- Marketing/Market Research
- Consultancy
- Research and Development
- Training Programs
- Educational Institutions
- Vocational training

INNOVATION AND ENTREPRENEURSHIP OPORTUNITIES FOR AGRIC ENGINEERS IN THE AGRI-FOOD VALUE CHAIN: CASSAVA VALUE CHAIN IN NIGERIA

- Presidential Initiative on Cassava
- Research & Development: Improved cassava varieties developed and released- high yielding and disease resistant - NAROs, NARIs, IARCs.
- Improved Crop management practices.
- Postharvest Technology Generation and Promotion: equipment and processing technologies
- Cassava recipes for household and small scale applications developed**.**
- Processing Equip.: Cassava chipping &Grating mechanized, improved, Pressing mechanism improved, Improved Garri processing equip., rotary dryer, flash dryer.
- New products for commercial application developed-High Quality Cassava Flour (HQCF), Odourless foo-foo flour, cassava starch, etc
- Mandatory inclusion of cassava flour in wheat flour products by all the flour mills in Nigeria
- Industrial use expand-Flour mills, bakeries, etc.

SMEs EMERGING FROM INNOVATION AND ETREPRENEURSHIP IN THE CASSAVA VALUE CHAIN IN NIGERIA

- Cassava roots farming/cassava cuttings suppliers

- Local fabrication and marketing of Cassava processing equipment: Graters, Chippers, Pressing and Drying Machines (Rotary, Flash and Cabinet Dryers),
- Cassava processing enterprises: Flour, starch, chips, Gari, foo-foo, animal feeds, etc
- Bakeries/Confectioneries – Bread, Cake and snacks making using composite flour
- Export of cassava products

CASSAVA PROCESSING: INNOVATION AND ENTREPRENEURSHIP



Fresh cassava roots





Bread containing cassava flour



ĠMĐon display for sale



Bag of Cassava Flour

Source: James et. al. 2012.

INNOVATION AND ENTREPRENEURSHIP IN NIGERIA: SOME CASSAVA PROCESSING EQUIPMENT



A motorized grater used to crush cassava roots into a wet mash



Fermentation Rack



Hydraulic presses used to remove excess water from cassava mash



A gari sieve made from stainless steel mesh



A gari roasting bay with a shallow stainless steel tray or a moulded aluminium pot.



An automatic gari roaster is ideal for producing large volumes of gari

Source: James et. al. 2012.

AGRICULTURAL ENGINEERS AS ENTREPREUNEURS IN THE AGRI-FOOD VALUE CHAIN IN AFRICA

Several opportunities exist for agric engineers to engage in entrepreneurial activities:

- **Pre-harvest-**Farm Inputs/Implements, Tractors, Planters, Harvesters, Sprayers, Applicators, Pesticide Sprayers, Power Tools/Machines, etc.
- **Post-harvest- processing and handling equip/tools-**Shellers, Crackers, Peelers, Graters, Chippers, Dryers, Ovens, Aspirators, Fryers, Grinders-Plate Mills, Hammer Mills, Decorticators/Dehullers, Conveyors, Extruders, Pelletizers, Storage bins/Silos, Destoners, Pressing Machines, Dehuskers, Carriages, Kneading Machines, Expellers, Toasters, Etc
- Marketing
- Produce handling
- Food processing
- Feed processing
- Training
- Consultancy

CONCLUSIONS

Africa is currently not realizing the full potential of a major strategic asset – the continent's agri-food sector. Innovation and entrepreneurship is required to unlock and harness the potentials. The consequences of low agricultural productivity and falling profitability, lost opportunity, and declining relevance are impairing the continent's agri-food industry. The ongoing changes in the global context for agriculture and food industries are increasing demand and opportunities for agricultural products including high-value and processed products. Some of the key changes affecting demand include improved rural–urban linkages, changing diets, expansion of private sector engagement and emergence of supermarkets as major factors in food retailing that affect all aspects of food production. Agriculturally-driven economic growth through innovation and entrepreneurship can have a strong impact on reducing poverty and hunger in Africa.

Raising productivity of the agriculture sector in Africa through innovation and entrepreneurship will stimulate growth in non-agricultural sectors. Growth in demand for agricultural products will expand market opportunities for farmers and agribusiness entrepreneurs. Developments in the cassava value chain in Nigeria shows that innovation and entrepreneurship are keys for value delivery and sustainable food production. Business opportunities exist in the agri-food sector in Africa for innovative and entrepreneurial Agricultural Engineers.

REFERENCES

Asian Development BANK (ADB), 2012. Support for Agricultural Value Chain Development-Evaluation Knowledge Study Report. ADB.

Calvin Miller and Linda Jones, 2010. Agricultural Value Chain Finance-Tools and Lessons. Published by Food and Agriculture Organization of the United Nations and Practical Action Publishing. FAO. Rome.

Canadian Agri-Food Policy Institute (CAPI), 2011. Canada's Agri-Food Destination: A new strategic Approach. CAPI, Ottawa, Canada.

James, B., Okechukwu, R., Abass, A., Fannah, S., Maziya-Dixon, B., Sanni, L., Osei-Sarfoh, A., Fomba, S. and Lukombo, S. 2012. Producing Gari from Cassava: An illustrated guide for smallholder cassava processors. International Institute of Tropical Agriculture (IITA): Ibadan, Nigeria.

KPMG. 2013. The agricultural and food value chain: Entering a new era of cooperation. KPMG International, Switzerland.

Okoruwa, A.E. 2010. Agriculture-food security and sustainable economic development. Invited Paper presented at the Seminar "Beyond Oil: Implication for Niger Delta", organised by Club 401, 25-26 February, 2010. Conference Hall, Ministry of Justice, Rivers State Secretariat, Port Harcourt.

Okoruwa, A.E. 2011. Sourcing and Utilization of High Quality Proteins in Nigerian Food Products: Issues, Challenges and Opportunities. Invited paper presented at the USDA Seminar tagged High Quality Proteins: The Missing Link in Development? Protea Hotel, Ikeja, Lagos, Nigeria. March 8, 2011

Okoruwa, A.E. 2010. Market trends and business opportunities in the soybean industry. Invited paper presented at the "SOYBEAN SUMMIT 2010" organised by the Federal Institute of Industrial Research, Oshodi (FIIRO) in collaboration with Raw Material Research and Dev. Council (RMRDC) and Spectra Industries Ltd, May 27, 2010, Lagos, Nigeria.

Okoruwa, A.E. 2004. Appropriate processing technologies for cassava: key to food security and economic development. Paper presented at the National Workshop/Exhibition on Post harvest Technology as a Panacea for Food Security and Economic Development, Organised by the Office of the Special Assistant to the President on Food Security, 22-23 March 2004, Calabar, Cross River State, Nigeria.

Sanni, L., B. Maziya-Dixon, A.E. Okoruwa, B, Arowosafe, J. Lemchi, F. Ogbe, C. Ezedinma, R. Okechukwu, M. Akoroda, E Okoro, P. Ilona, T. Babaleye and A. Dixon (2004). Cassava utilization training for bakers, caterers and processors in south-south and south-east Nigeria. 75pp. IITA, Ibadan, Nigeria.

DESIGN, CONSTRUCTION, AND TESTING OF A MANUALLY OPERATED MAIZE SHELLER

[1]Edet, U. , [2]Ituen, E.U and [3]Alonge, A.F.
Agricultural and Food Engineering Department, University of Uyo,
Akwa Ibom State, Nigeria.
1uduakedet@uniuyo.edu.ng, 2euuituen@yahoo.com, 3akindelealonge@uniuyo.edu.ng

ABSTRACT
A manually operated maize shelling machine was designed, constructed and tested. The Sheller was fabricated from mild steel. It consist of the disc with spikes, the hand operated wheel, the pressure plate, and the adjustable spring. The Sheller also has the discharge outlet, the tray and the support stand. The Sheller uses abrasion between the rotating disc with spikes and the adjustable pressure plate to achieve its shelling. Seven (7) samples of cobs of maize at different moisture contents were used to test its performance. It was observed that the shelling rate of the machine increased from 10.16kg/hr to 49.968kg/hr as the moisture content decreased from 13.39% to 10.63%. The shelling efficiency also increased from 50% to 80.95% as the moisture content decreased from 13.39% to 10.63%. Although a higher shelling rate and efficiency were obtained as the moisture content decreased, some of the grains were broken and dust particles were produced. This showed that there is a particular moisture content range of about 11 to 12% (w.b) which shelling with the machine was optimum. This range gave a shelling efficiency of about 78%.

Keywords: Maize, Moisture Content, Shelling, Shelling Machine, Shelling Efficiency.

1.0 INTRODUCTION

Maize is a cereal plant of the *Germaine* family of grasses. It constitutes the most widely distributed food plant in the world. According to Purselgroove (1979), maize is the second most important cereal crop in Nigeria (ranking next to sorghum) with an annual production of 2.2 million tones. The nutritional value of maize per 100g is 19g Carbohydrate, 3.24g Sugar, 2.7g Dietary fiber, 1.18g Fat, 3.22g Protein, 75.96g Water,270mg Potassium, 37mg Magnesium, 0.52mg Iron, and 1.96mg Vitamins, (USDA Nutritional Database, 1999).

This highly nutritional cereal constitutes a staple food in many regions of the world. It can be made into thick porridge (ogi or pap) or processed as cornflakes or popcorn or even consumed directly by boiling or roasting the whole ears and eating the grain right off the cob. Economically, starch from maize is made into fabrics, adhesive, cooking oil (corn oil), and many other chemical products. Ground maize constitutes a major fraction of livestock feeds.

Post-harvest processing of maize includes drying, shelling, cleaning, grading, fumigation and grinding. Industrial and domestic utilization of maize grain demand that the crop be shelled immediately it reaches the desired dry harvest maturity before it can be processed into other forms. (Danilo, 1991). Shelling involves separating the grains from the portion of the plant that holds them (cob). This separation can be carried out manually or by the use of machines.

Most farmers in Nigeria still operate at subsistence level and even, with the small quantity of maize they harvest, they find it difficult and time consuming shelling the grains from the cob manually. Shelling machines are scare and the few available are imported. Local farmers cannot afford to buy them due to their costs and complexity in design and operation. Because of this, many maize farmers cannot increase their production. Hence there is shortfall of maize in the market. This has impacted negatively on many food and livestock industries which depend on maize for their production. The specific objective of this research work was to design and fabricate a simple manually operated maize sheller based on the improvement of an existing one.

Also, it was evaluate the performance of the maize sheller and to make recommendations based on the results.

2.0 MATERIALS AND METHOD

2.1 Design Consideration

The design of the maize sheller is based on the following consideration.

- The ease of construction (fabrication)
- The operation of the machine should be simple for small scale farmers.
- Materials of adequate strength and stability for durability.
- The materials available locally were used in the fabrication of the components.
- The safety of the operator.
- Cost of the materials for construction was also considered.

2.2 Description of the Maize Sheller

Figure 1 shows the assembly drawing of the sheller. The sheller was fabricated from mild steel. It consists of a 200mm diameter disc with round spikes fitted along the circumference of five different radii of different pitches. A hand operated wheel with wooden handle that rotate the disc via 15mm diameter shaft attached to the disc, a pressure plate and an adjustable spring. The sheller also has a frame which acts as the housing for the disc and a place where the pressure plate and discharge outlet were fitted and bolted respectively in order to function effectively.

The assembled machine was bolted to a support stand 300mm high for stability and ease of use. Attached to the stand 100mm above its base is a 300mm diameter tray or collector which collects the shelled grains. It is constructed in a way that it can hold grains as well as allows grains to flow. This, it does with the aid of a removable barrier placed along the exit of the tray. The tray can be removed when not in use or when cleaning is required. The height of the sheller is 230mm and 500mm when mounted on the support stand.

2.3 Mode of Operation

The sheller uses abrasion between the rotating disc with spikes and an adjustable pressure plate. Maize ear is fed one after another with its smaller end into a cup-shaped opening as the wheel is rotated with the aid of its wooden handle. The wheel rotates a shaft which in turn rotates the disc with spikes. In the process, the spike on the disc pulls the cob downward and also presses the cob firmly against the adjustable spring loaded pressure plate. This action of the disc causes the removal of the grains from the cob into the tray attached to the support stand of the sheller.

As the cob moves downward, the bottom of the pressure plate together with the rotary movement of the disc pushes the cob upward at an angle of 45^{o} into the discharge outlet where the tail end of the cob is shelled before it is then removed from the machine.

2.4 Design Analysis

2.4.1 Shaft design

Average speed of the shaft rotated manually before fatigue begins was found to be 165rpm. Thus;

$$\acute{\omega} = \frac{2\pi N}{60} = \frac{2 \times \pi \times 165}{60} = 17.28 \text{rad/s}$$

Tangential Force

$$F = M\acute{\omega}^2 r + \mu R$$

M = mass of disc = 5kg

r = radius of the disc = 100mm = 0.1m

According to Osunade and Lasisi (2003), the coefficient of friction (μ) of maize of galvanized sheet is 0.30 and from Albert (1983), the average mass of maize ear (R= grain + cob) at 13% moisture content is 200g or 0.2kg

Thus; Force:

$$F = 5 \times (17.28)^2 \times 0.1 + 0.30(0.2)$$
$$= 149.278 + 0.06$$
$$F = 149.3378\text{N}$$

Torque, T =F.R = 149.3378N × 0.1m

= 14.93378Nm or 14933.78Nmm

Diameter of Solid Shaft

$D = v^3 16T/\pi\tau$

τ = 42MPa (ASME code for design of transmission shaft with allowance for keyway. Source: Khurmi, 2008)

$D = v^3 \frac{16 \ 14933.78Nmm}{\pi 42N/mm2}$

$D = (1810.883)^{1/3} = 12.19mm$

A shaft of 15mm diameter was used.

2.4.1 Design of key

For a rectangular key,

$W = D/4$

Where; W= Key width, D= Shaft diameter

$W = 15/4 = 3.75mm \simeq 4mm$

$T_k = D/6$

Where; T_k= Key Thickness

$T_k = 15/6 = 2.5mm \simeq 3mm$

2.5 Test Procedures

Maize was bought from Akpanandem market in Uyo, Nigeria and used for the experiment. It was divided into seven (7) samples each weighing 1000g.

In order to vary the moisture content, sample 1, and 2 were dried in the oven at a temperature of 50°c for 1hour and 30mins respectively while sample3 had the market storage moisture content. Samples 4, 5, 6, and 7 were soaked in water for 2mins, 10mins, 20mins, and 1hour respectively.

Moisture content (MC_{wb}): The moisture content of the grains and cobs of each sample were first determined using the oven drying method and calculated using the equation below;

$$MC_{wb} = \frac{\Delta W}{W} \times \frac{100}{1} \quad \text{..... (1)}$$

where; ΔW= change in moisture content, W=initial moisture content

Shelling rate (Q): The shelling rate for each sample was determined by continually feeding a known mass of cobs into the shelling machine and recording the time it took to shell each sample with the aid of a stop watch. The values were then converted to kg/hr to have the capacity.

i.e $$Q = \frac{W_C}{T} \text{ (Kg/hr)} \quad \text{..... (2)}$$

Shelling efficiency (η_s): To evaluate the shelling efficiency of the machine for each sample, the quantity of unshelled grains were weighed after the unshelled grains were removed from the cobs manually (with the hand) and weighed. The shelling efficiencies were then determined by using the equation;

$$\eta_s = \frac{\text{Mass of shelled grains by machine}}{\text{Mass of shelled grains by machine + mass of unshelled grains}} \times \frac{100}{1} \quad \text{..... (3)}$$

3.0 RESULTS AND DISCUSSION

The results obtained from seven (7) samples are presented in the tables 1-3. Table 1 shows the moisture content of the seven (7) samples that were subjected to different conditions. It was found that above sample 3(market storage moisture content), the moisture content of the maize decreased from11.32% to 10.63% due to heating while below sample 3, the moisture content increased from 11.32% to 13.39% as the period during which the maize cob was soaked increased. This was due to increase in the moisture absorbed by the maize cob.

From Table 2 above, sample 1 had a mass of shelled grains to be 680g and an unshelled grain mass of 160g. Sample 2, 3, 4, 5, 6, and 7 had their mass of shelled grains to be 650, 600, 600,530, 500, and 500g respectively while their unshelled grain masses were 180, 200, 220, 270, 300, and 500g. Though samples 6 and 7 had equal mass of shelled grain, an overall mass (sum of shelled, unshelled, and cob) showed that the equal mass is due to absorption of moisture by sample 7 likewise between samples 3 and 4.

After shelling, sample 1 had most dust (grain particles) while samples 2, and 3 had little or no dust. Samples 4 and 5 were noticed to have broken grains while sample 6, and 7 had both broken grains and cobs inside the shelled maize. When a grain is soaked, it starts absorbing water. There is initial crack especially along the lines of defects. If it is under grinding, the particles will tear out along the crack lines. As the soaking continues, the cracks are many and the particles are smaller when the grains are grind.

Figure 1 shows the effect which moisture content has on the rate of shelling. It is revealed that the rate of shelling decreased as the moisture content of the maize increases. This is as a result of the time used in adjusting the spring stiffness to accommodate the variation in the size of the maize cob. The effect of grain moisture content on the shelling efficiency of maize is shown in Fig 2. It shows that the shelling efficiency of the maize sheller varied from 80.95% to 50% for a moisture content between 10.63% and 13.39%. This decreased in shelling efficiency with increased in moisture content is as a result of reduction in coefficient of friction between the spikes and the maize which causes slippage which tend to make the spikes slide over the maize ear instead of pulling it downward.Also, the compressible strength of the cobs with high moisture content could not withstand the force needed to push it through the shelling aperture. The cobs were broken and hence shelling of the grains decreased.

4.0 CONCLUSIONS

A manually operated maize shelling machine has been designed, constructed, and evaluated for performance. The shelling rate or capacity of the shelling machine increased from 10.116 to 49.968kg/hr as the moisture content decreased from 13.39% to 10.63%. Although the highest efficiency was achieved at a moisture content of 10.63%, there was much dust (grain particle). Thus, a moisture content of 11.32 would be more effective and efficient as little or no dust was produced at that moisture content.

This means that the shelling machine can be operated at the market storage moisture content (11.32% (w.b)). Thus, there is no need for drying or addition of moisture to the maize ear before shelling it**.** However, the recommended moisture content is 12 to 13% as the maize was bought in the height of the dry season, January, when the harmattan caused the moisture content to go down greatly. This work has shown that to shell maize cobs effectively, the cobs should be dried for the grain to obtain a moisture content of about 11%.

RECOMMENDATIONS

This shelling machine is recommended for low income earners and subsistence farmers to enable them speed up their post harvest operations and thereby make the grains available to the market or consumers. The grains can be stored longer when removed from the cobs.

Further research should be conducted to improve on the shelling rate, shelling efficiency, and the collector or tray of the machine. This may be achieved in various ways including;

- Increasing the diameter and height of the tray
- Changing the material used for the disc with spike to plastic
- The machine should be mechanically powered through pulley-belt arrangement.

REFERENCES

Albert .M.A (1983): Maize Production in Nigeria. An Agricultural Atlas of Nigeria. Pp. 32

Alonge A.F and Adegbulugbe T. A(2000): Performance Evaluation of a locally Developed Grain Thresher (II). Agricultural Mechanisation in Asia, Africa and Latin America (AMA). Vol. 31 No2, Pp. 52-54.

Dauda, A (2001): Some Physical Properties of Maize Grain Damage In AMA. Vol. 32, pg. 43-46.

Danilo.M (1991): Post-Production Operation. FAO Technical Report.

Evans, A.O (1991): Effect of Grain Moisture Content on the Shelling of Maize in ASAE. Vol. 14(2) pg. 32-34.

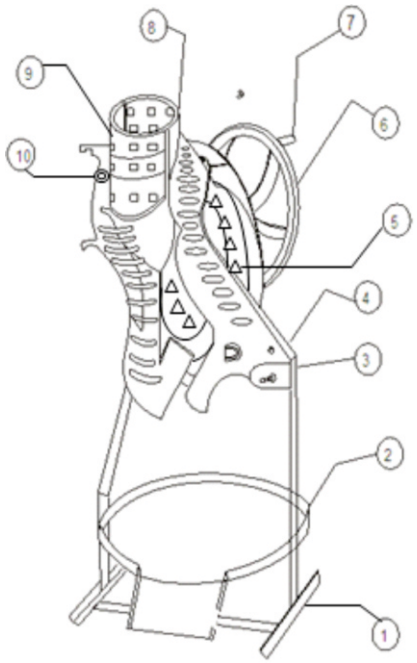
Khurmi R.S and Gupta J.K.(2009): Machine Design. Published by Eurasia Publishing House,

New Dehli, India

King et al. (2009). Maize: Wikipedia In http://en.wikipedia.org/wiki/Maize. Accessed 6th. 2009

Osunade J.A and Lasisi, Fola (2003): Determination of Coefficient of Maize and Sorghum in Annual Conference of NIAE. Vol.38 (2) Pp. 39-42.

Purselgroove (1979): Corn Harvesters. Encyclopedia Britannica. Encyclopedia Britannica 2009 Student and Home Edition. Chicago.



S/N	DESCRIPTION	MATERIAL	QUANTITY
1	Support Frame	Mild Steel	1
2	Tray	Mild Steel	1
3	Bolt and Nut	Mild Steel	11
4	Discharge Outlet	Mild Steel	1
5	Disc with Spike	Mild Steel	1
6	Pulley	Mild Steel	1
7	Handle	Wood	1
8	Compression Spring	Mild Steel	1
9	Pressure Plate	Mild Steel	1
10	Washer	Mild Steel	3

Fig 1: Assembly Drawing Of The Maize Shelling Machine

Table 1: Moisture Content for Maize Samples

Sample	Sample Treatment	Grain(w.b)	Cob(w.b)
1	Oven drying for 1 hour	10.63	10.59
2	Drying for 30mins	10.95	10.99
3	Market storage condition	11. 32	11.30
4	Soaking in water for 2mins	11.52	18.57
5	Soaking in water for 10mins	12.59	33.07
6	Soaking in water for 20mins	12.74	34.12
7	Soaking in water for 1hour	13.39	42.72

Table 2: Parameters Affecting Maize Shelling

Sample (in cobs)	Weight of Maize in cobs		Grain Moisture Content (w.b) %	Time (s)	weight of Shelled Grains		Weight of unshelled grain		Capacity	
S/N	Initial weight (g)	Weight after treatment (g)			G	kg	G	Kg	kg/s	Kg/hr
1	1000	990	10.63	49	680	0.68	150	0.150	0.0138	49.968
2	1000	995	10.95	65	650	0.65	165	0.165	0.0100	36.000
3	1000	1000	11.32	73	600	0.60	200	0.200	0.1182	29.592
4	1000	1020	11.52	70	600	0.60	210	0.210	0.0086	30.852
5	1000	1050	12.59	110	530	0.53	250	0.250	0.0048	17.352
6	1000	1150	12.74	128	500	0.50	250	0.250	0.0039	14.076
7	1000	1250	13.39	178	500	0.50	300	0.300	0.0028	10.116

Table 3: Shelling Efficiency of Maize As Affected By Moisture Content

Grain moisture content (w.b) %	Mass of Shelled Grains (g)	Mass of Unshelled Grains (g)	Shelling Efficiency %	Mass of Cobs (g)
10.63	680	160	80.95	150
10.95	650	180	78.31	165
11.32	600	200	75.00	200
11.52	600	220	73.17	210
12.59	530	270	62.25	250
12.74	500	300	62.50	250
13.39	500	500	50.00	300

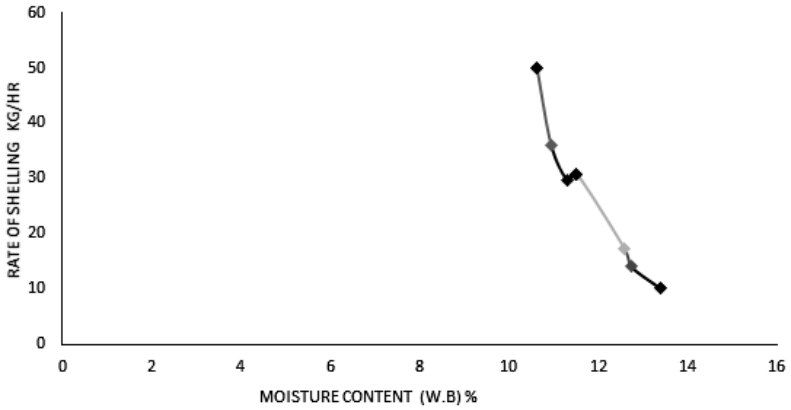


Fig 1: Effect Of Moisture Content On Shelling Rate.

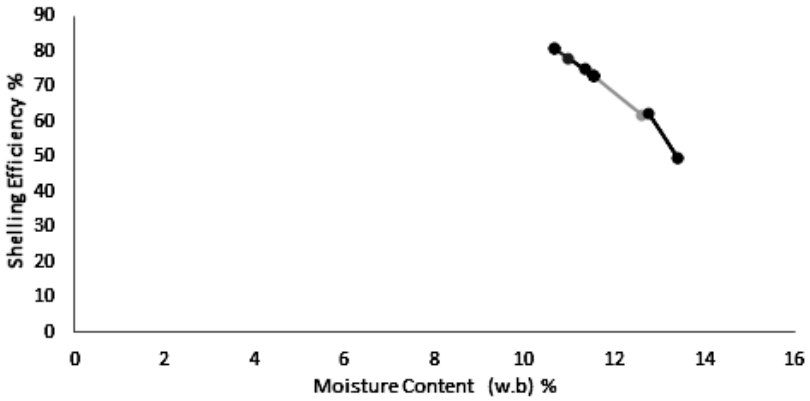


Fig 2: Effect Of Moisture Content On Shelling Efficiency

PERFORMANCE EVALUATION OF SOME SELECTED TILLAGE IMPLEMENTS

N.A Sale[1], M.A Gwarzo[2], O. G Felix[3] and S.I Idris[4]
[1&4]National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Samaru- Zaria, e-mail nuraalhajisale@yahoo.com
[2&3]Department of Agricultural Engineering Ahmadu Bello University, Zaria

ABSTRACT
As agriculture is very sensitive to timely operations and bad weather conditions, and huge amount of money is spent on investment, there is the need to evaluate the capacity performance of agricultural machine for proper machinery selection, optimization and farm scheduling. The capacity performances of a 3-botton plough, an offset disc harrow and a conventional 3-row ridger tillage implement were evaluated at the experimental farm of the Institute for Agricultural Research (IAR) Samaru, Zaria. The power unit used for all tillage implement was 48.5kW tractor in a 0.836ha field and field efficiency, theoretical and effective field capacities and fuel consumption rate were determined.
The average speed, field efficiency and fuel consumption rate for ploughing, harrowing, and ridging operations were found to be 5.26km/hr, 78.98%, 19.98lit/ha, 6.93km/hr, 75.80% , 18. 23 lit/ha, and 5.50km/hr, 76.63%, 15.45lit/ha respectively. The theoretical, mean and effective field capacities of plough, harrow and ridger were obtained as 0.445ha/hr, 0.354ha/hr, 0.99ha/hr, 0.750ha/hr, 1.118ha/hr and.91ha/hr respectively.

1.0 INTRODUCTION

Agricultural task must be well planned and timely executed since agriculture is essentially affected by weather and climate. Especially in rain-fed farming, agricultural operations must be carried out within a time frame to achieve maximum yield. However, there is a limited time frame within which agricultural fieldworks must be done at minimum cost and obtain optimum crop yield. The huge investment involved in tractors and machinery give cause for a better understanding of the capacitive performance of some common tillage implement used. Braid and Gwarzo (1985) described four types of machine performance that must be evaluated if a true knowledge of an agricultural machine is to be secured. They include functional, mechanical, capacitive and economic performances. Agricultural machinery field performance is affected by many factors. The major factors include those of power unit/machine combination, field and crop conditions, weather, soil type and condition and management.

Capacitive performance describes how a machine completes a job within allowable constrains of time. The capacitive performance of an agricultural machine gives the answer to the question "will the machine complete the job or task given within the allowable constraints of time under a variety of field conditions" or is it a poor investment regardless of its cost. Tillage implements should prepare a satisfactory seedbed while conserving moisture, destroying early weed growth and minimizing erosion potential. Energy plays a key role in the various tillage systems. Implement width, operating depth and speed are factors that affect draught of a tillage implement (Upadhyaya et al., 1984). Bukhari and Baloch (1982) reported that the speed of operation, width of cut, depth of cut, type of soil, and skill of operator affects fuel consumption. Collins et al. (1981) **c**oncluded that implement size and speed must be matched to tractor size

Farmers mostly depend on past experience for selecting tractors and implements for various farming operations. This previous experience may not be sufficient in

selecting newly available implements. Therefore performance data under different soil conditions is important for tractor selection and implements matching as these are important parameters for measuring and evaluating performance of tillage implements (Anozodo et al., 1983).

Agricultural engineers have concentrated and put more interest on the design and manufacture of agricultural machines but few interests are given to the managerial problems facing these machinery. Data on capacitive performance of such machines were not readily available to Nigerian farmers. Such data is needed for better selection and understanding the capabilities of various makes and model of farm machinery. Each piece of machinery must perform reliably. Farm managers and consultants used these data of tillage implements in specific soil types to determine the size of tractor required and to calculate the cost and energy requirement of different tillage implements (Anozodo 1983). Therefore, the main objective of this study was to determine the capacitive performance of some selected tillage implements and power unit for ploughing, harrowing and ridging. For machinery selection and future prediction of operation cost best on our local condition.

2.0 MATERIALAND METHODS

Site selection:

The machinery performance study was carried out at the experimental farm of Institute for Agricultural Research (IAR), Samaru. The size of the field was 0.836ha and relatively flat

Machinery study:

The machinery studied was FIAT 640 model tractor (48.5kW), 3-botton 1.3m mounted disc plough, and 1.68m offset disc harrow and 1.6m 3-row conventional ridger

Machinery performance:

The total width of the field worked was divided into three equal parts such that the tillage operations were carried out on each portion. The area for each portion was 0.278ha (80 X34.75m^2) and several observations for primary time turning time management stop and operating time were made from each while actually performing field operations to determine the performance parameters to be measured. The equipment used for field observation includes digital type stop watch, weighing balance and air tight tin container for collecting soil sample.

A stop watch was used for the time and motion study of machine operations and the activity times of operation. The field operated by each machine combination was determined using a good measuring tape. Air tight tin container was use to collect soil sample for determination of soil characteristics.

Time for stoppage were summed up and deducted from the total time spend on the entire row length. At the end of a field length row just when the plough, harrow or ridger was raised. The turning activity was commenced. The time spends in making the turn was recorded as turning time.

Determination of machine speed:

The speed of operation for machine combination was measured in km/hr. It was repeated three times for each operation. Measurements of the time it took each machine to travel along the field row during an operation were taken.

Determination of fuel consumption:

Fuel consumption from the machine during an operation was measure as Ahaneku et al (2007) by filling the tank to full capacity before and after the test. Amount

of refueling after each test is measured as the fuel consumption for the test

Determination of soil characteristics:
Soil sample were taken immediately after ploughing, harrowing and ridging operation and placed in air tight tin container. The sample was weighed and then, taken to laboratory for the determination of bulk density, moisture content, soil type and structural analysis.

Determination of tillage depth:
Machine depth of operation for tillage was measured in centimeters immediately after each tillage operation. A graduated measuring stick, specially made to penetrate tilled soil was used to measure ploughing, harrowing and ridging depth. The depths of tilled soil at several points along each ploughed, harrowed and ridged field were measured and then their averages were computed to arrive at the soil depth of each tillage operation.

Effective field capacity:
Effective field capacity was evaluated using the relation.
$S = A / (T_p + T_i)$.....1
Where: S = effective field capacity
A = Area cover (ha)
T_p = productive time (hr)
T_I = Non productive time (hr) (lost for turning time, loading and adjustment excluding refueling and machine trouble)

Field efficiency:
This give an indication of the time lost in the field and the failure to utilize the full working of the machine it is calculate from the test data as follows
E_f = effective field capacity/Theoretical field capacity
$E_f = W_e X T_p / (w_t(T_p + T_i))$ 2
Where:
E_f = field efficiency
W_e = effective working width (m)
W_t = Theoretical working width (m)
Man- machine activity, $M_{ma=}((E + F)/H)X100$
Where:
E= Operating time (min)
F = turning time (min)
H = Total field time (E +F + G)
G = Delay time (min)

3.0 RESULT AND DISCUSSION

The time study for the entire machine operations were computed and given in Table 3.0, 3.1 and 3.2.The mean speed of ploughing operation was obtained as 5.26km/hr which is lower than that of harrowing (6.93Km/hr) and ridging (5.50km/hr) operation. This may be due to higher tractive force required in ploughing operation.

Another reason may be attributed to the mean time required to complete ploughing (37.80min), which was higher than that of harrowing and ridging operations of 16.81min and 14.06min respectively. The turning time for ploughing, harrowing and ridging were 7.27min, 4.61min and 4.27min respectively.

The field efficiencies for ploughing, harrowing and ridging operation were 78.98%, 75.80% and 76.63% respectively. The field efficiency was found within the

acceptable range as cited from (Alabi, 2006) for plough operation likewise for harrow and ridging operation as stated by Gwarzo,1991). The man-machine productivity for ploughing operations was higher than the effective field capacities. This was expected since man-machine performances are always higher than correspondingly attained mean effective capacities this explain the minimum stoppage or delay during the operations ordinarily this should be an indication of good operator performance and/or machine reliability (Alabi, 2006).

From Table 4.10, the soil moisture content during the operation for plough, harrow and ridging were 10%, 9.8% and 9.0% (wet basis) respectively. The depth of operation for plough, harrow and ridger were 2cm, 15cm and 28cm respectively.

CONCLUSION

The effective field capacities obtained during the study were 0.354ha/hr, 0.750ha/hr and 0.910ha/hr for ploughing, harrowing and ridging operations respectively. The operating speed for ploughing, harrowing and ridging operation was 5.26km/hr, 6.93km/hr and 5.50km/hr respectively. The mean field efficiencies obtained from the study was 78.98%, 75.80% and 76.63% for ploughing, harrowing and ridging operations.

REFERENCE

Ahaneku, I. E. and A. P. Onwualu (2007). Tillage effects on maize performance and physical properties of a sandy soil. Journal of Applied Science, Engineering

Anozodo U.G.N (1983). Survey and comparative analysis of farm power and machinery management system in Nigeria. Proceeding. NSAE, Vol.7 pp59-73

Alabi J.B.(2006): Capacitive performance studies of ploughing operations in Birnin Kebbi "Proceeding of the Seventh International Conference of Institute For Agricultural Engineers" Vol. 28:pp; 113-117.

Braid F. G and Gwarzo M. A (1985). Capacitive performance of selected tillage machinery used in irrigated land condition. Paper presented at the 8th annual conference of the Nigerian Society of Agricultural engineers Owerri 2nd -6th September,1985.

Bukhari, S., M. A. Bhutto, J. M. Baloch., A. B. Bhutto and A. N. Mirani (1982). Performance of Selected Tillage Implements. Agricultural Mechanization in

Collins, N.E., T.H. Williams, and L.J. Kemble (1981). Measured machine implements, AMA, Vol. (13): 20-22. Energy requirements for grain production system. ASAE Publ. 4-81: 407-411. Asia, Africa and Latin America. 19(4): 9 – 14.and Technology. Vol. 7, No. 1:42 – 49.

Gwarzo (1991). Capacitive performance of selected tillage machinery used in irrigated land condition. Paper presented at the 8th annual conference of the Nigerian Society of Agricultural engineers Owerri 2nd -6th September,1991.

Upadhyaya, S.K., T.H. Williams, L.J. Kemble and N.E. Collins (1984). Energy requirement for chiseling in coastal plain soils. *Transactions of the ASAE, 27(6): 1643-1649*.7; 2

Table: 3.0 Time Study Information for Ploughing Operation

b ◘□◘ź observation	Speed (km/hr)	Plough Time (min)	Turn Time (min)	Machine failure (min)	Management stop (min)	Total Time (min)
1	4.25	42.03	7.85	0	9.48	59.39
2	5.66	37.87	7.52	0	0	45.39
3	5.87	33.50	6.45	0	0.53	40.48
mean	5.26	3.48	7.27	0	5.005	48.41
SD	0.719	3.48	0.597	0	4.475	7.998

Table: 3.1. Time Study Information for Harrowing Operation

No. of observation	Speed (km/hr)	Harrowing Time (min)	Turn Time (min)	Machine failure (min)	Management stop (min)	Total Time (min)
1	6.51	17.85	4.65	0	1.07	23.57
2	7.38	15.75	4.67	0	1.22	21.64
3	6.91	16.82	4.50	0	0	21.32
Mean	6.93	16.81	4.61	0	1.145	22.18
SD	0.2603	0.8573	0.0759	0	0.0750	1.72

Table 3.2: Time Study Information for Ridging Operation

No. of observation	Speed (km/hr)	Ridging Time (min)	Turn Time (min)	Machine failure (min)	Management stop (min)	Total Time (min)
1	5.05	14.13	3.97	0	0.7	
2	5.80	13.83	4.20	0	0	
3	5.65	14.23	4.63	0	0	
mean	5.50	14.06	4.27	0	0.7	
SD	0.324	0.170	0.2735	0	0	

Number of observation	Speed (km/hr)	Theoretical field capacity (ha/hr)	Effective field capacity (ha/hr)	Field efficiency (%)	Man-Machine productivity (ha/hr)	Man-Machine activity (%)	Man-Machine Performance (Ha/hr)
1	4.25	0.396	0.281	70.80	0.33	84	0.28
2	5.66	0.441	0.368	83.40	0.37	100	0.37
3	5.87	0.497	0.412	82.76	0.42	98.6	0.41
Mean	5.26	0.445	0.354	78.98	0.37	94.2	0.35
SD	0.7193	0.0413	0.0544	5.79	0.0369	7.23	0.0545

Table 4.1: Field Performance of Tractor and Implement in Ploughing Operation

Number of observa-tion	Speed (km/hr)	Theoretical field capacity (ha/hr)	Effective field capacity (ha/hr)	Field efficiency (%)	Man-Machine producti vity (ha/hr)	Man-Machine activity (%)	Man-Machine Performance (Ha/hr)
1	6.51	0.93	0.71	75.70	0.741	95	0.704
2	7.38	1.06	0.77	72.90	0.818	94	0.772
3	6.91	0.99	0.78	78.80	0.783	100	0.783
Mean	6.93	0.99	0.75	75.80	0.781	96.30	0.753
SD	0.356	0.053	0.0311	2.409	0.0315	1.887	0.035

Table: 4.2 Field Performance of Tractor and Implement in Harrowing Operation

Number of observa-tion	Speed (km/hr)	Theoretical field capacity (ha/hr)	Effective field capacity (ha/hr)	Field efficiency (%)	Man-Machine producti vity (ha/hr)	Man-Machine activity (%)	Man-Machine Performance (Ha/hr)
1	6.51	0.93	0.71	75.70	0.741	95	0.704
2	7.38	1.06	0.77	72.90	0.818	94	0.772
3	6.91	0.99	0.78	78.80	0.783	100	0.783
Mean	6.93	0.99	0.75	75.80	0.781	96.30	0.753
SD	0.356	0.053	0.0311	2.409	0.0315	1.887	0.035

Table 4.3: Field Performance of Tractor and Implement in Ridging Operation

Number of observa tion	Speed (km/hr)	Theoretical field capacity (ha/hr)	Effective field capacity (ha/hr)	Field efficiency (%)	Man-Machine productivity (ha/hr)	Man-Machine activity (%)	Man-Machine Performance (Ha/hr)
1	5.05	1.18	0.88	75.00	0.92	96.00	0.887
2	5.80	1.21	0.95	78.50	0.93	100.00	0.925
3	5.65	1.16	0.89	76.40	0.89	100.00	0.885
Mean	5.50	1.18	0.91	76.63	0.91	98.67	0.899
SD	0.324	0.0208	0.0311	1.438	0.0173	1.8856	0.0184

Table 4.4: Fuel Consumed In Ploughing Operation

N/observation	Speed (Km/hr)	Fuel consumed (lit/ha)
1	4.25	18.95
2	5.66	20.94
3	5.87	19.94
Mean	5.26	19.98
SD	0.7195	0.8132

Table 4.5: Fuel Consumed in Harrowing Operation

N/observation	Speed (Km/hr)	Fuel consumed (lit/ha)
1	6.51	19.94
2	7.38	18.94
3	6.91	15.95
Mean	6.93	18.28
SD	0.364	1.695

Table 4.6: Fuel Consumed in Ridging Operation

N/observation	Speed (Km/hr)	Fuel consumed (lit/ha)
1	5.05	15.95
2	5.80	14.95
3	5.65	15.45
Mean	5.50	15.45
SD	0.324	0.4082

Table 4.7: Soil Characteristic

Operation	Clay (%)	Silt (%)	Sand (%)	Moisture content (%)	Bulk density (g/cm^3)	Textural class
Ploughing	14	26	60	10	1.47	Sandy loam
Harrowing	14	26	60	9.8	1.47	Sandy loam
Ridging	14	26	60	9	1.47	Sandy loam

DESIGN OF INDUCTION FURNACE FOR HEAT TREATMENT OF AGRICULTURAL TOOLS

***Ilori, Abolaji Okikiade, Jimo, Kabiru Adekunle, Akangbe, Oluseyi Emmanuel, Gbopa, Akeem Rotimi, Balogun, Lawal Adedamola and Ogunsina, Omotayo Ayoade**

Department of Agricultural & Bio-Environmental Engineering,Oyo State College of Agriculture, Igboora.

*Corresponding Author: bjtemilor@yahoo.com (08030698768)

ABSTRACT

Going round farm settlements, the big farms and most state and federal owned Agricultural agencies, one of the most disturbing issues is the way countless number of Agricultural equipment and implements, for land clearing, tillage, farm projection, harvesting and processing, litters their compounds and at different stages of deterioration. Investigation revealed that most of these equipment and implements were down because of one or two simple component parts that can be produced even at their workshop except for the heat treatment. Most Agricultural hand tools that can be fabricated by the local fabricator are still being imported because heat treatment required for the tools cannot be done locally. It is this situation that demands the design and construction of Induction furnace for heat treatment of Agricultural tools. A 25kVA induction heater was designed to consist of 4 major divisions viz: the conversion section, the inverting section, the filter unit and the damped tank oscillator unit. The conversion section makes use of IGBT (Insulated-Gate Bipolar Transistor) to convert AC to DC. The DC produced is then passed through adjustable DC pulse control circuit and a capacitor to get a straight line DC current. This DC current in inverted with the use of IGBT to get full wave AC which is passed through a high pas filter before being connected to a 25kVA which is acting as an isolator as well as a stepdown transformer stepping 500V to 100V. The highly filtered AC power that is stepped down to 100V is then passed through the damped tank oscillator which contains a resistor and capacitor connected in parallel with the inductor that will do the heat treatment. The design model was then simulated using Proteus software. It can therefore be concluded that with such equipment, heat-treatment of Agricultural implements will be a problem of the past and in addition, the rate at which these implements litter the ground will greatly reduce. Also, availability of this induction furnace will in no small measure promote our economy because it will reduce the importation of component parts of Agricultural implements.

Keywords: Induction, Furnace, Heat Treatment, IGBT, Agricultural Tools

1.0 INTRODUCTION

Heat treatment is a group of industrial and metalworking processes used to alter the physical, sometimes chemical properties of a metal material. It involves the use of chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. (Dossett and Boyer, 2006)

Heat treating is often used to alter the mechanical properties of an alloy, manipulating properties such as hardness, strength, toughness, ductility and elasticity.

Gupta (2002) listed two mechanisms that may change an alloy's properties during heat treatment viz:

- Martensite, which causes the crystal to deform intrinsically
- The diffusion mechanism which causes changes in the homogeneity of the alloy.

Among the various methods of heat treatment available, induction heating is the most widely employed, to improve component durability (Rudnev *et al*., 2002).

An induction furnace however, is an electrical furnace in which the heat is applied by induction heating of metal. Its advantage is that it is clean, energy-efficient and well-controllable melting process compared to most other means of metal melting (Ostwald, 1997).

Induction heating is a non-contact heating process which utilizes the principle of electromagnetic induction to produce heat inside the surface layer of a work-piece. (Davis and Simpson, 1979). By placing a conductive material into a strong alternating magnetic field, electrical current can be made to flow in the material, thereby creating heat due to the I^2R losses in the material.

The current generated flows predominantly in the surface layer, the depth of this layer being dictated by the frequency of the alternating field, the surface power density, the permeability of the material, the heat time and the diameter of the bar or material. (Edgar and Yulia, 2006)

Edgar and Yulia (2006) stressed that by quenching the heated layer of a metal in water, oil or polymer based quench, the surface layer is altered to form a Martensitic structure which is harder than the base metal.

2.0 MATERIALS AND METHOD

The 25kVA induction heater was designed to consist of 4 major divisions viz: the conversion section which is made up of Insulated-gate Bipolar transistor (IGBT) and a 3-phase power supply as its input, the inverting section, the filter unit-made up of a 5μF capacitor and a 6.35k? resistor arranged in a high-pass model and the damped tank oscillator unit made up of a 2.52? resistor, 126nF capacitor and a 20μH inductor as shown in figure 1.

2.1 Simulation: The simulations were accomplished using Proteus professional software 7.8 version. A 3-phase AC voltage of 415V which served as the input of the conversion section was converted to a DC voltage with the use of an IGBT and the DC voltage produced was passed through an adjustable DC pulse control circuit to get a straight line DC current. At the inverter section, this DC current was then inverted with IGBT to get a full wave AC voltage which was thereafter passed through a high pass filter. The output of the filter section served as input into a 25kVA transformer, which serves a dual purpose of an isolator as well as a step-down transformer stepping down the resultant voltage of 500V to 100V.

The highly filtered AC power that was stepped down to 100V was thereafter passed through the damped tank oscillator containing a 2.52? resistor and a 126nF capacitor connected in parallel with a 20μH inductor that will do the heat treatment.

Because of the high heat generated by the inductor, the inductor is made of copper pipe having ten turns and cooling water is made to pass through the pipe to maintain a temperature of below 80°C. The cooling water then passes through a radiator re-circulation.

As shown in Figure 2, the converter section takes in a 3-phase power supply and

the conversion is done with the aid of 600V, 120A IGBT connected coupled with 600V, 30A Fast Recovery Diodes

Unlike in the converting section, the inverter section as shown in Fig 3 is made up of 1200V, 80A IGBT coupled with a 600V, 30A Fast Recovery Diodes. This section takes in the DC output of the conversion section as its input and produced a single phase AC output voltage

Figure 4 shows the High pass filter section, it is also called the Feedback Control circuit. It is meant to filter the full wave AC signal generated from the Inverter section and filter off any ripple and unwanted noise that might have been introduced due to the components used while figure 5 shows the damped tank oscillator circuit which is the final stage of the 25kVA High Frequency induction Heater. Its function is to maintain the same amplitude value of the output voltage for an infinite amount of time that the equipment is in use.

3.0 RESULT AND DISCUSSION

The results of the simulations were presented in figure 7. The output of the converter section is a straight line DC voltage of 600V; this voltage is then inverted to get a full wave AC voltage of 500V which serves as an input into a high pass filter to filter any ripple and unwanted noise present in the full wave AC signal.

The output of the high pass filter is then connected to a25kVA transformer which then steps the 500V down to 100V and this voltage serves as the input into a damped tank oscillator.

4.0 CONCLUSION

From the simulations result above, the output of the full wave inverter was simulated and the result was inverter voltage 500V, peak inverter current of 50A while the tank voltage is 80V and the current is 250A.

The induction coil and the material to be heated will act as another transformer. The inductor coil will serve as the primary winding of 10 turns with a 80V, 250A while the material to be heated will serve as the secondary coil which is usually one turn. From the ratio of turns, a current of about 2500A will pass through the material and that is what does the heating.

It can therefore be concluded that with such equipment, heat-treatment of Agricultural implements will be a problem of the past and in addition, the rate at which these implements litter the ground will greatly reduce. Also, availability of this induction furnace will in no small measure promote our economy because it will reduce to the nearest minimum, the importation of component parts of Agricultural implements.

REFERENCES

Davies John and Simpson Peter (1979) “Induction heating handbook” McGraw-Hill, ISBN 0-07-084515-8.

Dossett Jon L and Boyer Howard E. (2006) “Practical heat treating” ASM International, pp 17-22

Phillip f. Ostward (1997) “Manufacturing processes and systems (9th Edition), John

Wiley & Sons,ISBN 978-0-471-04741-4, p48

Rapoport Edgar and Pleshivtseva Yulia (2006) "Optimal Control of Induction heating Processes" CRC Press, 2006, ISBN) 0-8493-3754-2

Rudnev Valery, Loveless Don, Cook Raymond and (2002) Black Micah "Handbook of Induction heating" CRC Press,ISBN 0-8247-0848-2

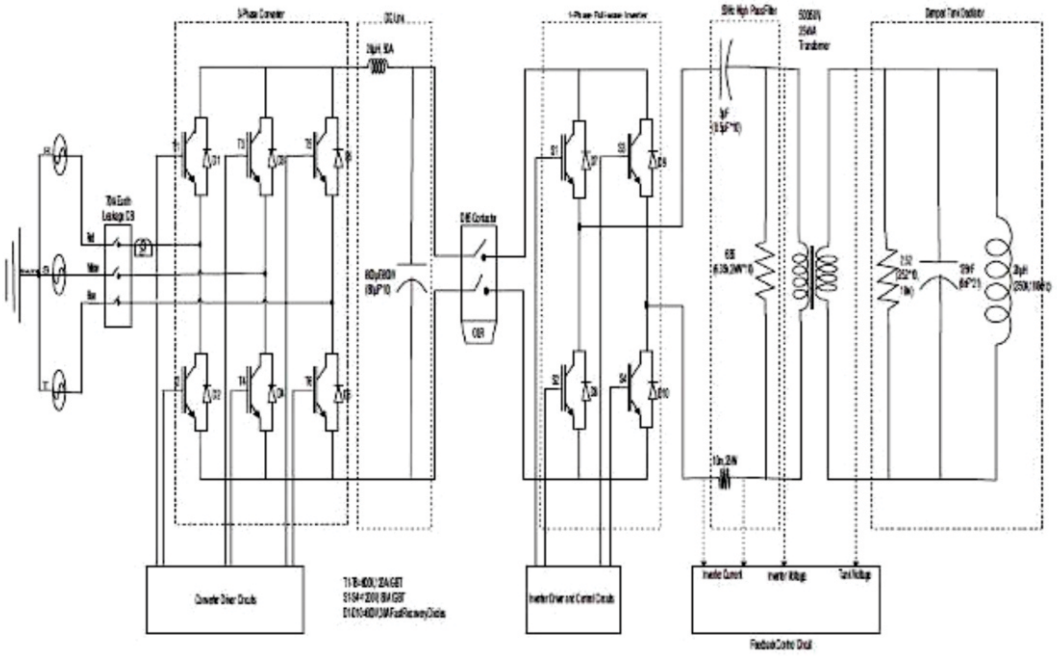


Fig.1: Power Schematics of a 25kVA High Frequency Induction Heater

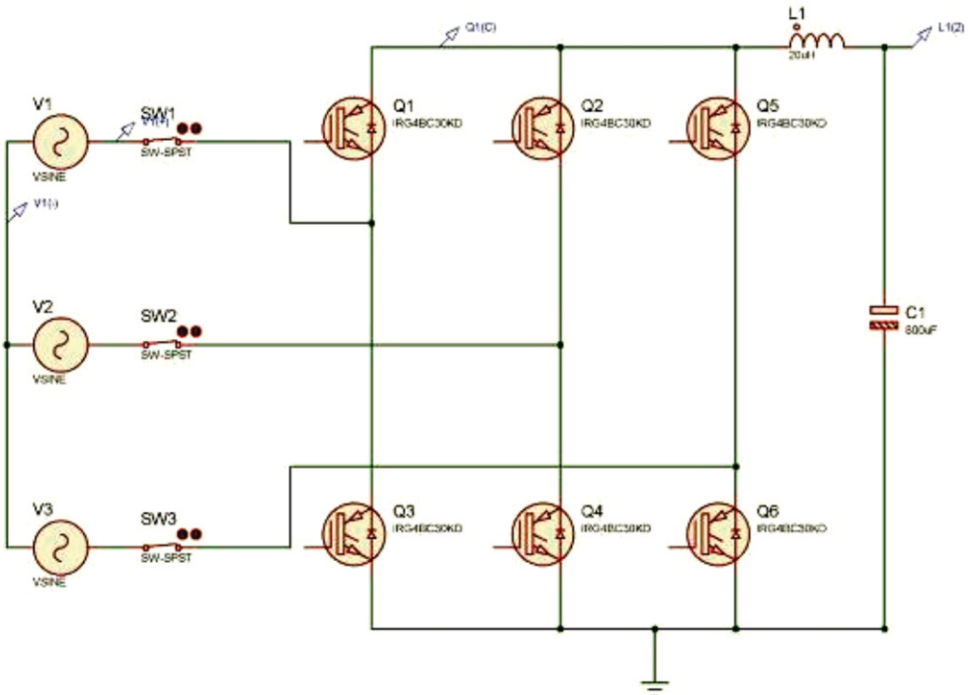


Fig 2: Circuit Diagram Of The Converter Driver Of The Induction Heater

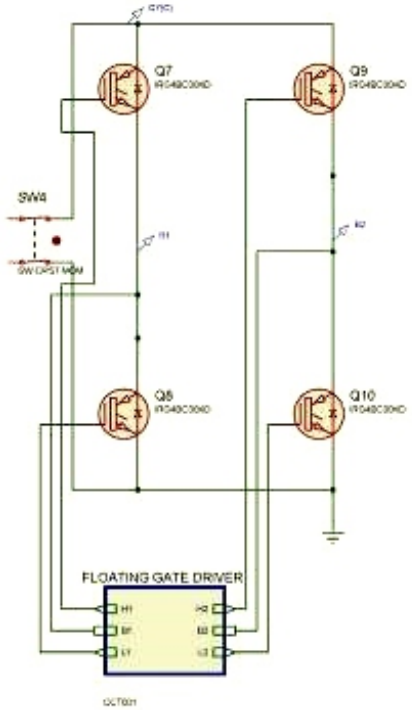


Fig. 3: The Inverting Driver And Control Circuit

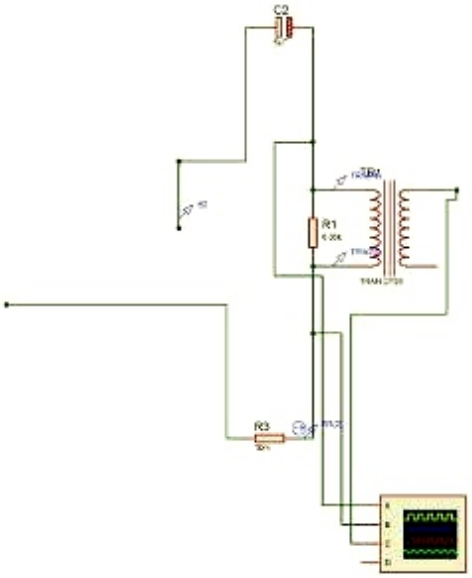


Fig. 4: The High Pass Filter Section.

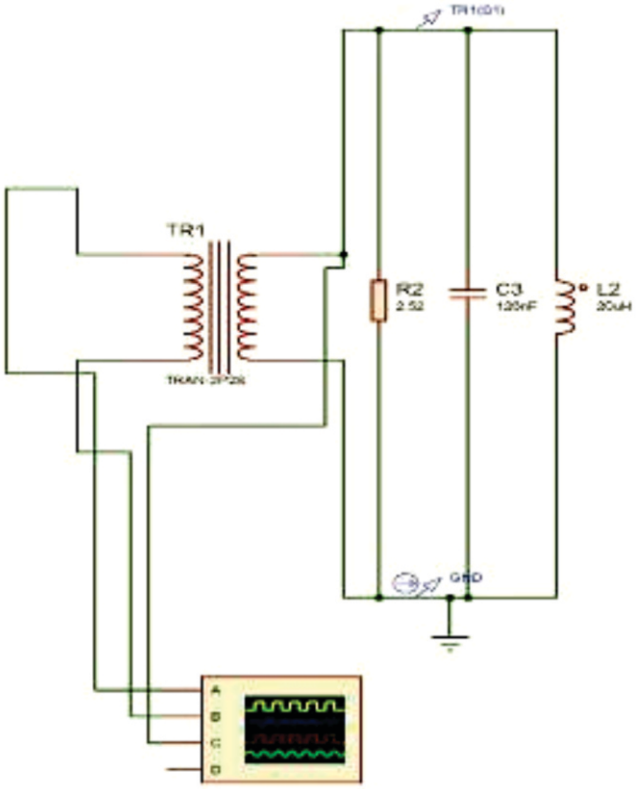


Fig 5: The Damp Oscillator Circuit.

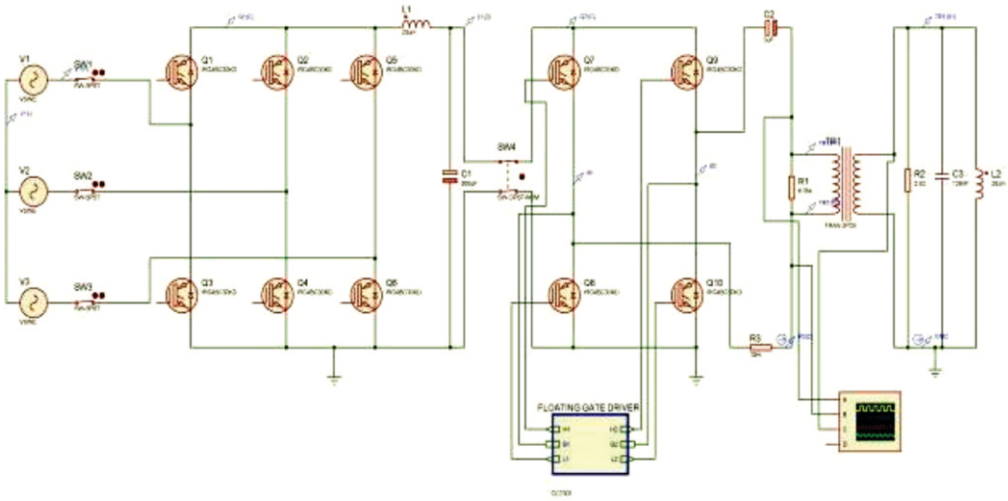


Fig 6: The Complete Simulation Model For An Induction Heater.

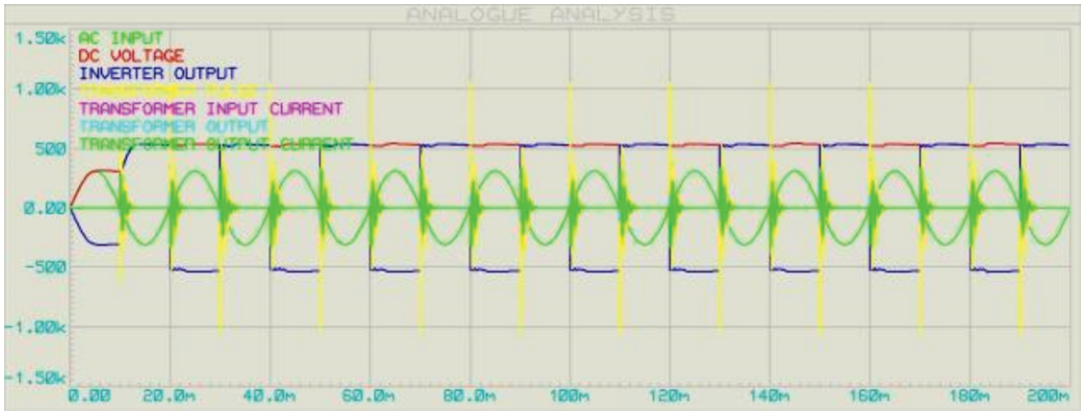


Fig. 7: Results Of The Simulations.

ASSEMBLY AND PERFORMANCE EVALUATION OF THE INSTRUMENTATION SYSTEM OF A SOIL BIN FOR TILLAGE STUDY

[1]Ale, M.O, [2]Ademosun, O.C., [2]Manuwa, S.I., [2]Agbetoye, L.A.S., [2]Adesina, A, and [3]Ewetumo, T.

[*1]Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic, Owo.

[2]Department of Agricultural Engineering, Federal University of Technology, Akure.

[3]Department of Physics, Federal University of Technology, Akure.

*Corresponding author: alebosunenator@gmail.com

ABSTRACT

An instrumentation system was assembled to measure and record draught in soil-tool interaction in tillage study. The instrumentation system consists of a load cell, strain gauge amplifier, data logger and a computer system (laptop). The soil bin facility consists of the soil bin, soil levelling blade, smooth compaction roller, spiked roller, implement carriage system, sub implement carriage system, tool bar and fixing device, drive system(45 kw-4 wheel drive tractor) and the instrumentation system. Two experiments were conducted on the outdoor soil bin to determine the effects of speed and compaction (cone index) on draught and soil disturbance parameters. The soil in the bin was sandy clay loam. In the first experiment, speeds of tillage were 10, 15, and 20km/h at constant degree of compaction of 3 passes of compaction roller. In the second experiment, 5, 10, 15 and 20 passes of compaction roller of respective mean values of cone index (compaction) of 1550, 2829, 3126 and 3775kN/m^2 at 8km/h constant tillage speed. The tillage depth was 120mm and the tool was a mouldboard plough for both experiments. The result of the soil bin experiments showed that the value of draught increased with increase in speed and later decreased with further increase in speed. A polynomial relationship was observed between the speed and the soil disturbance parameters except with the height of ridge and left soil throw in which inverse relationship was observed. It was also found that the value of draught increased with increase in the values of cone index and bulk density, whereas the values of the soil disturbance parameters decreased with increase in cone index.

Keywords: Assembly, Instrumentation System, Performance Evaluation, Soil Bin, Tillage

1. INTRODUCTION

Soil bin is a generic term for a test facility for studying soil dynamics, specifically on soil-machine interaction research in agriculture. The application of soil bin for soil machine interaction research was initially established by several research institutes, like the National Tillage and Machinery Laboratory (NTML) in the United States, the U.S. Army Tank Automotive Centre, the Vicksburg Waterways experimental Station and Caterpillar Tractor Co. (Oni et al, 1992). Soil bins can be used for indoor and outdoor testing. But, many soil bins are intended for indoor testing. There are two broad divisions of soil-machine interaction studies. The first is on the applications of tools related to soil engaging and materials incorporation operations. While the second is on the applications related to tractive devices, such as wheels and tracks. Soil bins were used more often in the first division than in the second. For research purpose on investigation into these important soil dynamic parameters, it is difficult to

quantificationally analyse the dynamic mechanical behavior of soil directly as the constituent of the soil is complex and the mechanical behavioural changing of disturbed soil is unstable. Soil bins can be classified into large scale soil bins and small scale soil bins and small scale soil bins; moveable (with stationary tools and stationary with movable tools); indoor and outdoor; straight (rectangular) and circular (Mardani, et al 2010; Mamman and Oni, 2002). Today measuring instrument and electronics technology develops quickly, though they have been applicable to some areas of agriculture, but scarcely adopted in Africa especially in the areas of soil tillage dynamic and research development of which the use of soil bins has been adopted to replace the existing mechanical devices like the dynamometer. Therefore, this study was on assembly and performance evaluation on the instrumentation system for soil tillage study on a soil bin.

2. MATERIALS AND METHODS

2.1 Experiment Site

The research was conducted on the outdoor soil bin of the STEP B (Science and Technology Education Post Basic) Project Site of the Federal University of Technology, Akure, Nigeria, located on latitude 7°10' N and longitude5°05' E. The soil of the study area from which the soil bin was filled is a sandy clay loam soil according to USDA textural classification of soil.

2.2. Soil Bin And Its Components

The soil bin had dimensions 48.0 x 1.5 x 1.2m of length, width and height, respectively. The walls of the soil bin were constructed with concrete block, Soil Leveling blade consisted essentially of a plane steel board with light curvature, 1400mm wide and 350mm high. It was reinforced, at the middle to provide sufficient strength and rigidity. The soil compaction roller consisted mainly of a cylindrical drum, the roller axle and bearing, and ballast weights. Its major function was to compact the bin soil in layers desired for testing. The spiked roller whose function is to ensure a satisfactory bond between successive soil layers is similar to the compaction roller.

2.3 Implement Carriage System

The implement carriage was made of rectangular hollow section steel and was supported on four wheels mounted. The carriage dimension was 1.623 m x 0.70 m x 1.117 m of length, width and height, respectively. The main function of the carriage was to mount the implement sub-carriage system which in turn carried the toolbar in place and for mounting any tillage or traction devices such as traction or towed wheels for testing or for transportation. The carriage can be coupled to the drive system through the 3-point linkage.

2.4 The Drive System

The drive system(Figure1) was an MF 415 tractor with the following specifications: power, 31.6 kW; 2WD; Diesel engine; water cool; oil bath air cleaner with PTO drive shaft and 3-point linkage; a good range of forward speeds (2.59 – 34.21 km/h); a slow and fast reverse speeds of 3.5 and 14.2 km/h respectively.

2.5 Experimental Tillage Tool

A single bottom mouldboard plough was used as the tillage tool for this study.

2.6 Instrumentation and Data Acquisition Systems

A 10 tonne load cell (Figure 2) of no. 100201022 and output 2.50mV/V-(TM

AUTO INSTRUCO, LTD) was interfaced with a computer system and the sensor outputs. The data acquisition (Figure 1) was made up a (load cell) outputs interfaced to a computer (laptop) system (DELL, Poland) and a data logger (Grant Instruments Cambridge Ltd, U.K). The system could receive, monitor, display and store the measured signals from the load cell. The load cell was installed on the tool carriage system by the use of brackets. The software for the data logger as provided by the manufacturer was installed. The interfaced system was powered by a pair of 6volts batteries (12 volts).

2.7 Performance Evaluation

2.7.1 Variable speed experiment

In this experiment, after the soil bin had been filled, the soil was compacted by driving the compaction roller on the soil bin three times(three passes). Soil samples were taken for both moisture content and bulk density determinations. The tillage tool(single bottom plough) was mounted on the tool bar of the carriage system for the experiment. The rake angle was kept constant at 60° and the tool carriage was towed for each of the three treatments at operating speed of 10, 15 and 20 km/hr respectively and at operating depth of 120mm. The soil disturbance measurement was taken. The draught data as recorded and stored by the data logger was downloaded to the computer system(lab-top) for analysis.

2.7.2 Constant speed experiment

In constant speed experiment, the soil was hipped and divided into four equal blocks. Each block was subjected to compaction by driving the compaction roller through each of the block according the desired number of passes(degree of compaction); 5, 10, 15 and 20 passes respectively. The compaction value of each of the treatments was taken from two points of reasonable distance by the use of a hand-held penetrometer graduated in psi, but converted to KN/m^2 by multiplying the Psi value by a conversion factor of 6.894757. The moisture content was taken and soil samples were collected for bulk density determination. The mould board plough was attached and towed at constant operating speed of 8km/hr, operating depth of 120mm and rake angle of 60°. The soil disturbance measurement was also taken and the data downloaded for analysis.

2.8 Soil Measurement

Soil disturbance: The soil failure parameters; maximum width of soil throw(TDW), maximum width of cut(Wfs), ridge to ridge distance(RRD), small height of ridge(h_{rs}) , large height of ridge(h_{rl}) and after plough depth(d_f) were measured with the use of a profile meter.

Soil bulk density: Soil samples were collected from the depth of 0-6, 6-12 and 12-18cm by the use of core sampler of 5.8cm diameter and 6cm height. The core sampler was driven into each depth of the soil and the collected soil was kept in an air tight polythene bag to avoid moisture loss. The sample was oven dried and weighted. The oven dried soil was allowed to cool for one hour. The bulk density was determined using the standard equation;

$$\text{Bulk Density} = \text{Mass(g)}/\text{Volume(cm}^3\text{)} \quad \text{..... equation 1}$$

Soil moisture content: Soil moisture meter was used to determine the moisture content at 0-6, 6-12 and 12-18cm soil depths.

Compaction (cone index): The compaction (cone index) of two points in each block(of varied number of passes of the compaction roller) was taken by the use of a soil cone penetrometer by continuous hand pushing of the cone tipped shank of the penetrometer into each depth (6,12,18,24 and 30cm) and maximum reading at each depth taken and recorded. This was repeated for every treatment. To convert these readings from psi to $KN/m^{2,}$ a conversion factor of 6.894757 was used to multiply the field reading.

3. RESULTS AND DISCUSSION

3.1 Effect of Speed on Draught and Soil Disturbance

The results showed that draught increased with increase in forward speed of the tractor and later decreased with increase in forward speed at average moisture content of 4.9% (Figure 7). The experiment of 15km/h had the highest mean value of 4,435.40 N while speed of 10km/h had the lowest mean value of 3775.67N. This polynomial (linear and quadratic) relationship is in good agreement with Mamman and Oni(2005) who reported that beyond a certain speed level, the draught decreased or remained constant. Variations of the soil disturbance parameters with speed are presented in Figure 8. The results showed a polynomial relationship between the speed and the soil disturbance parameters except with height of the large ridge and the small soil throw which decreased with increase in speed with coefficient of determination r^2 of 0.9434 for large ridge height (h_{rl}) and 0.9948 for small soil throw. This is in good agreement with Morris et al (2007). This may be due to higher speed and the type of tool used for the experiment..

3.2 Effect of Compaction on Draught and Soil Disturbance

The result (Figure 9) of this study indicated that draught increased with increase in compaction from mean value of 1550 to 3775KN/m^2 with coefficient of determination r^2 of 0.807. This is in conformity with Manuwa and Ademosun(2007). A quadratic relationship was observed from 1500KN/m^2 (compaction)/549.28N (draught) to 3126KN/m^2(compaction)/1757.13(draught) while perfect linearity was observed from from 3126KN/m^2 (compaction) to 3775N (draught). This is due to normal increase of soil strength with compaction. The Variation of bulk density (1.18g/cm3 to 1.52g/cm3) was observed to have a linear relationship with tillage draught with coefficient of determination r^2 of 0.8897(figure 10). The draught increased with increase in bulk density at average moisture content of 5.9%. This result is in conformity with Seidi et al (2010).

In the constant speed experiment, it was also observed as presented in Figure 11 that the values of soil disturbance decreased with increase in compaction. Except the height of the small ridge which increased with increase in compaction. Soil disturbance parameters (Figure 11) with linear relationship are of the coefficient of determination r^2 ranging from 0.6521 to 0.9678. This is due to the increase in the bond between the soil grains. This can be attributed to increase in soil weight of the sheared soil segments as bulk density increases with cone index of the soil and the tillage tool used.

4. CONCLUSIONS

The following conclusions can be drawn from this study:

1. The instrumentation system was calibrated and found suitable for measurement of soil forces in tillage studies.
2. A polynomial relationship between speed and draught that showed that draught increased with increase in speed and later decreased with further increase in speed was observed.

3. A polynomial relationship was also observed between the soil disturbance parameters and the speed except the height of the ridge and small soil throw in which a good inverse relationship was found.
4. There was a good correlation between draught and compaction as well as between draught and bulk density of the soil.
5. Good correlation was also observed between compaction and soil disturbance parameters as they decreased with increase in compaction except with the height of ridge which increased with increase in compaction.

REFERENCES

Mamman, E. and Oni, K. C. 2002. Effect of draught on the performance of model chisel furrowers in a laboratory soil bin. Proceedings of the second international conference of WASAE and NIAE. pp.239 – 251.

Mamman, E. and Oni, K. C. 2005. Draught performances of a range of model chisel furrowers. Agricultural Engineering International: the CIGR Ejournal. Manuscripts PM 05 003. Volume 7 November 2005.

Manuwa, S. I and Ademosun, O. C. 2007. Draught and soil disturbance of model tillage tines under varying soil parameters. Agricultural Engineering international, CIGR Journal manuscript PMO 6016 Vol. 9 March 2007.

Mardani, A., Shahidi, K., Rahman, A., Mashoofi, B. and Karimmaslak, H. 2010. Studies on a long soil bin for soil-tool interaction. Cercetari Agronomice in Moldova. 43(2/142):5-10.

Morris, N. L., Miller, P. C. H., Orson, J. H. and Froud-Williams, R. J. 2007. Soil disturbed using a strip tillage implement on a range of soil types and the effect on sugar beet establishment. Soil use and Management. British Society of Soil Science. 23(1):119.

Oni, K. C. Clark, S. J. and Johnson, W. H. 1992. The effects of design on the draught of under-cutter-sweep tillage tools. Soil Tillage Research, 22: 117-130.



Figure 1: Data Acquisition System Located On The Drive System



Figure 2: Load Cell And Its Brackets.

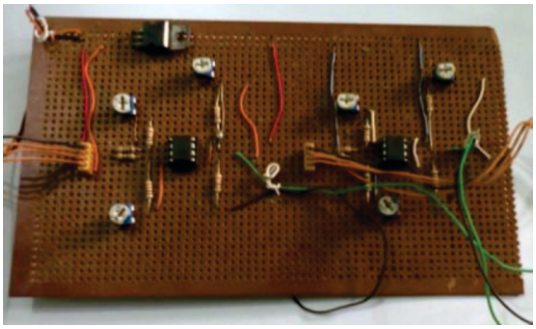


Figure 3: Circuited Amplifier Board

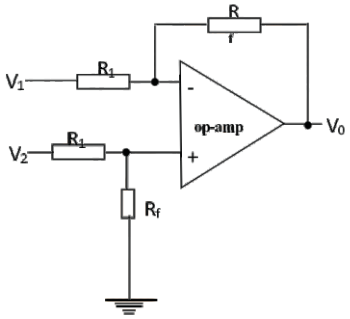


Figure 4: The Circuit Diagram of the Figure…: Differential Strain Gauge Amplifier (LM 358).



Figure 5: An Aspect Of The Calibration System

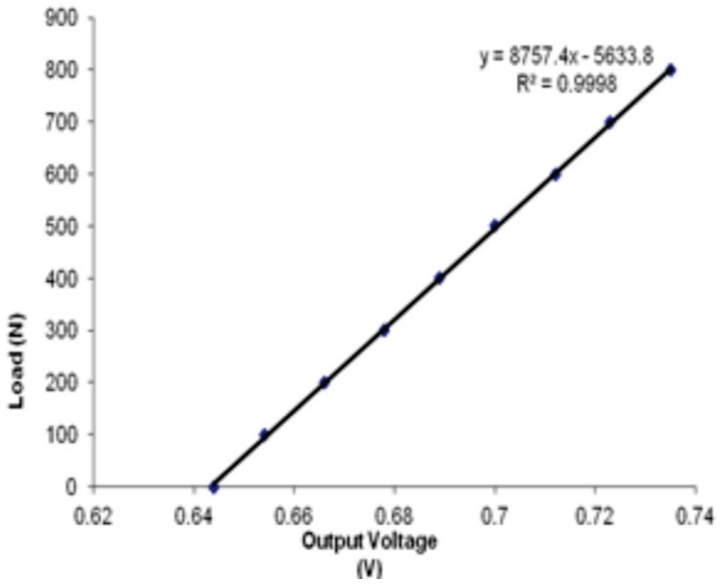


Figure 6: Calibration Curve of the Load Cell

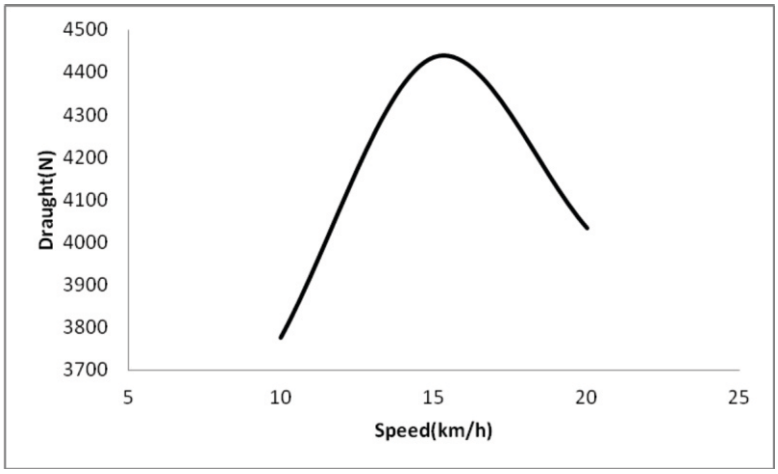


Figure 7: Variation Of Draught With Speed

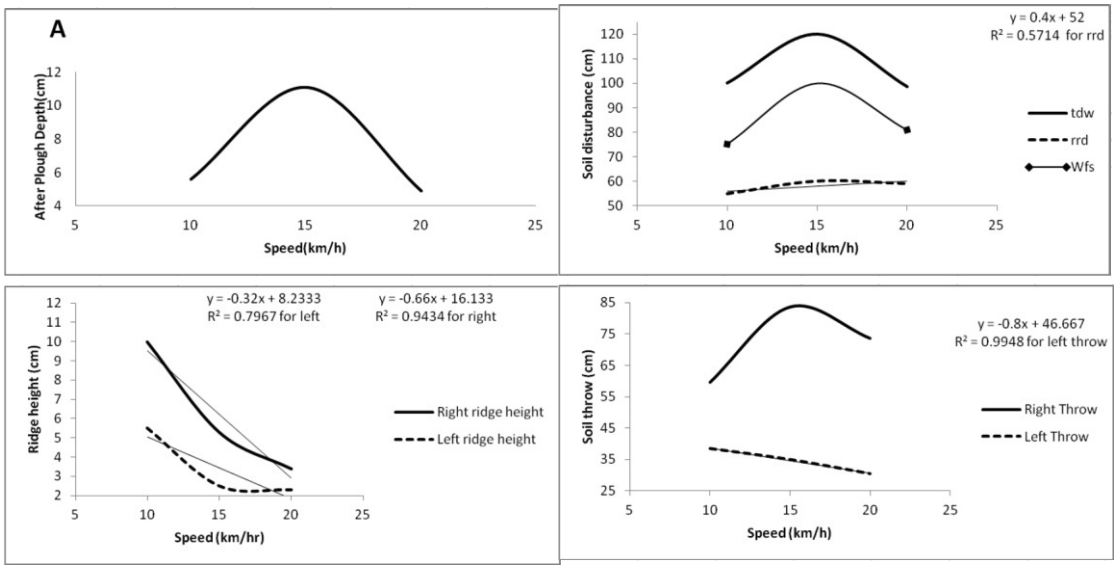


Figure 8: Variation Of Soil Disturbance Parameters With Speed

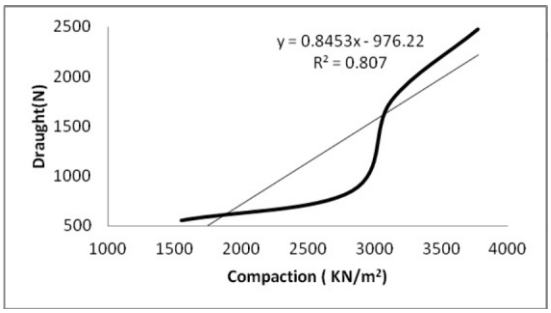


Figure 9: Variation Of Draught With Compaction

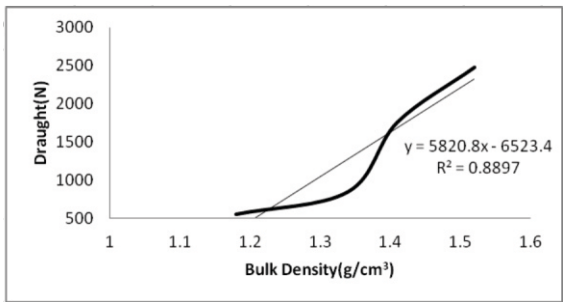


Figure 10: Variation Of Draught With Bulk Density

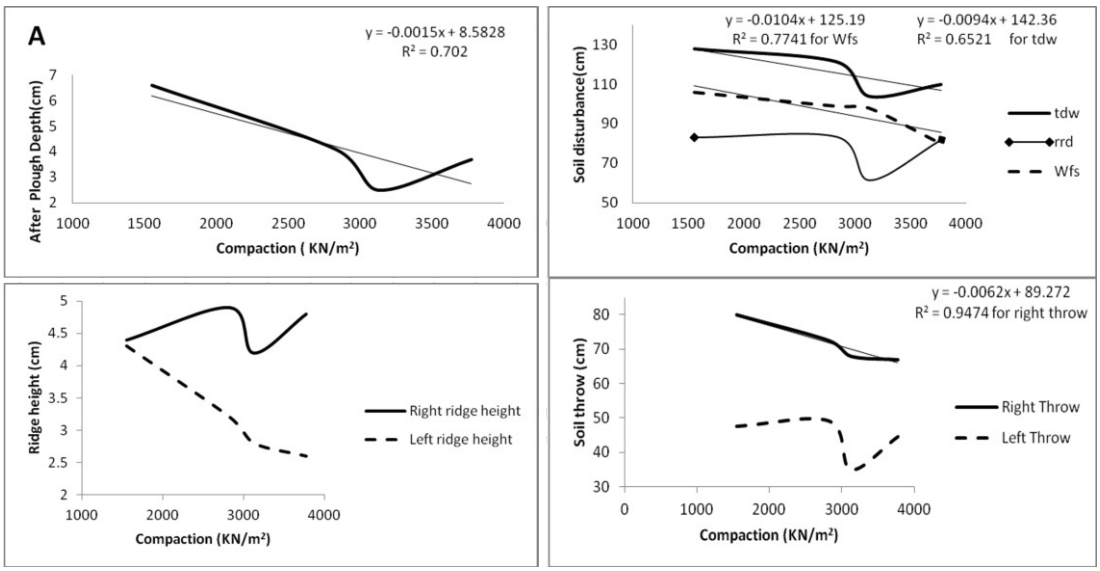


Figure 11: Variation Of Soil Disturbance Parameters With Compaction

ASSESSMENT OF TRACTOR HIRING SERVICES IN KADUNA STATE

Dalha I. B., M. A. Gwarzo, and O. E. Olayinka
Department of Agricultural Engineering, Ahmadu Bello University, Zaria
Correspondence: irobabangida13@yahoo.com
Phone Number: 08037688044, 08055501727

ABSTRACT
Areas were used to obtain some information regarding the general affairs of the scheme. Descriptive and inferential statistical methods were employed to analyze the results obtained. The results showed that, in the selected areas the scheme has a total number of 26 tractors with 81% functionality. Sabon gari L. G. A was found to have the highest number of 9 tractors while Kaduna North and Kachia L. G. A have the lowest Kaduna state tractor hiring scheme was assessed for functional tractors availability, level of utilization, mode of operations and the prevailing scheme's challenges in the selected areas, an explorative method which involved administering questionnaires to tractor hiring unit in Kaduna state ministry of agriculture, Kaduna South, Kaduna North, Sabon Gari, Zangon Kataf, and Kachia Local Governmentnumber each of 3 tractors. An average hectares covered from 2009 to 2012 were determined for each unit to assess the level of utilization and however, the rate of coverage per tractor was found to be 289.25ha/yr, 26.5ha/yr, 69.75ha/yr, 69ha/yr and 31ha/yr for Kaduna South, Kaduna North, Sabon Gari, Zangon Kataf, and Kachia Local Government Areas respectively. An average rate of coverage was determined to be 103.57ha/yr for all the units with only Kaduna South emerges to breakthrough. The mode of operation of the scheme was found to be based on two approaches adapted by both commercial and governmental hiring unit. The scheme was also found to have so many challenges such as managerial competencies, poor field supervision among others.

Keywords: Hiring Scheme, Functionality, Availability, Utilization, Coverage rate

1.0 INTRODUCTION

The Nigerian agricultural sector, driven by the demand for food and cash crops production was at its center for economic growth during the 1960s, contributing 54.7% to the growth domestic product (GDP) as against 40.3% recorded between 2001 to 2009 (NBS 2010). The second decade of independence saw the emergence of the oil industry as main driver of economic growth on which Nigeria depended solely as its major source of income (Sunusi, 2010). Due to rural-urban migrations in search of opportunities in the early 1970s, there was decrease in the strength of rural labor. According to Oyejide (1986), the hired labor is now an important component of the cost structure of Nigerian farming system, since the rural labor appeared insufficient for the needed increase in food and cash crops production. Development of agriculture in Nigeria depends on the effective labor productivity.

The need to increase the level of productivity in staple food crops of savanna areas of Nigeria has long been recognized. Since 1960s, one of the key interventions of Government to increase productivity in the agricultural sector has been to make tractor hiring services available to farmers (Bida, 1978). At the states level tractor hiring services have been created for the purpose of acquiring, maintaining, and hiring out tractors to farmers at the subsidized hourly prices (Philip and Ezeh, 1988). Hamidu and Simon, (1999) reported that even though the establishment of tractor hiring services was

expected to enable farmers to access tractors and implement for various farm operations, the opportunity had not been fully exploited because of untimely availability of the tractors. Several attempts have been made to set up tractor hiring services in Nigeria and the schemes failed to have the desired impact on farmers as they failed within few years after commissioning. Therefore, this research work aimed at surveying tractor hiring services scheme in Kaduna state to access its functionality, level of utilization, level of adoption, mode of operations and why they fail, among others.

2.0 MATERIALS AND METHOD

2.1 Multi Farm Use of Agricultural Machinery

Multi Farm Use of Agricultural Machinery is the various ways employed to use machinery on more than one farm. This could either be based on contract work or mutual assistance. Contract work may be provided by either commercial undertaking or government and there may or may not be a profit. However, most of the tractor hiring services rendered in Kaduna State happened to be based on contract work.

2.2 Data Collection and Instrumentation

The study focused on the northern and southern parts of Kaduna State considering two local government areas in the northern part and three in the southern part. These parts were selected on the bases of different level of agricultural practices. The tractor hiring units were the main samples employed for this study. The data from primary and secondary sources were collected using participatory approaches. The data collection techniques which involves the use of questionnaires was use to collect information from the tractor hiring units. The information collected includes; number of tractors, number of functional tractors, kind of operations undertaken, system of tractor hiring services, problems encountered, labor cost per hectares, rate of coverage per tractor, level of patronage among others.

2.3 Data Analysis

Descriptive and inferential statistics were employed for the data analysis. The analysis involved an intensive use frequency distribution, cross tabulation, means and standard deviations, Pearson product moment correlation, percent and illustrative techniques. The average hectares covered per tractor is expressed below;

$$R_{ct} = \frac{Average\ hectares\ covered}{Number\ of\ tractors} \qquad (2)$$

R_{ct} = Average hectares covered/Number of tractors
Where: R_{ct} is the average hectares covered per tractor

3.0 RESULTS AND DISCUSSION

3.1 Available and Functional Tractors in the Various Units

Table 1 shows the data collected from the various tractor hiring units with number of available and functional tractors. Functionality and availability are two important factors that greatly affect the services rendered by tractor hiring units. The number of available tractors must be able to meet the demand of the farmers bound to it. It could be seen from the table that a total number 26 tractors were found available in the selected LGAs with total number of 21 functional tractors resulting at 81% general functionality. Sabon Gari LGA has the highest number of 9 tractors with 89% specific functionality followed by Zangon Kataf having 6 tractors with 83% functionality. Kaduna South has 5 tractors with 80% functionality while Kachia and Kaduna North have the least number

each of 3 with 67% functionality. The table also shows that the most available tractor type was found to be MASSEY FERGUSON which was available in Sabon Gari, Zangon Kataf, and Kaduna North LGAs with total number of 18 tractors. 5 STYRE type were found available in Kaduna South LGA and 3 FORD type were also found available in Kachia LGA.

3.2 Level of Utilization of the Various Tractor Hiring Units

The level of utilization of tractors in the selected areas reflected the demand of the respective tractor hiring services. For an attainable level of agricultural production, the demand and supply of tractor hiring services must be at equilibrium. For the assessment of level of utilization of the tractor hiring units, the number of hectares covered in a year of which the average hectares covered within the span of four years for each unit was determined. Table 2 shows the percentage level of utilization for which Kaduna South has 53% level of utilization, 26%, 16%, 3%, and 2% level of utilization for Sabon Gari, Zangon Kataf, Kachia and Kaduna North respectively. The result shows that the tractor hiring unit in Kaduna South is much utilized than other units. An average hectares covered from 2009 to 2012 determined for each unit to assess the level of utilization was however used to determined the rate of coverage per tractor which was found to be 289.25ha/yr , 26.5ha/yr, 69.75ha/yr, 69ha/yr and 31ha/yr for Kaduna South, Kaduna North, Sabon Gari, Zangon Kataf, and Kachia Local Government Areas respectively. An average rate of coverage was determined to be 103.57ha/yr for all the units with only Kaduna South emerges to breakthrough.

3.3 Level of Adoption and Accessibility of the Various Tractor Hiring Units

Level of adoption and accessibility determined the level of success of the various tractor hiring units. Table 3 shows the data obtained on adoption and accessibility of the various hiring units. Since both level of adoption and accessibility affect agricultural productivity, the strength of their relationship was determined using Pearson moment correlation. The analyzed result shows a correlation of 0.75 implying a strong relationship between the two indices, however signifying high yield of agricultural production.

3.4 Mode of Operation of the Tractor Hiring Units

It was determined that each of the selected units adapted one or combination of the direct and indirect approach. Direct approach is practiced by both government and private owned tractor hiring scheme. For the government owned hiring scheme farmers used to tender their request and registered their names directly with the appropriate personnel for which the request will be granted accordingly. In this case, the farmer takes the responsibility of fueling, operator, breakdowns, repair and maintenance. This enabled the farmer to use the tractor for an extra period of time equivalent to the cost incurred for the repair and maintenance services. For the private owned hiring scheme, the farmers tendered their request directly to the service provider for approval. In this case, the service provider is responsible for fueling, operator, repair and maintenance. The indirect approach involved the use of agents as intermediary persons who searches for the work in return of their commission as 10%. The owner is responsible for fueling, operator, repair and maintenance. For the two approaches the services are delivered after payment of the charges.

3.5 Challenges of Tractor Hiring Scheme

Some of the challenges of the schemes are; poor maintenance culture: tractor owners often wait for tractors to breakdown before maintenance is done instead of carrying periodic maintenance, none payment of charges after the operation, lack of

managerial competencies: most of the time the tractor hiring units lack proper organizational planning and management, efficiency: the private tractor hiring unit has been discovered to be more efficient than government owned hiring unit because of poor charging and funding policy which led to the failure of the scheme, poor supervision: tractor operators and other field staffs indulge in dubious activity that affect the smooth running of the scheme, scattered and fragmented farm land: operators do not find it easy to work on this type of land as more cost will be incurred due to amount of fuel to be consumed in moving from one farm to another.

4. CONCLUSION

In conclusion, the results showed that, in the selected areas the schemes have a total number of 26 tractors with 81% functionality. Sabon gari L. G. A was found to have the highest number of 9 tractors while Kaduna North and Kachia L. G. A have the lowest number each of 3 tractors. It can also be concluded that tractor hiring unit in Kaduna South is best utilized with 53% level of utilization and Kaduna North is poorly utilized with only 2% level of utilization. The result shows that the tractor hiring unit in Kaduna South is much utilized than other units. An average hectares covered from 2009 to 2012 were determined for each unit to assess the level of utilization and however, the rate of coverage per tractor was found to be 289.25ha/yr , 26.5ha/yr, 69.75ha/yr, 69ha/yr and 31ha/yr for Kaduna South, Kaduna North, Sabon Gari, Zangon Kataf, and Kachia Local Government Areas respectively. An average rate of coverage was determined to be 103.57ha/yr for all the units with only Kaduna South emerges to breakthrough. However, the strength of the relationship between level of adoption and accessibility of the various tractor hiring units which was determined using Pearson moment correlation indicated a correlation of 0.75 implying a strong relationship between the two indices. The mode of operation of the scheme was found to be based on two approaches adapted by both commercial and governmental hiring unit. The scheme was also found to have so many challenges such as managerial competencies, poor field supervision among others.

REFERENCES:

Bida, N. M., (1978), A Study of Tractor Hiring Services in Kaduna State, Unpublished B. Eng Project, Department of Agricultural Engineering, Ahmadu Bello University, Zaria.

Hamidu, B. M., and Simon D.U., (1999), Comparative Analysis of Tractor and Non Tractor Farm Operations among Rice Farmers in Bauchi Local Government Area, Bauchi State, Proceedings of Annual Conference of the Nigerian Institute of Agricultural Engineers, 21: 222-271

NBS (2010), National Bureau of Statistics, 2010 Issue

Oyejide, T. A., (1986), The Effects of Trade and Exchange Rate Policies on Agriculture in Nigeria, Research Report 55, International Food Policy Research Institute, Washington DC, USA (E)

Philip, D. O., and Ezeh C. C. (1988), Operation of Tractor Hiring Unit in Nigeria, Lesson From Kaduna State, Nigerian Journal of Agricultural Extension, 5 (1)

Sunusi, L. S. (2010), Growth Prospects for the Nigerian Economy, A Convocation

Lecture Delivered at the Igbinedion University, Eighth Convocation Ceremony, Okada, Edo State, November, 26, 2010.

Table 1: Number Of Available And Functional Tractors With Their Types

LGAs	NAT	TAT	NFT	%NFT
Kaduna South	5	STYRE	4	80
Sabon Gari	9	MASSEY F	8	89
Zangon Kataf	6	MASSEY F	5	83
Kachia	3	FORD	2	67
Kaduna North	3	MASSEY F	2	67
Total	26		21	

Where: NAT = Number of available tractors, TAT = Type of available tractors, NFT = Number of functional tractors

Table 2: Hectares Covered and Level of Utilization of Tractor Hiring Services

LGAs	HC 2009	HC 2010	HC 2011	HC 2012	THC	AHC	%LU
Kaduna South	786	940	1650	1250	4626	1157	53
Sabon Gari	550	400	600	680	2230	558	26
Zangon Kataf	220	360	400	400	1380	345	16
Kachia	-	70	66	50	186	62	3
Kaduna North	45	50	50	60	211	53	2
Total						2175	

Where: HC = Hectares covered, THC = Total hectares covered, AHC = Average hectares covered, %LU = Percentage level of utilization

Table 3: Data for Correlating Levels of Adoption and Accessibility

LGAs	Level of adoption (X)	Level of accessibility (Y)
Kaduna South	80	80
Sabon Gari	50	80
Zangon Kataf	50	50
Kachia	25	50
Kaduna North	25	50
Total	230	310

DEVELOPMENT OF A ROTARY POWER WEEDER FOR SMALL AND MEDIUM SCALE FARMERS.

Muhammed, U. S., M. Abdulsalam and A. Abdullahi
Agricultural Engineering Department, Ahmadu Bello University, Zaria.
Correspondent: daniyasalam@yahoo.co.uk, 08036052632

ABSTRACT
Weed control is one of the most difficult tasks in agriculture that accounts for a considerable share of the cost involved in agricultural production. A rotary weeder is designed and constructed. It consists of the weeding tines, powered wheel, sprocket and chain transmission system, the handle and the frame. The performance of the weeder was evaluated using the following performance indicators; weeding efficiency, fuel consumption and field capacity in the performances indices at various Engine speeds (1804, 2004, 2265, 2407 and 3236 rpm). The results were compared with the existing weeder. The results showed that maximum field efficiency and field capacity were at Engine speeds of (2407rpm and 3236rpm) respectively. While minimum fuel consumption was at Engine speed of 1804rpm. The optimum operation condition was at Engine speed of 2407rpm with corresponding field efficiency, field capacity and fuel consumption of 63.73% ,0.23ha/hr and 0.94l/hr respectively. The machine had a higher field capacity and weeding efficiency than the existing weeder.

1.0 INTRODUCTION

Weed growth is a major problem for dry land crops particularly oil seed crops and mustard causing a considerable reduction in yield. Weed control is as old as farming itself. However, progress in mechanized weed management did not begin until the early eighteenth century, when Jethro Tull led by cultivation. (Encarta encyclopedia, 2011). In the absence of an effective control measure weeds remove 30 to 40% of applied nutrients resulting in significant yield reduction (Dryden and krishnamurthy, 1997). Delay and negligence in weeding operation affects the crop yield and the loss of crop yield due to weeds which amount to about 16 to 42% reduction every year in Nigeria (Ragasamy et.al., 1993).

Mechanical weed control is very effective as it helps to reduce drudgery involved in manual weeding. It kills the weeds and also keeps the soil surface loose ensuring soil aeration and water intake capacity. Weeding is an important but equally labour intensive agricultural unit operation.

Weeds are resilient and sometimes require more than one method for effective control.

Manual weeding is common in Africa particularly in Nigeria where about 75% of the population engaged in farming. This method is labour intensive and is one of the major problems of farming in Nigeria. Weed management has undergone a great deal of change overtime. For this purpose, weed control methods are according to (Hunt, 1983) classified as indigenous and modern methods. The indigenous method involves all the indigenous techniques that employ simple hand tools as well as the hand picking weeding techniques. The hand picking technique entails the process of the farmer removing the weeds by holding the weed plant and applying force to pull it out from the soil where it is growing. The act of applying force to detach the weed leaves holes on the spots formally occupied by the weeds, these holes has the negative effect of disturbing the soil structure on the farm and this can provides points where erosion can pick up.

Tiwari (1988) described the hand tools used as sickle and hand hoes. The sickle is design in such a way that it will have a curved blade which will make it possible for the farmer to cut a bunch of weeds in a single cut. While the hand hoe is a locally made implement which is employed for weeding among other things which it is used for that includes land preparation, planting and harvesting operations. The weeding process of the hoe involves cutting weeds along with the soil it grows on. The farmer usually needs to shake off the soil that comes along with the weed. However, above methods of weed control are labour intensive, and time, energy and capital consuming.

The mechanical weed control devices (weeder) are usually attached behind a tractor or farm animal dragged to dislodges weeds. For centuries, farmers have pulled weeds by hand or used hoes to cut them from the ground. Mowing machines are more efficient for large-scale weed control. These machines remove the weeds' leaves, the photosynthetic organs that provide the plants with a steady supply of carbohydrates. Repeated mowing gradually depletes the carbohydrate supply, so that the weed is unable to produce new leaves and eventually dies. (Encarta encyclopedia, 2011). Mowing kills existing shoot growth but mowed plants can produce additional flushes of shoot material. Repeated mowing not only prevents seed production of perennial weeds, but may also starve the underground parts. Cutting the leaves removes the food (photosynthesis) producing organs. Secondly, the re-growth stimulated by the cutting draws on the stored food reserves. Mowing for harvest and maintenance of hay, pastures, turf and cover crops help eliminate the tall growing weeds. Crop plants grown in this situation are adapted to mowing and the cutting favors them over non adapted weeds. As is generally the case, combination of mowing with competitive crop is more effective for weed suppression than either element alone.

Development of a rotary power row crop weeder is a viable option in order to ensure sustainable crop production and optimum environmental conditions. A pair of work bulls or any other trailed animal pulls the implement for the weeding operation, the tines rotate on either side of the ridge, digging the soil and removing the weeds. The implement has sitting position where the operator sits and controls the movement and direction of travel of the hitching animal pair. For maximum work efficiency, it is suggested that the elbow flexon angle would be 85 to 110 degrees (Grandjean, 1988). For push pull operation of a machine, the elbow flexon angle would be 90 degrees (Tiwari, 1985) and the optimum holding height for male is 630-677mm and that of female is 534-630mm (Tiwari et. al. 2007). As the time period available for weeding is limited, improved mechanical weeders are to be used to complete the weeding operation in due time at less cost. The Straddle rotary weeder consists of two parts of rotary hoes mounted on a Straddling tool bar. This arrangement which straddles the ridge provides clearance for tall crops up to a crop height of 1m, beyond which usually no weeding is necessary. The implement can be adapted for different ridge configuration, spacing and size by adjusting the tines spacing and angle of sweep along the direction of travel. The inclination of the ridge profile conforms to the angle of repose of the ridge, its alignment being such that the amount of weeds removed is maximized. In using this implement the operator suffers less fatigue when compared with other animal drawn implements because in this case the farmer is sitting comfortably on the implement. The Animal-drawn Straddle row rotary weeder has a draft force of 91.35N. It has a working capacity of 1.46ha/hr when operated on a clay loam soil with an average moisture content of 12.73%. The Straddle weeder has a weeding efficiency of 70%, weeding index of 87.71% and plant damage of 9.32%.

The Animal-drawn Emcott rotary weeder, with its' rotary weeder attachment, is inter-row in its operation. It consists of a pair of rotary hoes mounted on the rear of the ridging body, each of the two hoes weeding on half of the adjacent ridges. The rotary

ridging share clears the weeds on the furrow bottom while the gangs rotate on both sides of the furrow digging up the soil and removing the weeds as they rotate. The implement is also powered by a pair of the work bulls or any other draught animal. Bulls pull the implement with a draft force of 88.90N.

The design of the four wheel row weeder starts with the cutting edge. The cutting edge is the point where steel meets the soil and weeds. The weeding operation is mostly achieved during the forward travel of the machine, as the vee-shape blades point in the direction of travel and the blades exert force on the weeds by cutting and shearing effect as the wheel rolls. It has an average draft force of about 43.86N. However, farming business is majorly done in small scale in Nigeria. This work was targeted to meet the need of small scales farm holders. The specific objective of this work is to develop a rotary power weeder and evaluate the performance of the prototype weeding machine.

2.0 METHODOLOGY

2.1 Design Considerations and Materials Selection

The design parameters considered are the ease of operations, machine and plant factors which include:
Average walking speed of the operator (0.5m/s)
The energy requirement of the machine
Length of tines and the minimum speed of its rotation
Types of weeds to be operated upon
The machine is to be operated within furrow or flat field only.

The material used for the frame and the shaft is mild steel; this material was chosen because of its availability, low cost as compared to other construction materials. It can also be cut and turned into required shapes with ease as compared to high carbon steels and other materials. Specifically, round iron of mild steel (C1040) was used for the shaft. The selection of chain depends on the length, no. of links and properties of the chain material. The length and size properties consideration is based on the power to be transmitted and speed ratio etc. In this design, chain and sprocket linkages which prevent slippage are selected. Sprockets usually are made either of case semi steel, cast iron or pressed steel. A pair of sprocket with pitch of 0.04mm, tooth length of 0.03mm and Number of teeth for the drive and driven of 42 teeth were chosen to give a speed ratio of 1:1.

2.2 Design Parameters and Calculations

2.2.1 Width of the frame

The machine is to operate within furrow. Thus it should be equal to or less than the minimum width of furrow according to cultural practices. This minimum width is between the ranges of 25- 40cm. (Olukunle et al., 2006). The width and the length of the frame could be much less than the designed values but extra allowances were considered to accommodate the rotation of the tines and to avoid the accumulation of weeds beneath the rotary weeder.

2.2.2 Length of the weeding tines

Each hoe consists of twelve tines of equal lengths determined as follows:
Considering sector ABC, length of arc AB which forms the curved tines may be calculated as
$AB = (\theta_1 - \theta_2) + 2\pi r\theta/360$ (mm) (Hunt, 1983)

= 171 mm
Where,

r = 3R/5 = radius of curvature:
R = outer wheel radius, mm:
$O = 90^0$
O_1 = outer wheel diameter, mm
O_2 = Disk hole diameter, mm

The determination of the length is shown explicitly in appendix A.

2.2.3 Width of the weeding equipment

It is essential that the width of the rotary weeder be smaller than the space between consecutive ridges so that the weeder can be easily operated within the furrows.

2.2.4 Length of the handle bar

The length of the handle bar was chosen to be at least 3/4 times the length of the flat bar connecting the front and the edge of the machine (Olawole and Philip, 2006) as this does not affect the overall maneuverability of the weeder.

2.3 Design of the Shafts

2.3.1 Strength of the shaft material

The Association of Society of Metallurgical Engineers (ASME 1948) gave the yield stress and tensile stress for mild steel C1040 as 580 MN/m^2 and 770MN/m^2 respectively. Using ASME code for steel which gives the allowable stress, S_a as the lower value of 18% S_{ut} and 30% S_{yt}. The allowable stress is further reduced by 25% when there is stress concentration due to a keyway in the shaft. Thus:
$0.30S_{yt} = 0.30\,(580) = 174MN/m^2$
$0.18S_{ut} = 0.18(770) = 103.95MN/m^2$
The lower value of the above is $103.95MN/m^2$.
We then consider the smaller value to be the allowable shear stress of the material i.e. $103.95MN/m^2$. When considering the keyway, the allowable shearing stress is further reduced by 25%. i.e. $103.95(1-0.25)\ MN/m^2 = 77.96 \times 10^3\ kN/m^2$.

2.3.2 The shaft diameter calculations

Maximum shearing stress of a solid round bar subjected to steady combined static bending and torsion is given by Deutsman et al., 1975 as:

$$\tau_{max} = 16/\pi D^3 \sqrt{(K_m M)^2 + (K_t T)^2} \quad \text{.....(2.1)}$$

$$D = [16/\pi S_a \sqrt{(K_m M)^2 + (K_t T)^2}\,]^{1/3} \quad \text{.....(2.2)}$$

Where;

τ_{max} = maximum shearing stress (kN/m^2)
D = Diameter of the shaft (m)
K_m = shock factor
K_t = fatigue factor
T = Torsional moment (kNm).
M = Bending moment (kNm)

In the design for shaft diameter, the maximum shearing stress, τ_{max} is replaced by allowable shearing stress, and then making D as the subject of the equation as shown below:

$$d_0^3 = [16/\pi \times 103.95 \times 10^6 \sqrt{(1.5 \times 0.331)^2 + (1.0 \times 0.0047)^2}$$
$$d_0^3 = 4.899 \times 10^{-8} \quad \sqrt{0.2465}$$
$$d_0^3 = 2.432 \times 10^{-3}$$
$$d_0 = 28.97\text{mm}$$

2.4 Power Requirement for the Machine

2.4.1 Power requirement for weed removal

The power requirement to turn the soil for weed removal is by using the following equations as given by Liljedah et al., 1979

$$P_w = \frac{SR \times d \times w \times v}{75} \quad \ldots\ldots\ldots (2.3)$$

$$\text{Power required} = \frac{SR \times d \times w \times v}{75} = \frac{1.06 \times 5 \times 50 \times 1\text{m/s}}{75} = 3.5\text{hp}$$

$$3.5\text{hp} \times 0.746\text{kW} = 2.611\text{kW}$$

Where;

S_R = soil resistance, kN/m^2
d = depth of cut, cm
w = effective width of cut, cm
v = linear velocity of the tine at the point of contact with the soil.

2.4.2 Power requirement to move the machine on the field without weeding

This can be estimated using the following equations given by (Witney, 1988).

$$P_m = DV \quad \ldots\ldots\ldots (2.4)$$
$$\text{But } D = H_a - R \quad \ldots\ldots\ldots (2.5)$$
$$H_a = H_m [1 - \frac{k}{sl}(1 - e^{-sl/k})] \quad \ldots\ldots\ldots (2.6)$$
$$\tau = c + \delta \tan \phi \quad \ldots\ldots\ldots (2.7)$$
$$H_m = \tau A \quad \ldots\ldots\ldots (2.8)$$

$$H_a = H_m [1 - \frac{k}{sl}(1 - e^{-sl/k})]$$
$$H_a = 0.284 [1 - \frac{0.06}{0.05(0.28)}(1 - e^{-0.05(0.28)/0.06})]$$
$$H_a = 0.284 [1 - \frac{0.06}{0.014}(1 - e^{-0.014/0.06})]$$
$$H_a = 0.284 [1 - 4.286(1 - e^{-0.233})]$$
$$H_a = 0.031\text{kN}$$

$$P_m = DV$$
$$= 0.031 \times 0.5$$
$$= 0.0155\text{kW}$$

Where,

P_m = Power required to move the machine on the field (kW)
D = Draft required to move the machine on the field (kN)
V = Operation forward speed (m/s)
D = Draft required to move the machine on the field (kN)
H_a = Actual thrust of the traction wheel (kN/m^2)
R = Rolling resistance (assumed to be zero i.e. R=0)

Therefore, D = H
But D = H_a
H_m = Maximum Thrust (kN)

H_a = Actual thrust of the traction wheel (kN)
k = soil deformation modulus (6cm)
s = wheel slip (5%)
l = contact wheel length

Where,

τ = soil shearing stress (kN/m^2)
A = wheel contact area (m^2)
c= soil cohesion (kN/m^2)
δ= weight of the machine (kN)
Φ= angle of internal friction of the soil (degrees)

Therefore, the power required to move the machine on the field without weeding is 0.0155kW.

2.4.3 The total power required for the machine

The total power required is estimated as;

Pt = pw/η= 3.5/0.80 = 4.375˜ 5hp. or 3.73kW

Where,

P_w = Power required to turn the soil for weed removal
η= Transmission efficiency

2.5 Performance Evaluation of the Machine

The materials used for the field investigation were tachometer for measuring speed in revolution per minute of the shaft during operation, core samplers for determining soil moisture content, measuring tapes for measuring the field dimension a 0.3m x 0.3m square frame for measuring weeds density of the given dimensions, oven for the soil moisture analysis, stop watch. The Soil Parameter Measured are the soil moisture content which was determined using gravimetric method stated below. As in accordance to Henderson et al (Collins, 1976).

Mc = Mw/Md x 100 (%) …….. (2.9)

Where:

Mc = soil moisture content (%)
M_w = weight of moisture (g)
M_d = weight of dry soil (g)

Three parameters were tested against the working efficiency of the machine: the speed of the machine against weeding efficiency so as to determine the optimum weeding speed, the moisture content of the soil against the weeding efficiency and the weed density against the cutting efficiency. The experiments were carried out at the trial field behind the Agricultural Engineering Department. The experimental area was infested mostly with weeds like *Trifolium repens* (clover). Three such determinations were made for each experimental unit.

The field investigations were carried out to assess the performance of the rotary weeder under field conditions.

2.5.1 Determination of the effect of speed on the weeding efficiency

The machine was run at five different speeds on the selected furrowed area. The speeds of the weeding tines in revolutions per minute were recorded using a tachometer. The operator forward speeds remain constant as possible. In each case after weeding through a furrow of 10m length the samples were taken from the three speeds by randomly throwing a square frame at three locations on the weeded furrow. The total number of grasses weeded within the frame was determined. The efficiency of weeding and the measured speed of the weeding tines were recorded as shown in table 3.1.

The efficiency of weeding is given as:

Ew = Number of grasses weeded/Total number of grasses X 100 ……. (2.10)

2.5.2 Weed density against the weeding efficiency

The number of weeds is obtained by counting the number of weeds circumscribed by the walls of the quadrant measuring 30cm x 30cm. Data was collected such that the quadrant was randomly thrown ten times and data on the number of weeds inside the quadrant. The average of these data collected immediately after the first and the second weeding were recorded. The weed density was then calculated using the formular (Vallurupalli, 1983):

Weed density (No. /m^2) = No of weeds in Quadrant/Area of Quadrant …… (2.11)
The performance evaluation of the machine was based on the following parameters;

2.5.3 Field capacity of the machine

This is a measure of the area covered by the weeder per total time of effective operation. Field capacity is measured in units of Ha/hr. The effective row width covered by the weeder was measured and the total time of operation also recorded.
Field capacity (Fc) = Area/Time ……. (2.12)

The actual field capacity was obtained by measuring an area of 1m^2 and the length of the time taken by the weeder to completely weed the area was measured and recorded.

2.5.4 Determination of fuel consumption in relation to the engine-speed

The fuel consumption of the weeder for five different speeds are noted and recorded. The tank capacity of the prime mover is 4 litres, to determine the fuel consumption the tank was filled to the brim and the machine was run at the first speed for a given distance. The machine was stopped and the fuel tank is filled again using a graduated container; the quantity was recorded. Similar runs were carried out for the next four speeds and the fuel consumptions were recorded.

3.0 RESULT AND DISCUSSION

This was determined by counting the number of weeds before and after using the developed weeder on the 3 blocks (replicated three times). Detail records are presented in Table 3.1below. From the result recorded in this table, it is obvious that higher engine speed leads to higher weeding efficiency. For the relationship between forward speed and weeding efficiency, it was observed that operating the weeder at higher speeds above 0.8 m/s was characterized with rough weeding. 2265 rpm was ideal speed for this weeder as shown in Figure 3.1. Figure 3.1 shows the effect of speed of the machine on the weeding efficiency of the prototype machine. The weeding efficiency which may be defined as given in equation 2.1. From figure 3.1, we can see that the weeding efficiency increases with increasing speed of the machine up to the optimum speed of the machine. Therefore the speed of the tines had an effect on the weeding efficiency. The field capacity of the power weeder at various levels of speed was observed to range from 0.162 ha/hr and 0.274 ha/hr as shown in Figure 3.2. From this figure, the field capacity increases with increase in the engine speed. The highest field capacity recorded was 0.36 ha/hr at 3236 rpm of engine speed and the least field capacity was 0.162 ha/hr at 1804 rpm of engine speed. Figure 3.3 shows effect of weed density on the efficiency of the machine performances. The weeding efficiency increases with increase in the weeds density as shown in figure 3.3. in this study the highest weeding efficiency recorded was 73.36 % at 12058 no/m^2 weed density. Also the least efficiency 55 % was recorded when the weed

density was 6211 no/m^2 which marks the least weed density in this study. The economic performance of the machine was observed satisfactory, from the table 3.1 it is observed that the machine takes only 1.2 liter of petrol to weed 0.35 ha (3500 m^2). The figure 3.4 shows the relationship between the fuel consumption and the engine speed. From this figure it is obvious that the machine fuel consumption increases with an increase in the engine speed as shown in figure 3.4.

4.0 CONCLUSIONS

The prototype weeder had been developed, constructed and evaluated. The results show that the weeder has great potential on weeding operations for variety of weeds around, specifically in Northern Guinea Savanna of Nigerian. From the results obtained, the following conclusions can be drawn:

a. There exists a linear relationship between the weeding efficiency and the engine speed.
b. The weeder has fuel consumption within the range of 0.62l/hr and 1.2l/hr based upon the engine
c. speed during the weeding operation.
d. The values of the field capacity of the weeder (0.162ha/hr, 0.192ha/hr, 0.23ha/hr,0.23 ha/hr,0.35ha/hr) and weeding efficiency (55%,57.93%, 59%, 63.73% ,73.36%) all depends on the weeder speed, weed density and the resistance offered by the soil to the weeding process.

REFERENCES

B. Witney (1988). Choosing and Using Farm Machines. 1st Edition. Longman Scientific and Technical, Longman House, Burn Mill, Harlow Essex CM 20 2JE, England.

Dryden, R.D. and C.H. Krishnamurthy. 1977. Year round Tillage, Indian Journal of weed Science, (9) 14-18

Grandjean, E. 1988. Fitting the task to the Man. Taylor and Francis, London.

Henderson, B.P. and C.H Wilkes (1976). Farm Machinery and Equipment. 6th Edition, Mc Graw- Hill Book Company, New York.

Hunt, R.P, and L.W. Garner (1973), Farm Machinery Mechanisms. The Iowa State University Press, Ames, Iowa.

Microsoft Encarta Encyclopedia, 2011

Olawole O.J and Philip 2005. Optimisation of primary and secondary Tillage operations. Unpublished M.Eng Thesis, Department of Agricultural Engineering, federal university of Technology, Akure.

Olukunle O.J. 2006. Appraisal Row crop Weedder. Unpublished Lecture Manual, Depaartment of k2Agricultural Engineering, Federal University of Technology, Akure.

Rangasamy, K. Balasubramaniam, M and Swaminuthan, K.R. 1993. Evaluation of power weeder performance. AMA 24 (4)16-18.

Tiwari V.K., R Ailavadi, K.N. Dewangan and S Sharangi. 2007. Rationalised database of Indian Agricultural Workers for Equipment Design. Agricultural Engineering International: the CIGR Ejournal. Manual script MES 05 004, VOL. IX. August 2007.

Liljedah, J. B., Carleton, P. K. and Smith, D. W. (1979). Tractor and their Power Units. 3rd Edition. John Wiley and Sons. New York.

Table 3.1: Results Obtained During Performance Evaluation Of The Machine.

Engine speed (rpm)	Efficiency (%)	Field capacity (ha/hr)	Weed density (No./m^2)	Fuel Consumption (l/hr)
1804	55.00	0.162	6211	0.62
2004	58.03	0.173	6896	0.77
2265	59.03	0.23	7781	0.83
2407	63.73	0.28	8373	0.94
3236	73.36	0.35	12058	1.2

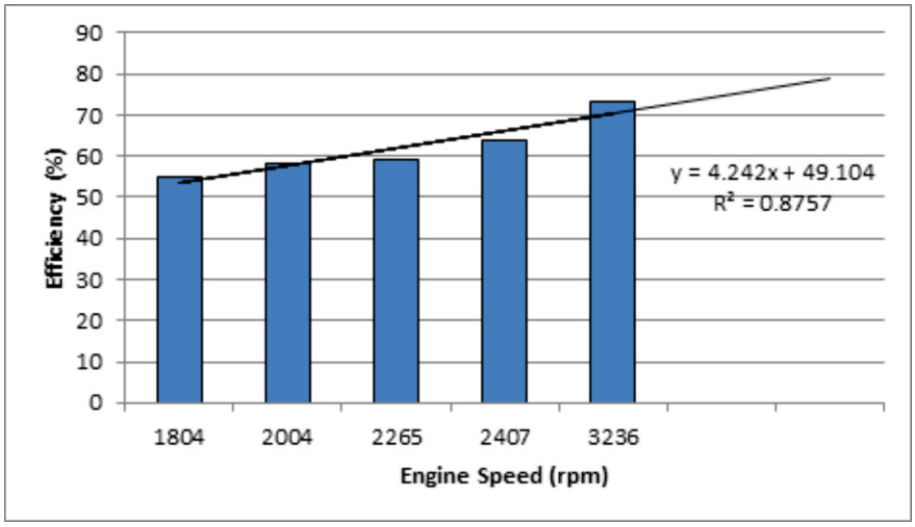


Figure 3.1 Effect Of Speed On The Weeding Efficiency Of The Prototype Machine

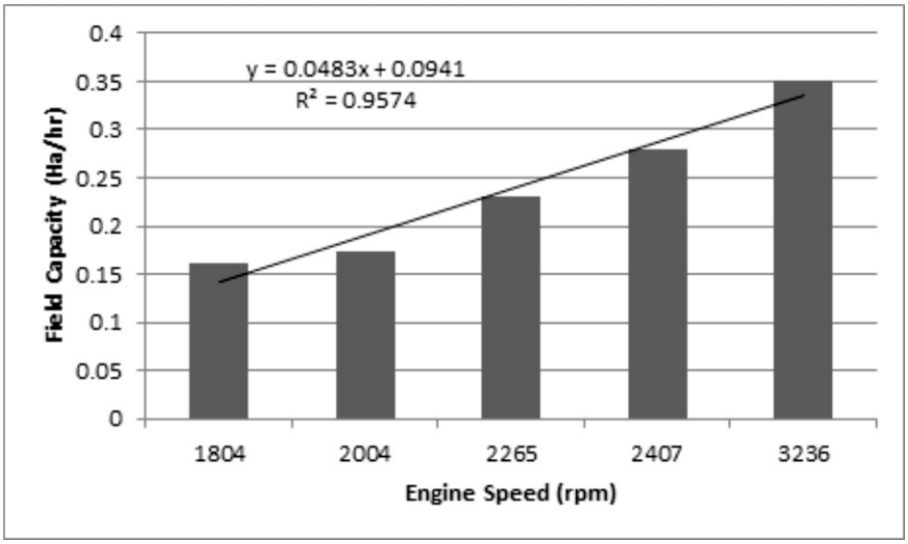


Figure 3.2 Effect Of Field Capacity Against Machine Speed

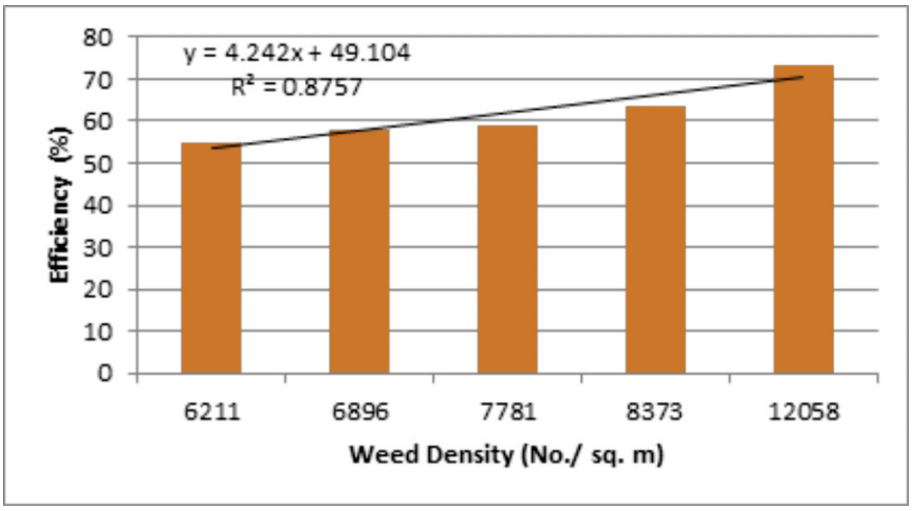


Figure 3.3 Effect of Weed Density on the Machine Efficiency

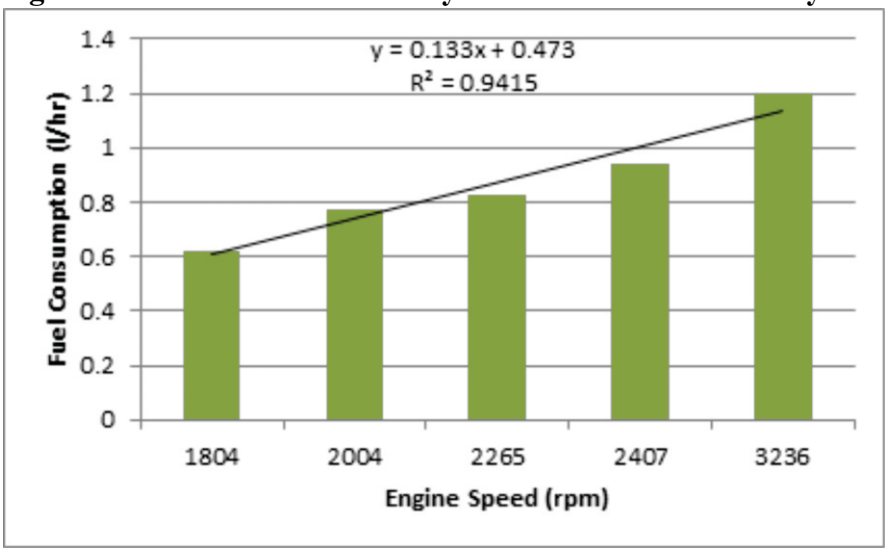


Figure 3.4 Relationship Between The Fuel Consumption And Engine Speed

SOME CHALLENGES IN THE MECHANISATION OF MANGO HARVESTING IN NIGERIA

***E.O. Atanda, *P.A Imanogor and **R.O. Akinbamowo**
*Department of Agricultural & Bio-Environmental Engineering Technology, School of Engineering, Auchi Polytechnic, P.M.B. 13, Auchi, Edo State, Nigeria. e-mail: olugbenga.atanda@yahoo.com; imanogorpa@yahoo.com
**Ondo State Ministry of Agriculture, Akure, Ondo State, Nigeria.
e-mail:akinba@yahoo.com

ABSTRACT
The demand for fruits like mango, orange, cashew, etc have been on the increase due to their domestic and ever-increasing industrial potentials. Fruits are highly perishable and utmost care must be taken in handling them at harvest and processing to reduce postharvest losses. Harvesting is one of the most important activities affecting postharvest life of a fruit like mango. In Nigeria, harvesting of mango is mostly carried out manually and this consumes more time and labour. This manual method of harvesting often results in injury to the epicarp thereby making it more susceptible to attack by spoilage agents with consequent reduction in consumer demand in the market. The need for the mechanization of mango production especially harvesting cannot be over-emphasized in view of the non- availability of a commercial harvester for mango in Nigeria. This paper, therefore, reviewed some challenges in the mechanization of mango harvesting in Nigeria. To achieve this objective, the present status of mango harvesting in Nigeria was discussed. Some related literatures on the mechanization of mango harvesting are also discussed while some challenges militating against successful mechanization of mango harvesting in Nigeria were identified and discussed. Some recommendations aimed at enhancing successful mechanization of mango harvesting in Nigeria are also presented for adoption by all the stakeholders towards development of a mango harvester.

Keywords: Mango, Mango Harvester, Mechanization, Harvesting, Nigeria.

1. INTRODUCTION

Mango (*mangifera indica*) is one of the commonest and heavily consumed tropical fruits in Nigeria. It is a good source of Vitamin C. Mango is grown in Nigeria mainly by the peasant farmers in virtually all the agro-ecological zones for a reasonably longer part of the year due to the diverse agro-climatic conditions suitable for the production of different varieties of mango. The important varieties of mango grown in Nigeria include Aphonso, Julie, Palmer, Zill, Edwards, Haden, Saigon, Keitt and early Gold (Adeyemi, 1988). Data on mango fruits produced annually in all the six agro-ecological zones in Nigeria are not available but worldwide output of about 33 million tons in 2008 has been reported by Sauco (2013). Currently, the leading exporters are Mexico, Brazil, Pakistan, Peru and India.

In Nigeria, the benefits of harvesting, processing and utilization of fruits like mango, cashew, and orange etc are related essentially to their dietary, medicinal, industrial and export potentials. They are also excellent sources of raw materials for our agro- industrial

markets. After harvest, fruits like mango, cashew, orange, etc undergo chemical changes and may also undergo spoilage by bacteria, yeast and fungi. Typical changes show up in texture, colour and flavour as well as respiratory activities. The major causes of wastage in fruits like mango, cashew, orange, etc are directly related to mechanical, physiological or microbial damage or insect attack. All these factors are inter-related (Kordylas, 1990). Severe bruising of mango, orange; during manual harvesting leads to tissue breakdown at the point of injury. This physiological injury leads eventually to rotting by microbial action (Kordylas, 1990 and Atanda, 2006).

Over the years, mango production in most rural areas of Nigeria has been on the increase as a result of its nutritional quality and the income it provides to many people when they sell the produce during the season. Mango, being a seasonal produce also create a glut during the season and become scarce during the off-season due to lack of appropriate processing methods and storage facilities in Nigeria. Mango production especially harvesting is mostly carried out manually, which consumes more time and labour particularly if large quantities of mangoes are to be harvested. In addition, the need for proper handling of mango at harvest is not given proper attention in Nigeria as mango harvested manually results in rough handling leading to severe damage and losses to the mango farmers with consequent reduction in consumer appeal in the market.

Moreover, little or no research work has been carried out on the mechanization of mango harvesting in Nigeria. Presently, there is no commercially available mango harvester in Nigeria due to some challenges in the path of developing a suitable harvester for mango in Nigeria. A concerted effort of all the stakeholders like the Mango farmers, Agricultural Engineers, Food Technologist, Plant Scientists, Crop breeders, Mango processors, Educational and Research institutions, Federal and State Ministries of Agriculture and Rural Development including local government councils is therefore necessary to make appreciable contribution and progress in this direction as mechanical harvesters are expected to result in the availability of higher quantity and quality produce preparatory to processing as compared to manual harvesting.

This paper, therefore, examines some challenges in the mechanization of mango harvesting in Nigeria. To accomplish this objective, the present status of mango harvesting in Nigeria was reviewed. Some related literatures on the mechanization of mango harvesting are reviewed while some challenges militating against successful mechanization of mango harvesting in Nigeria are identified. Some recommendations aimed at enhancing successful mechanization of mango harvesting in Nigeria are also presented for meaningful adoption by all the stakeholders towards increased mango production, processing and utilization.

2. THE PRESENT STATUS OF MANGO HARVESTING IN NIGERIA

Fruits and vegetables undergo two types of processes: (i) the constructive building of new tissue and the storing of reserve nutrients, and (ii) a destructive breaking down of carbohydrates during respiration (Kordylas, 1990). Both of these activities are promoted by enzymes contained within the crop tissue (Kordylas, 1990). During rapid growth, the constructive build up processes overtake the destructive loses of respiration. At maturity, an equilibrium point is reached. This is the point at which fruits and vegetables are at their best form and should be harvested (Kordylas, 1990).

Harvesting of mango is still being carried out manually in all the six agro-ecological zones where they are grown in Nigeria. Commonly, a long pole or bamboo stick is used to pluck the mango on branches of trees. This method may be adequate for short mango trees up to 15metres height but becomes inadequate as tree height increases. Other means of reaching the mangoes are by means of ladders or climbing the trees.

times throw sticks and stones on very high mango tree branches. Such harvested mangoes are eaten raw since sticks or stones thrown present bruises on the epicarp of mango plucked through this method.

The practice of harvesting mango by shaking the trees and branches so that the fruits drop freely on the ground frequently results in cuts and bruises. It also renders the mango more susceptible to physiological and pathological damage. Other effects associated with this method of harvesting include high labour and energy requirement, endangering of the lives of the harvesters, drudgery and damage to tree branches.

3. SOME RELATED LITERATURES ON THE MECHANISATION OF MANGO HARVESTING

The traditional manual harvesting of mango is time and labour intensive. In order to overcome these difficulties, three models of improved mango harvesting devices namely : impact type, shear type and impact-cum-shear type were developed by Sapowadia et al., (2001) as shown in Figures 1, 2 & 3. Their performance in comparison to the traditional devices as shown in Figure 4 was evaluated. The impact type model was found to be the best among the three models with improved harvesting capacity, cost efficiency and less damage to the fruits. On the other hand, the shear type model could not work due to the fibrous nature of pedicle of the kesar variety of mango. With the use of impact type model, harvesting capacity could be increased by 18% and visible damage to the mango fruit was reduced by 50% (Sapowadia et al., 2001).

In order to reduce losses sustained during harvesting of mango and to maintain fruit quality, a tractor-mounted positioner as shown in Figure 5 was developed by Gupta et al., (2004) for mango harvesting at the Sagadividi farm of the Gujarat Agricultural University, Junagadh Campus, India. During operation (as shown in Figures 6 &7), it was observed that using the positioner for harvesting only the mature fruits with stalk of 10-20mm length without sap burns and any other damage to the fruits could be harvested. White layer (bloom), which is desirable from quality point of view was also maintained. Though the work output was slightly reduced, over all economics was in favour of the use of the positioner for harvesting as compared to the traditional picker. Using a positioner in orchards can save about 1,000 Rupees per tree in a good season in India.

Risvy and Thanaraj (2011), compared the performance of different mango harvesting devices in Eastern University, Sri Lanka. The harvesting techniques such as improved mango harvester, picking poles and hand picking were taken to the selected testing area and mangoes were harvested in a particular period from different mango varieties like Willard, Karutha Columban and Vellai Columban. Then the harvesting rate and post harvest losses were compared in each technique with different varieties. Harvesting performance was high in improved mango harvester in all tested mango varieties (270 mangoes in Williard, 188 and 196 mangoes in Karutha Columban and Vellai Columban, respectively). The lowest harvesting performance was observed in hand picking in all varieties (170 mangoes in Willard, 130 and 130 mangoes in Karutha Columban and Vellai Columban respectively). Higher harvesting performance was observed in Willard mango tree in all tested mango harvesting devices (270, 220 and 170 mangoes in improved harvesting device, picking pole and hand picking respectively). Harvesting performance in Karutha Columban and Vellai Columban mango trees were almost the same in all tested harvesting devices. Harvest and postharvest losses of mango were minimum in improved mango harvesting technique when compared to other techniques.

4. SOME CHALLENGES MILITATING AGAINST SUCCESSFUL MECHANIZATION OF MANGO HARVESTING IN NIGERIA

The followings are some challenges that make research into the mechanization of mango harvesting difficult in Nigeria:

- ✓ The structure and morphology of the mango tree.
- ✓ Irregular maturity period of mango differs from one variety to another variety.
- ✓ Difficulty in designing for the mechanical properties of mango which can be exploited for selective harvesting such as resistance to pressure and strength of the attachment point to the fruit tree.
- ✓ Inadequate fund to carry out research into mechanization of mango harvesting by research and educational institutions in Nigeria.
- ✓ Lack of collaboration between all the stakeholders like the farmers, researchers and processors involved in harvesting, processing and storage of mango fruits.
- ✓ Non-availability of processing machines and storage structures in the rural areas where mangoes are produced extensively due to the absence of infrastructures such as electricity, water, etc.
- ✓ Bad roads linking most rural areas in Nigeria where mangoes are produced abundantly contribute to lack of interest by some stakeholders to carry out research into mechanization of mango harvesting.
- ✓ Lack of co-ordinated extension services among the stakeholders focusing on the need to introduce harvester for mango in order to reduce drudgery associated with manual harvesting methods.
- ✓ Indiscriminate importation of various brands of fruit juices which appear on the retail market in cans, bottles, tetra-pak, etc derived from citrus fruits like mango, orange, cashew, lemon, grapefruit, pineapple, etc often discourage stakeholders like Agricultural Engineers, Food engineers and processors thereby creating doubts about the economic potential of mango .
- ✓ Lack of awareness in the export potentials of mango hinders research into the mechanization of mango harvesting. Since mangoes are mostly consumed locally in Nigeria and not exported as it is in countries like Mexico, Brazil India, Pakistan, etc where it is a major source of export product and earnings.

5. SOME RECOMMENDATIONS ON HOW TO ACHIEVE MECHANIZATION OF MANGO HARVESTING IN NIGERIA

In view of the lack of a commercial harvester for mango and the potential for huge earning of foreign exchange from mango coupled with the large amount of mangoes produced locally in the rural areas from all the agro-ecological zones in Nigeria, the need for more research into the mechanization of mango harvesting cannot be over-emphasized. The way forward on how to achieve mechanization of mango harvesting includes the followings:

- ✓ There should be adequate extension services to mango farmers as well as proper linkage between farmers and end-users concerning mechanical harvesting methods that can be developed for various varieties of mangoes grown in Nigeria.
- ✓ Establishment of pilot stations in all the agro-ecological zones in Nigeria where different mango varieties are grown for the purpose of carrying out research into

Atanda, E.O. 2006. Development of an Orange peeler. Unpublished M.Eng Thesis Report, Submitted to the Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State, Nigeria. Pp 1-15.

Gupta, R.A., Mohnot, P., Satasiya, R.M and Gontia, N.K. 2004. Development and Testing of a Tractor- mounted Positioner for Mango harvesting. Agricultural Mechanization in Asia, Africa and Latin America., Volume 35 No1, Pp 28-32.

Kordylas, J.M. 1990. Processing and preservation of tropical and sub-tropical foods, Macmillan Education Limited, London. Pp 171-252.

Risvy, H.M.M and Thanaraj, T. 2011.Comparison of the performance of different Mango harvesting devices. http://www.esm.ac.Ik/FAG/ agric east/ Volume 5/4 pdf. Retrieved on 10th April, 2011.

Sapowadia, B.D., Patel, H.N.,Gupta, R.A. and Pund, S.R. 2001. Design and Development of a Mango harvesting device. Agricultural Mechanization in Asia, Africa and Latin America, Volume 32 No1, Pp31-34.

Sauco V. Galan, 2013. Worldwide mango production and market: current situation and future prospects. ISHS Acta Horticulture 992: IX International Mango Symposium. Sanya Hainan Island, China. http://www.actahort.org/books/992/ .

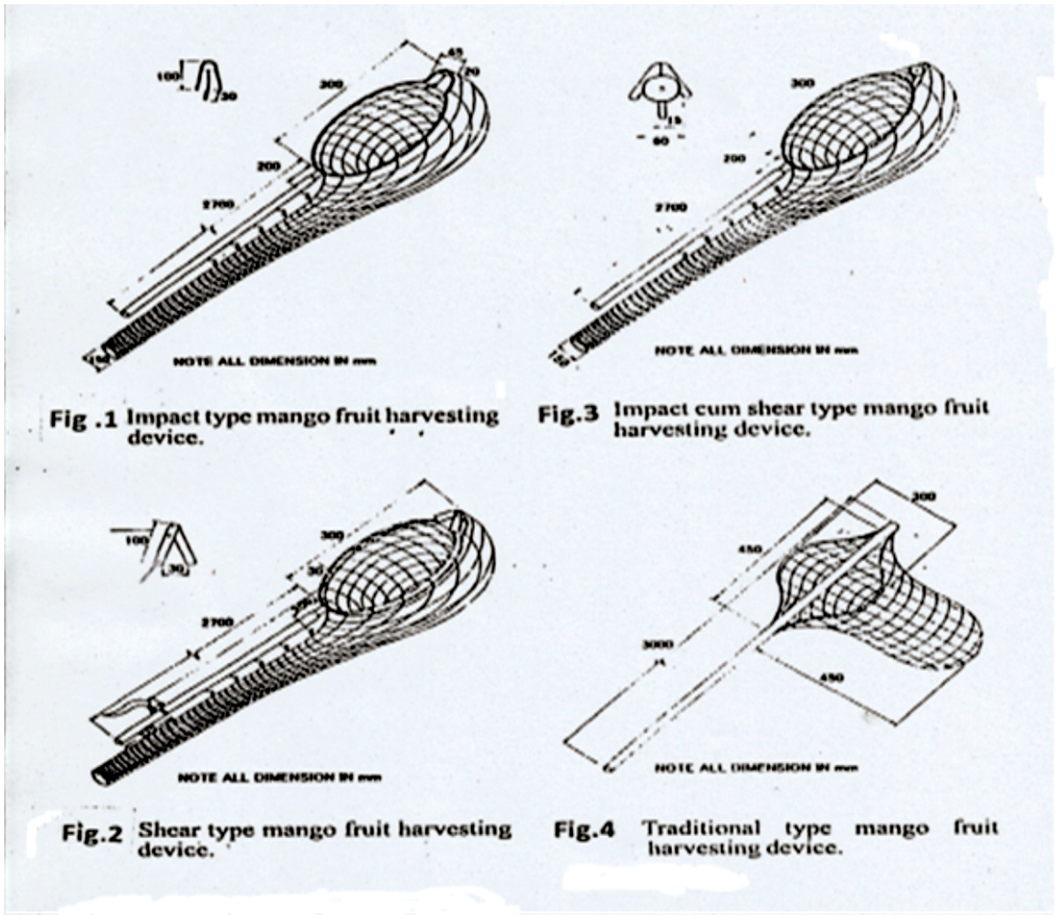
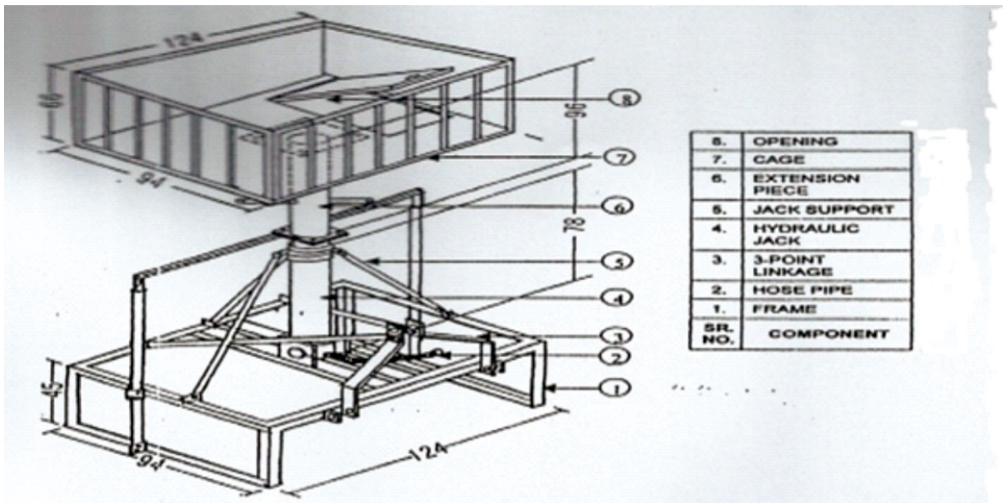


Fig .1 Impact type mango fruit harvesting device.

Fig.3 Impact cum shear type mango fruit harvesting device.

Fig.2 Shear type mango fruit harvesting device.

Fig.4 Traditional type mango fruit harvesting device.



SR. NO.	COMPONENT
8.	OPENING
7.	CAGE
6.	EXTENSION PIECE
5.	JACK SUPPORT
4.	HYDRAULIC JACK
3.	3-POINT LINKAGE
2.	HOSE PIPE
1.	FRAME

Fig.5 Tractor-mounted positioner for harvesting mango.

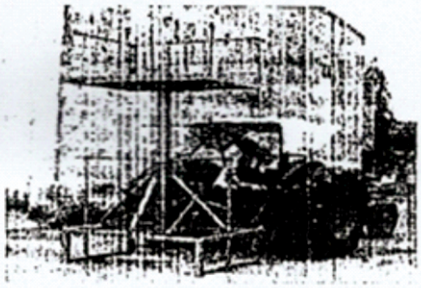


Fig.6 Positioner attached with power source.

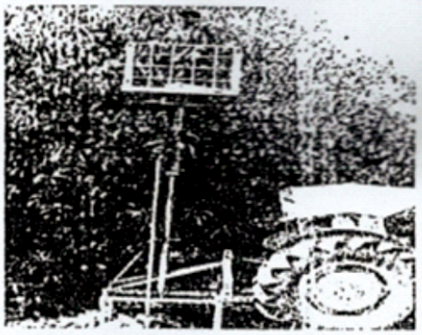


Fig.7 Operator picking mango using positioner.

DESIGN, CONSTRUCTION AND TESTING OF MANUAL ROW WEEDER

[1]Sam, E. O.; [2]Okokon, F. B.
emmanuelsam822@yahoo.com; fbokokon@yahoo.com
08169913711; 08131963530
[1]Agricultural Engineering Department, Akwa Ibom State University.
[2]Agricultural Engineering Department, University of Uyo.

ABSTRACT
Design and construction of a manual row weeder is viewed on the level of application of Engineering principle in the development of a weeder, which act as intermediate between the crude implement used by subsistence farmers in weeding operation and more complex imported weeding machines, which is more costly and at time without spare parts. The development and subsequent production of this implement help to reduce drudgery and tedium by depending less on human effort, during weeding.
The wheel radius of the machine is 150mm and the diameter of the rotor is 200mm with 12 L-shape blade set in offset to the disc, at 52mm spacing. The length of each blade is 200mm and total working width is 750mm. After the design, the construction was carried out locally, with metals used in almost all the parts except the tyre. At the process of construction, problems were encountered, which include the alignment of the rear sprocket with that in-between the two centre disc for easy rotation of chain. The weeder is most suitable for weeding in maize and cassava farm, taking crop spacing into consideration. At the process of weeding, the machine also helps in pulverizing the soil, scrape the top soil along with weeds and return it over as it moves. However, testing of the machine was carried out at the University of Uyo intensive program site. Other problems encountered during the testing process and maintenance procedure is laid down in this report. The limiting factors in the testing are based on the use of the weeder on well spaced row crops particularly on flat land. The field efficiency is approximately 43.4%

Keywords: Weeding, Weeder, Design, Row, Implement.

1.0 INTRODUCTION

The importance of machine in agricultural operations in the world today should never be underestimated. Be it manually operated or powered. The transformation of subsistence agriculture to more productive form of agriculture requires the development of agricultural training and research such as in weeding operation.

According to Odigboh and Ahmed (1978), it was determined that weeding constitutes a major bottleneck limiting agricultural production in the country. Weeding of root and crops planted on ridges pose a special problem because imported mechanical weeders are mostly for crops planted on flat land and are usually too expensive for small scale farmers. To this end, it was also recommended among others that Agricultural Engineers should be challenged to develop suitable machines for solving the problem of weeding in Nigeria farms.

Subsistence farming gave way to large scale farming and this entail the use of bigger implement than the hoes, knife, spade and shovel, which were the early farm implement used for weeding. Gradually, new designs of farm machinery have enabled modern farm operations to depend on man's invention and less on manual power.

Weeding is one of such operations, which have brought about the inventions of weeder implement to reduce drudgery and tedium by depending less on human effort.

1.1 Method of Mechanical Weed Control

This is achieved by disturbing the soil and on cutting the root so that the weeds die from the disturbance or desiccation. It controls weeds in three (3) different ways.

i) By uprooting the weeds, separating its root from the soil and exposing them to die.
ii) Smoothening the aerial part of the weed by covering with soil.
iii) By cutting off the stem just below the ground surface which is usually done to deep rooted weeds.

In the developing countries where small scale farmers predominate, there is little or no infrastructure for mass production of mechanical weeders to justify cheap cost per unit while large scale farmers could rely more economically on importation of large machines to use on the large hectorages. On this note, the options are made on what type of machine to design, whether to:

- Design for a large machine, or
- Design a complicated ones, or
- Design a small machine to handle small scale operations.

To manufacture this machine depends on the type of farmers, the producer points of view and the users point of view.

1.2 The Concept of Manual Row Weeder Design

Odigboh (1979) reported that, "the row/ridge weeder is designed in the principle of the rotary tiller, it may be hand pushed (manually operated) or powered by a small internal combustion engine. In either case, only a small earthening up, enough to remove small young weeds will be done. The machine thus requires straight and parallel row for effective weeding".

Row weeder is a specially designed machine for weeding in row crops. It is rolled along by hand to cause weeding by rotating members.

The fabrication of the manual row weeders, however, is a simple and less complex in terms of design. As such most of the small-scale farmers who cannot afford the imported one can spend the little funds they have in fabricating it. The fabrication can be carried out by a small manufacturing entrepreneur.

2.0 MATERIALS AND METHOD

2.1 Design Variables

The components / material used in the construction of the machine include:

(a) Ball Bearing
(b) Disc
(c) Cuter Hoes
(d) Handle
(e) Shaft
(f) Small Tyre
(g) Sprocket and Chain
(h) Bolt and Nuts

2.2 Material/Description

The details of the design, construction and assembly of the row weeder are shown in this work. The disc is made of a metal plate mounted on the common axle of the wheel and provides attachment position for all other component parts of the weeder. It is design

at the maximum of 50mm depth of cut. The weeder is provided with a handle for pushing. The handle made of high carbon steel is fitted at the position suitable for the operator. The gang of the rotary hoe weeder has six hoes. The small disc serves mainly to take up the weight of the hoes and other components of the machine.
It is assembled with enough clearance on both sides to avoid injury to young crops. The operator walks between the rows as he pushes the weeder along the farm. For thorough weeding, the maximum worked surface is chosen in relation to the depth of cut, in such a way that no weeds escape the action of the cutter hoes.

2.2.1 Ball bearing: The Ball roller Bearing is used to allow easy rotation of the wheel about the shaft and disc which the hoes are mounted. It permits relative motion of two parts in one or two direction with a minimum of friction while resisting motion in the direction of applied load. The type of Bearing used are journal bearing which the inside cylindrical parts is a rotating shaft. It consists of Balls being separated from each other separator linings. The bore (inner) diameter is 20cm, the outer is 42mm and the thickness is 13mm.

Dynamic Load Rating for Ball Bearing under Load
The approximate rating (or service) life of ball bearing is based on the fundamental equation.

$$L = \left\{\frac{C}{W}\right\}^{k} \quad X\ 10^{6} \text{ revolution} \quad \text{.....Eqn.1}$$

or

$$C = \left\{\frac{L}{10^{6}}\right\}^{1/k} \quad \text{.....Eqn.2}$$

Where L = Rating life
C = Basic dynamic load
W = Equivalent dynamic load
K = 3 (i.e. for ball bearing)

The relationship between the life in revolution (L) and the life in working hours (L_H) is given by

$L = 60N.L_H$ revolution. Eqn.3

Where N is the speed in r.p.m.

Taking all the variables load that will act on the bearing into consideration, bearing number 302, with outside diameter 42mm, width 13mm and service factor (K_s = 2.0) for moderate shock load is selected for the construction of the rotary hoe weeder. The bearings are five (5) in number performing the same function, which is to avoid the two surfaces in contact from robbing against each other, which will result in wear and tear. The mounting arrangement for Bearing on a rotating shaft is illustrated in figure 3.1. the fit between the inner ring and the shaft is an interference fit with small allowance to prevent relative rotation and wear between the rings and the shaft.

2.2.2 Disc: This consists of hubs (bearings), and the cutter blades or hoes. The disc is made of high quality carbon steel with a diameter of 200mm (20cm) and a width of 4mm (0.4cm) thickness. They are four in number. The hoes are set on the edge of the circumference so that they shear or dig as they go downward toward the earth (soil) and pick up the soil as they rotates upward. The number sets depends on the width of cut chosen and the overlap need of the blades. (fig.2)

At the centre of the disc is the nave or hub where the shaft is being passed through. The disc is made to rotate with the aid of the bearing, sprocket and chain.

For a particular revolution, the wheel will cover a distance of 2Πrw.

Where

Π = 3.142 constant
r = radius of the disc
w = angular velocity

2.2.3 Handle: Steel pipe of 30mm diameter and a length of 750mm is cut, and two (2) pieces of the same material with length of 18cm welded normal at both ends. Another two steel pipe of the same material with the length of 700mm is welded together at the upper end and left at the lower end to form a v-shape arm. The free ends of the second are welded to the first to inclined at 45^0. A short crossbar of 220mm long is welded across the top end to form the handle for pushing the machine along the ground. To the V-shape arm, is welded another two pieces of length 400mm which carries the tyre and the rear sprocket at it lower end. The handle are held in the vertical position and pushed or pulled the machine along the row.

2.2.4 Shaft: Shaft is the rod or spindles in the members to transmit torque and speed. It is made of steel upon or with which the disc turns. The shaft fills the nave of the wheel (hub or central part of the disc) through which the bearings are mounted. The shaft passes through the bearing boxes on the frame attached to each disc The shaft and the hub are fastened together by the tapered pin. The purpose is to keep the wheel from sliding axially down the shaft and becoming loose.

2.2.5 Tyre: Tyres become acceptable means of transporting farm equipment. Primary advantages includes faster field speed, faster highway speed and ability to travel on and across paved highway and reduce draft requirements. Two basic design concepts developed for tyres are bias ply and radial ply. Tyres used in this machine is a small inflated tyre with the small wheel through which is fitted to the machine. It is fixed at the central point in-between the handles with the rear sprocket attached to it to transfer the rotation to the blades with the aid of chain. To aid the relative movement of the wheel, it is fitted with a small ball bearing. This help in the idle traveling of the machine, and in turning at the end of the row/ridges in which the cutting mechanism is not allowed to touch the soil.

2.2.6 Sprocket and chain: Two sprocket of diameter 100mm and 50mm with 6mm thickness are used in the construction of the machine. One fixed in-between the two-center disc carrying the weeder hoes, while the other is bolted together with the tyre wheel. Chain is used to connect the front and rear sprockets, such that, when force of push is applied to roll the weeder, the rotation will then be transferred to the disc, thereby aiding the turning of the blades. The type of chain used is adjustable, so that it can easily be change or adjusted in the field. The sprockets and the chain are thus constrained to move together without slipping and ensure perfect velocity ratio. (fig.3)

Velocity Ratio Of Chain Drives

The velocity ratio of a chain is given by

$$V.R = \frac{N_1}{N_2} = \frac{T_2}{T_1} \quad \text{.....} \quad \text{Eqn4}$$

Where

N_1 = Speed of rotation of smaller sprocket in r.p.m.
N_2 = Speed of rotation of larger sprocket in r.p.m.

T_1 = Number of teeth on the smaller sprocket
T_2 = Number of teeth on the larger sprocket

Therefore V.R = $\frac{T_2}{T_1} = \frac{37}{15} = 2.47$ Eqn.5

Let T_1 = Number of teeth on the smaller sprocket
T_2 = Number of teeth on the larger sprocket
P_2 = Pitch of the chain, and
x = Centre distance

The length of the chain (L) must be equal to the product of the number of chain links (K) and the pitch of the chain (P).

$$L = KP$$

Where

$$K = \frac{T_1 + T_2}{2} + \frac{2x}{P} + \left\{\frac{T_2 + T_1}{2\Pi}\right\}^2 \frac{P}{X} \quad \text{.....Eqn.6}$$

But $T_1 = 15$ $T_2 = 37$
$P = 15mm = 0.015m$
$X = 635mm = 0635m$

$$K = \frac{15+37}{2} + \frac{2x0.635}{0.015} + \left\{\frac{37-15}{2\Pi}\right\} \frac{0.015}{0.635}$$

$$= 26+84.67+12.26(0.024)$$

$$K = 110.96$$

The number of chain link (K) = 111
Therefore, Length of Chain L = KP Eqn.7
= 111x0.015m = 1670mm

A bush roller chain chosen for this machine is extremely strong and simple in construction. It gives good services under severe conditions. There is little noise with this chain which is due to impact of the rollers on the sprocket wheel teeth. This chain may be used where there is a little lubrication.

2.2.7 Cutter blades or hoes: The cutter blades (Fig.4) or hoes are made of L-shaped flat iron and sharpened at one end of bevel shape. They are riveted alternately on the side of the disc so that it should give broader more complete coverage. It is staggered on both right and left hand side of the disc. It has a bevel or wedge shaped edge. The sharpness of the blade edge aid to shear or cut the weeds and pulverize the soil. As the machine is pushed or pulled along, the rotating hoes or cutter blades picks up and give tredding action which scrap the soil.

2.3 Crop Spacing

The front member of the frame is designed to suit the spacing of a particular crop. The spacing suits the commonest crops, which are maize and cassava (see table1). The spacing of these crops determines the length and width of the machine (weeder).

2.4 The Cutting Depth of the Machine

The cutting depth of these row weeders depends on the width of the cutting blades. The width of the blades is such that can penetrate to vulnerable weed root. This may be between 10 – 50mm.

Moving wheel will often sink deeper to the soil than a stationary wheel with the same load (weight). As the wheel rotates with rotating member, it sink down the soil and the cutter blades which are decked on the circumference of the wheel also enter to a certain depth, with its bevel shaped edge, it scraps or shear the soil surface together with the weeds (fig.5). In soft soil condition, the energy required would be lower but in total soil with a number of operations, the energy will be of a similar magnitude and this energy must be provided in order to carry out the operation.

2.5 Forces Acting on the Machine

An implement such as row crop weeder, moving at a constant velocity is subjected to three (3) main forces,

i) Forces acting between the implement and the operator
ii) The force of gravity acting upon the implement.
iii) The solid forces acting upon the implement or soil reaction.

These are those forces that act upon stabilizing surface of the machine members such as the cutter blades.

3.0 RESULTS AND DISCUSSIONS

After the construction and assembling of the machine, series of tests were carried out in the field to determine if actually the aims and objectives of the project is achieved, with much regards to it efficiency. However, test were carried out specifically

1. To determine the theoretical field capacity
2. To determine the field efficiency
3. To determine it actual field capacity.

The overall dimensional measurements and weighing was done and data collected as shown below:

Width of the machine	-	0.75m
Overall height of the machine	-	Adjustable between 1.03m and 1.10m
Overall length if the machine	-	Adjustable between 1.2m and 1.3m

3.1 Testing Procedure

In testing the machine, two other people were involved in the process. One helped in operating the machine, the other helped in checking time while I measured the distance and the width it covered. The exercise were repeated for five (5) times with difference time and distance. The parameters gotten were used in calculating;

(a) The efficiency of the machine
(b) The speed of operation
(c) The cultivatable depth

3.2 Testing Result

3.2.1 Test for field efficiency

Field efficiency of a machine is the relationship between the effective machine field capacity and the theoretical machine field capacity expressed in percent. It therefore help to describe the efficiency of the machine in operation.

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoretical Field Capacity}} \times 100$$

But average speed(s) = 18.34m/min = 1,100.4m/hr
Effective width(W) = 0.75m
Theoretical field capacity = speed x width
= 1,100.4x0.75 = 825.3m^2/hr
Effective field capacity = $\frac{\text{speed (km/hr) x width (m)}}{10}$ X Efficiency
= $\frac{1.10 \times 0.75}{1000}$ X 43.4
= 0.035805ha/hr
Therefore field efficiency = $\frac{0.035805}{0.08253}$ X 100
= 43.4%

3.2.2 Test for speed of operation

The speed of operation was determined as shown in table 2.

Average speed of operation = 18.34m/min
= 1.10km/hr

20m	=	20m/min or 35km/hr
41m	=	20.5m/min or 35km/hr
55m	=	18.3m/min or 1.16km/hr
67.5	=	16.9m/min or 1.01km/hr
80m	=	16.8m/min or 0.95km/hr

3.2.3 Test for cultivatable depth

The penetration depth measured during the test is as summarized in Table 3, with average, cultivatable depth efficiency = 43.4%

3.3 Problems Encountered During Testing

1. When the test was carried out in the field, some of the blades did not give accurate penetration, since few of it was not properly curved out to 60^0. As such, it tends to stamp on the ground.
2. Before the machine can perform effectively, it requires high speed and much energy to be applied.
3. Since the machine was worked in the soil that has already been tilled before planting, the soil particles enter the bearing and it become stiff.
4. At the process of testing, since the blade were not permanently welded on the disc, one of it got loosen out which I had to stop work and re-tighten it.
5. The problem of adjusting the chain was also encountered.

3.4 Maintenance For The Machine

The maintenance of the weeder is minimal, it does not involve too labourious job. However, to ensure the long-life and effectiveness of the machine, the following precaution should always be look into to care for the machine.

1. Always lubricate the bearing and all moving parts
2. Ensure that the cutting blades are always sharp
3. Try and free it from sand
4. Don't temper with adjustment unnecessarily.
5. Always check the tyre pressure.
6. Change or straighten the deform parts
7. Clean the machine and keep it in shelt.

4.0 CONCLUSION

The construction of the manual row weeder is as a result of the challenges given to Agricultural Engineers in solving most of the problems of weeding in Nigerian farms. Through this, the importation of weeding machines of which most of it are without spare part are minimize. Thereby reducing the level of expenses in agricultural business, particularly for small-scale farmer. Moreover, the construction of this machine can also helps to reduce drudgery and tedium by depending less on human efforts.

REFERENCES

Akinsami, O. (1973) Certificate Agricultural Science. Nigeria: Longman.

Crossley, Peter and Kilgour John (1983) Small Farm Mechanization for developing Countries. New York: John Wiley and Sons.

Kasasian, L. (1979) Weed Control in Tropics. London: Leonard Hill

Khurmi, R.S. and Gupta, J.K. (2005) Machine Design. Eurasia Publishing House (PVT.) Ram Nagar, New Delhi-110 055.

Komolafe, Adegbola, Are and Ashaye (1971) Agricultural Science for West African School and Colleges (2nd ed.) Oxford University Press.

Krutz, Gary, Thompson, Lester and Paul Clear (1984) Design of Agricultural Machines. New York: John Wiley and Sons.

Lovegrove, A. T. (1968). Crop Production Equipment London: Hitchinson.

Odigboh, E. U. and Ahmed, S. F. (1979). Developing of Ridge profile weeder. Proceeding of Nigeria Society of Agricultural Engineers. Nigeria: Pamco.

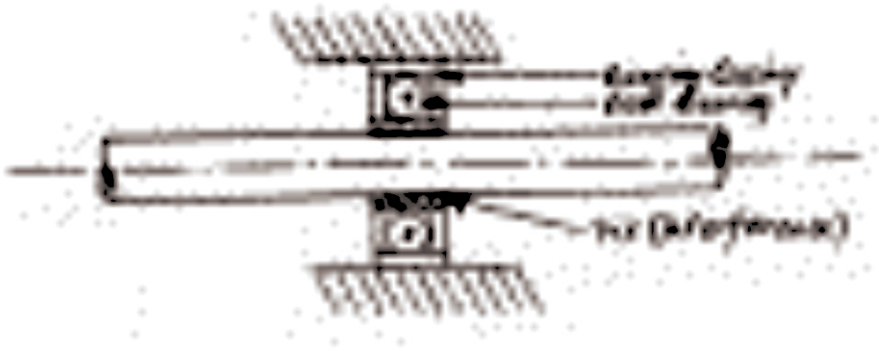


Fig.1 A Mounting Arrangement For Bearing On A Shaft

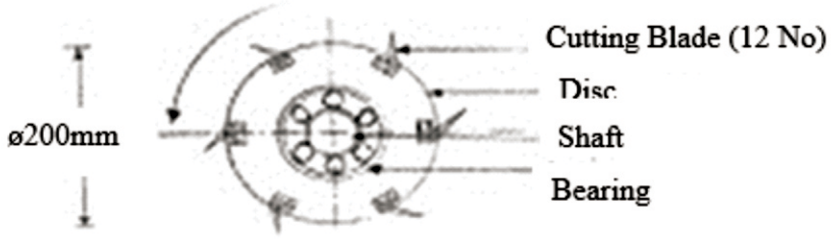


Fig.2 Sectional End View of the Disc Showing Cutter Blade Arrangement



Fig.3 An Open Chain Drive System Connecting Two Sprockets.

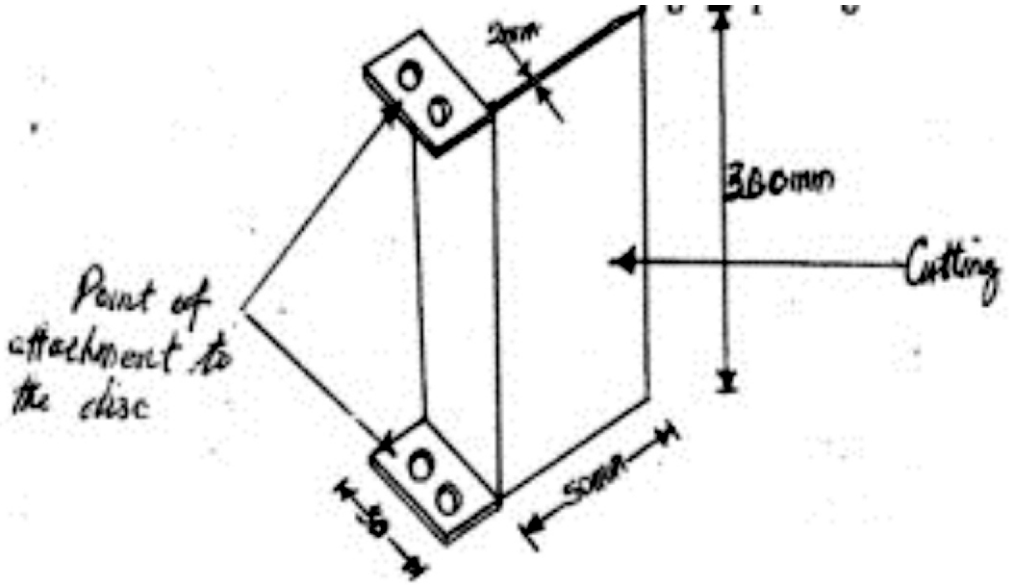


Fig.4 Diagram Showing the Construction of the Cutter Blades

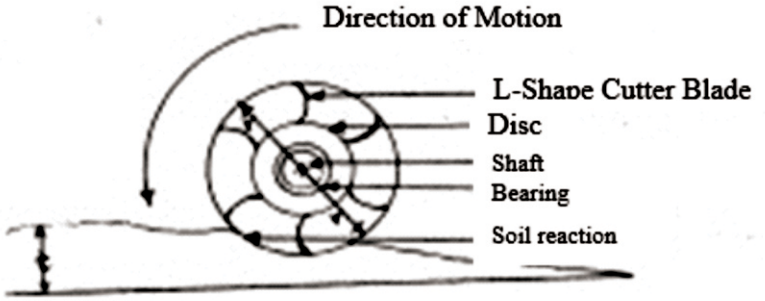
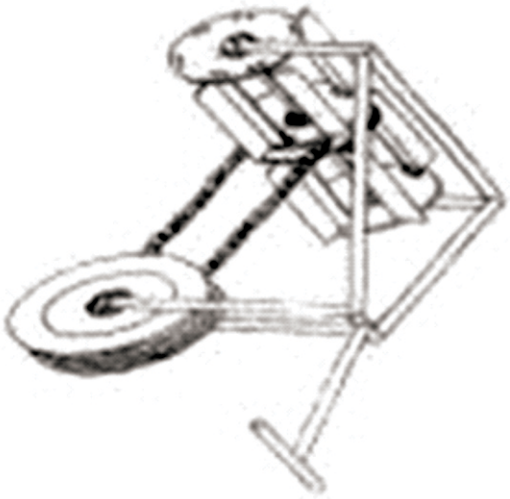


Fig.5 Rotary Weeder with L-shape Blades Showing Cutting Action and Depth of Cut (t)



Pictorial view of the Manual Row Weeder

Table 1: Row And Column Spacing For Crops

CROPS	BOTANICAL NAME	PLANTING SPACING FOR ROW (ROW WIDTH)	SPACING BETWEEN HOLES (COLUMN WIDTH)
Yam	Discorea esculentum	90cm (900mm)	Staggered in alternate row
Maize	Zea mays	80cm (800mm)	50cm (500mm)
Cassava	Manihot utilisima	100-150cm (1000-150cm)	100cm (1000mm)
Okro	Hibiscus esculentus	60cm (600mm)	60cm (600mm)

Table 2: Speed Of Operation

Width (m) a	Time (min) B	Distance (m) c	Speed (m/min) c/b
0.75	1	20	20/1 = 20
0.75	2	41	41/2 = 20.5
0.75	3	55	55/3 = 18.3
0.75	4	67.5	67.5/4 = 16.9
0.75	5	80	80/5 = 16

Table 3: Test For Cultivatable Depth

BLADE	DEPTH (M)	EFFICIENCY
1	0.03	0.033x12/0.75 x 100 = 48%
2	0.029	0.29x12/0.75 x 100 = 46%
3	0.028	0.028x12/0.75 x 100 = 45%
4	0.02	0.02x12/0.75 x 100 = 32%
5	0.025	0.025x12/0.75 x 100 = 40%
6	0.02	0.02x12/0.75 x 100 = 32 %
7	0.028	0.028x12/0.75 x 100 = 45%
8	0.03	0.03x12/0.75 x 100 = 48%
9	0.029	0.029x12/0.75 x 100 = 46%
10	0.027	0.027x12/0.75 x 100 = 43%
11	0.028	0.028x12/0.75 x 100 = 45%
12	0.032	0.032x12/0.75 x 100 = 51%

Average Cultivatable Depth Efficiency = 43.4%

DEVELOPMENT OF NRCRI CASSAVA ROOTS HARVESTING AID

Ikejiofor, M.C. and Okwesa, C.O
Engineering Research Unit, National Root Crops Research Institute, Umudike.P.M. B, 7006
Umuahia, Abia State, Nigeria
Email: mauikejiofor@yahoo.com

ABSTRACT
The need to reduce hard labour inherent in manual harvesting of cassava roots with traditional tools and the fact that the more complex tractor powered cassava harvesters are not within the reach of most cassava farmers, are the major considerations for the design and development of a simple, efficient and affordable harvesting machine for cassava roots. The machine is a hand push type which requires the operator to easily push the machine along the ridge, and harvest the cassava roots. The machine was developed in the Engineering Research Workshop of National Root Crops Research Institute, Umudike. The overall dimension of the machine is 115cm x 82cm x 60cm. The machine has four main sections: root lifting, grip adjustment, wheel and the handle. The preliminary testing of the developed machine was carried out under soft soil condition for different varieties of cassava and the machine performed satisfactorily very well in lifting the cassava roots with very low percentage of damaged roots. The average harvesting capacity of the machine is 0.038ha/hr. The machine has easy operational / maintenance procedures.

Keywords: Development, Cassava, Roots, Harvesting, Machine

1.0 INTRODUCTION

Cassava (Manihot esculenta), also called Yuca or Manioc, a woody shrub of the Euphorbiacae (Spurge family) native of South America, is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous root, a major source of carbohydrate. Phillips (1983) classified it as sweet or bitter, depending on the level of toxic cyanogenic glucosides. Cassava can be processed into flour, starch, snacks, baked foods, fufu, gari, eba, lafun and 'akpu' which are local delicacies in Nigeria, Ghana and other west African countries. Manual uprooting of cassava root is still predominant and the roots are harvested using cutlasses, hoes, diggers and hand. Mechanical method of cassava harvesting has advantages such as high efficiency, low tuber damage and low cost (Yang Wang, et al. 2011). The development of mechanical harvesters for cassava started in 1932 when Cantamby tried unsuccessfully to harvest cassava using praire mold board ploughs with different structural configurations. Many decades later, Makanjuola, et al. (1973) experimented with four machines for harvesting cassava. Furthermore, Sharma (1979) used animal and tractor drawn single disc and moldboard ploughs to harvest cassava. Odigboh (1985) reported the development of various prototypes of cassava harvesters. (Peipp and Maehnert (1992) also reported the development of a cassava harvester utilizing the principle of combined digging of the soil and pulling of the cassava stem to harvest the roots. A crowbar usually of a wooden lever 2.5 - 3.0m long was reported by Agbetoye (1999), and has been tried for lifting cassava. It was stated that the harvester was too cumbersome to use and it waste a lot of time to fix in order to lift the tubers.

Manual harvesting of cassava does not fit well with the modern processing factories. Also, the cost of manual harvesting is high; it takes about 25 to 35 man days to harvest a hectare of cassava. Currently, this is done manually by hand and consequently

farmers develop blisters in their palms, callus palms, arched spinal cord and waist pain over time. Manual uprooting is slow with low output and productivity, but the uprooting device will be faster with high productivity. It is against this background that an easy way of uprooting cassava is being considered in this paper. The objective of this paper is to report on the development of a simple cassava harvesting machine to facilitate easy uprooting of cassava roots for local farmers.

2.0 MATERIALS AND METHODS

The cassava harvester was designed based on the principle of moment of a force to maximize mechanical advantage such that relatively small amount of effort applied at the handle will overcome a greater load (cassava roots) on the other end. The device ensures productivity by uprooting easily the cassava roots. A simple gripping mechanism was adopted for easy and effective operation.

2.1 Description of the Cassava Harvesting Aid

The developed cassava harvesting aid is a manually operated, hand push machine which requires the operator to pull it easily along the ridge and harvest the cassava roots. The machine was designed and developed in the Engineering Research workshop of National Root Crops Research Institute, Umudike. The following materials were used: 50mm solid shaft, 50mm diameter hollow pipe, guide element, 30mm diameter rod, 10mm diameter rod, 2.5 inch angle iron, 2 inch angle iron, wheel, bearing, bolts and nuts. The overall dimension of the machine is 115cm x 82cm x 60cm.

2.2 Design Considerations

After conducting a survey and careful study on the various available designs and their shortcomings, it was decided to go for a fresh design of the harvesting machine based on the following design criteria.

1. The machine should be simple, light weight and sturdy in design.
2. The draft requirements of the machine should be low enough for one operator to operate.
3. It should be functional for harvesting of cassava roots of different sizes / varieties.
4. To meet the requirements of small and medium sized holdings, the unit should be affordable in price.
5. Harvesting losses by the machine should be within the acceptable limits; and
6. The machine should be trouble free and easy to operate.

2.3 Design Assumptions

1) The average lifting force required to uproot matured cassava was taken to be 1000N (Campbell, 1990).
2) The soil physical characteristic was assumed to be loose, moderately loose and moist soils.
3) The average height of ridge at harvest was expected to be about 0.3m

2.4 Performance Evaluation

The following steps were carried out before using the machine

- Plucking of the upper parts of the stems with the leaves before the harvest.
- Cutting of the stem about 0.3m above the soil surface and collecting the stems as planting material.
- Lifting the cassava root system out of the soil and separating the root system from adhering soil before collection of the roots

The following factors were evaluated: Effective field capacity, Efficiency and the % of damaged roots.

Effective field capacity (ha/hr) = $\frac{A \times 3600}{1000 \times t}$ (ha/hr)

Where A = Area harvested (m^2)
t = Time recorded during harvest (seconds)

Efficiency (%) = Q/P x 100
Where Q = Quantity of harvested undamaged roots
P = Total quantity of harvested roots

Percentage of damaged roots (%) = 1 - Q/P x 100
Where Q = Quantity of harvested undamaged roots
P = Total quantity of harvested roots

3.0 RESULTS AND DISCUSSIONS

Table 2 shows that the highest field capacity of 0.0391ha/hr was obtained when the cassava variety TME 419 were harvested with the machine. It also shows that the highest quantity of harvested roots was obtained from NR 8082 cassava variety, while the lowest quantity of damaged roots was obtained from TMS 98/0505 cassava variety. It is discovered that the machine is simple from the view shown in fig.1. The designed device is affordable as could be seen from the readily available materials used as shown in table 1, and also very efficient as shown from the efficiency values in table 2.

4.0 CONCLUSION

The machine requires less energy and the movement of the mechanisms is relatively smooth. It is therefore appropriate for high productivity, while the accuracy is reliable. The various parts of the device are easy to manufacture in the workshop, but requires good technical skill. The device is cheap, and does not contain intricate and expensive parts. It is also easy to construct.

5.0 RECOMMENDATIONS

- The device is recommended to the cassava growing farmers to enjoy the benefits
- The design is capable of uprooting one stand of cassava at a time; further research should be carried out to design a device that will uproot two or more cassava stands at a time.

REFERENCES

Agbetoye, L.A.S.1999. Developments in Cassava Harvesting mechanization. West Indian Journal of Engineering, Vol. 22, No. 1. Pg 11 – 19

Campbell, J.K. 1990. Dibble Sticks, Donkeys and Diesel: Machines in Crop Production. The International Rice Research Institute, Phillipines. Pg 1 – 336, ISSN: 971 – 104 – 185 - 5

Makanjuola, G.A.; Onochie, B.E. and Schulte, F.E. (1973). Preliminary Studies on Mechanical Harvesting of Cassava Roots in Nigeria. Paper at Third International Symposium on Tropical Root Crops. University of Ibadan, Nigeria.

Odigboh, E.U. 1985. Mechanization of Cassava Production and Processing: A Decade of Design and Development. An Inaugural Lecture Delivered at the University of Nigeria, Nsukka. Published by University of Nigeria Press. Pg 29 – 32.

Peipp, L. and Maehnert, E. 1992. Development of a Technical Solution to Cassava Harvesting Problem. Journal of Agricultural Mechanization in Asia, Africa and Latin America. Vol. 23. No. 1. Pg 33 – 36.

Phillips, T.P. 1983. An Overview of Cassava Toxicity and Thyroid. Proceedings of a Workshop, Ottawa, 1982. International Development Research Centre Monograph 207e. Cassava Toxicity and Thyroid: Research and Public Health Issues, Delange, F. and R. Ahluwalia (Eds), Ottawa (Canada), IDRC, Pg 83 – 88, ISBN 0 – 88936 – 368 - 4

Sharma, A.P. 1979. Studies on Mechanical Harvesting of Cassava in Fiji. Journal of Agricultural Mechanization in Asia, Africa and Latin America. Vol. 10. Pg 39 - 41.

Yang Wang; Cai Ganwei; Yang Jian. 2011. Mechanical and Mathematical Model Analysis of Uprooted Force on Cassava Roots. Transactions of the Chinese Society of Agricultural Engineers (CSAE); 27(11): Pg 95 – 100.

Table 1: Machine Parts List

Parts No.	Description	Material	Quantity
1	Gripping unit	6mm thick iron	2
2	Handle	30mm dia. rod	1
3	Main frame	2.5 inch angle iron	0.5 length
4	Adjusting unit	50mm dia. bolt / 10mm dia rod	2
5	Connecting shaft	50mm dia. solid shaft	1
6	Connecting pipe	60mm dia. Steel pipe	1
7	Wheel / Rim	400 rim 8	2
8	Bearing	6206 bearing – 2z	2
9	Wheel shaft	30mm dia. solid shaft	2
10	Supporting frame	2 inch angle iron	1 length

Table 2: Field Test Data For The Harvester

Varieties	Harvesting Time (s)	Area Harvested (m^2)	Field Capacity (ha/hr)	Quantity of Root Harvested (kg)	Quantity of Damaged Roots (kg)	Efficiency (%)
NR 8082	93	10	0.0387	42.6	2.6	93.9
TMS 98/ 0505	96	10	0.0375	35.2	1.9	94.6
TME 419	92	10	0.0391	38.7	3.1	92.0
TMS 30572	98	10	0.0367	32.4	2.3	92.9
Average	94.75	10	0.0379	37.2	2.5	93.4

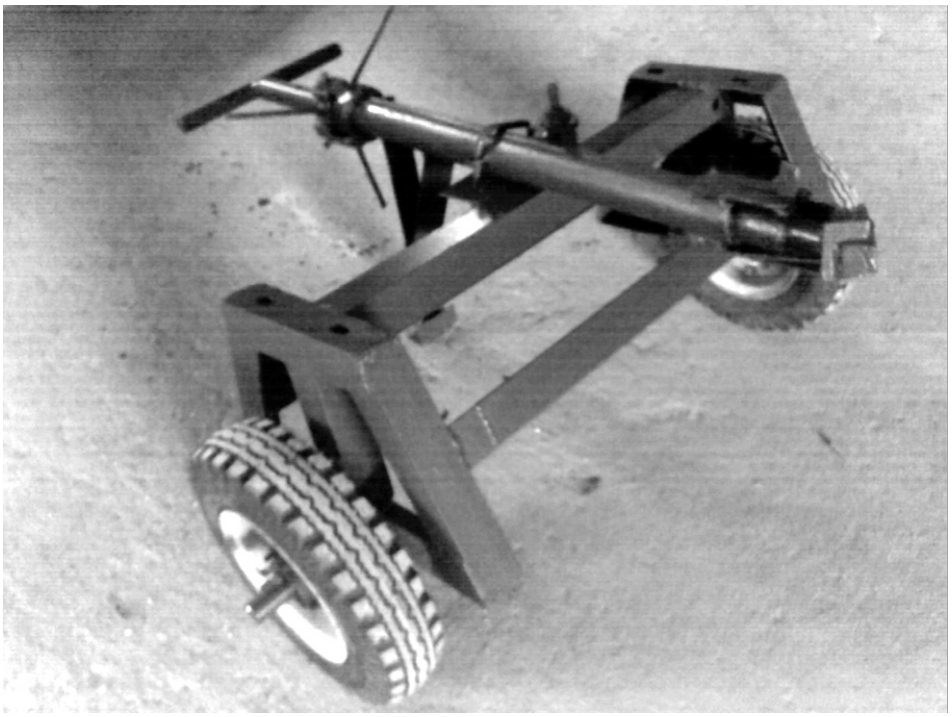


Fig. 1: Different Views Of The Developed Cassava Harvesting Machine

EFFECT OF RUNOFF AND HAULAGE VEHICLE TRAFFIC ON GULLY GROWTH ON ROADSIDE SLOPES OF UNPAVED SAND-QUARRY ROAD, UYO.

Obot Ekpo Essien
Department of Agricultural and Food Engineering, University of Nigeria, P. O. Box 4309, Uniuyo Post Office, Uyo, Nigeria. Postal Code 520003.
* Corresponding Author: obotessien@uniuyo.edu.ng; tobessien@yahoo.com
Phone: +2348023232195

ABSTRACT
Rainfall runoff and sand haulage truck traffic count were quantified and regressed on gully soil loss and gully morphometric volume growth on unpaved haulage roadside erosion. The gully erosion on unpaved roadside was accelerated by the agency of runoff in splash wash from the road, and high axle sand haulage trucks traffic. The effect of the Runoff discharge and traffic count, as in dependent variables and in cumulative quantities, on the cumulative soil loss from garged side slope gullies, and the gully volume growth were very significant at $P<0.01$ generally. Predicative coefficient of determination significant at $P<0.01$, were very perfect at $R^2 = 88.8$ to 98.9%. Different regimes of association were obtained such as: high runoff and high traffic count; high flow rate and low traffic count, and low runoff and high traffic count for effect and on gully loss and gully volume growth, and they gave accurate and significant relationship. Regulation of sand-mining over a catchment is recommended as it has otherwise destroyed landform and initiated unrestrained gullying.

Keywords: Sand Haulage Road, Sand Quarry, Unpaved Roadside/mechanized Soil Excavation, Runoff, Truck Traffic Count, Gully Soil Loss, Gully Volume Growth.

1.0 INTRODUCTION

Destructive land use leads to land degradation and structural inability. One destructive landuse is an unplanned and unregulated sand mining that leads to gully initiation and growth. This is the case at Uyo peri-urban where the whole subcatchment is quarried daily for laterite sand used for the extensive construction and building projects in the urbanization expansion of the Uyo state capital, and some contiguous communities in the rural-urban fringe. The process of sand quarrying in the study area uses different stages of mechanization. Generally the land is cut into clods of sand heaped out before scooping with human labour into haulage trucks.

Soil surface vegetal cover and fallows and farms have been removed, and soil has been cut down to the sublayer for laterite; leaving jagged undulations of localized depressions for sedimentation or ponding on water. The haulage road was built up with the burrowed soil from the sand mind land to a height above the land mined fields resulting in steep sides slopes of the road, which also is cleared of vegetal cover and top soil, so that no filtering strips was available to wedge runoff from the sides. The roadside slope is steep with no tuft or weed or drainage collecting drains to reduce runoff cascades down the side slope.

Usually there is some kind of erosion taking place along the roadside (Michael and Ojha, 2006), especially where road was constructed by cut and fill method. Under rainfall characteristic and increase in slope length, soil erosion increases on roadside (Xu, et al,

2009). The process of gully erosion on the roadside of unpaved haulage road in the sand quarried landform involve the rainfall, the runoff, soil particle distribution and human factor – the high axle haulage truck traffic; however only the effect of runoff and truck traffic count are considered in the study, since rainfall and soil particles were considered in previous study (Essien and Okon, 2012).

When trucks of loaded laterite move up and down the haulage road, the loaded trucks tires cause abrasion of the wet or dry soil surface, dislodging particles, digging out ditches across the crown and eventually splash-washing the sediments on traffic tyre impact to the roadsides, so that it flows down the road side slope. It causes levees at first, then the levees are broken by runoff wash off and rainfall impact (Suresh, 2006). Rills are created on the road crown across to the road side. Further runoff downstream finds the micro channels as easy drainage routes for flow rivulet to the sides. Steady rills are formed as weak parts of sediment on side slopes break up, and, eventually, these grow bigger into gully and the growth rate of the gullies need to be determined as the degradation continues especially in the rainy season.

Roadside erosion could have been checked if tufting, sodding, pitching (agronomic method) or erection of retaining wall or bench terracing permanent structure of slope of filled road took place Michael and Ojha, 2006). As the weed cover was removed during land mining and the road was unpaved and the side slope untamped and higher above the quarried land surface, a check in erosion, gully initiation and growth was hardly possible as no authority took functional responsibility on haulage road for sand quarrying, which is a private financial responsibility in haulage business.

This is the causative factors are anthropogenic degradation of landform through erosion agencies of rainfall-runoff, splash wash and traffic abrasion. The objectives of these research aims to quantify these factors and correlate them with gully growth and soil loss for erosion control check in such vulnerable land use areas.

2.0 MATERIALS AND METHODS

2.1 Measurement of Runoff Discharge

A five-litter collector was used to fill a 20L container. A mouthpiece of metal plate was constructed and inserted on the scarp head of the gully and water flow on it to the collector. The time taken to fill each 5L container was recorded using snap stop-watch. The total volume of container filled was divided by the total time taken, to give the discharge rate of runoff at respective gully line. Filling was so managed that no spillage was allowed. A fresh 5L – collector was waiting so as to change over and withdraw the filled sample collector without allowing it to brim nor overflow.

2.2 Determination of Gully Parameters

2.2.1 Slope length.

The length of the main gully slope from the crest to the slope base on the road side slope was measured with a 30m linen tape and expressed in metres. Five measurements were made in each sampling location. The average value for each sampling area was computed.

2.2.2 Truck traffic count

A check point was mounted at the road entrance. The number of trucks entering and leaving the unpaved haulage routes were recorded, loaded or empty. A sentry was

each day from 6am till 6pm.

2.3 Statistical Analysis

All data were organized into groups (see Results) and their description statistics, ANOVA, paved statistics, correlations and regression were carried out using SPSS software version 17.

3.0 RESULTS

The results are tabulated in tables below. Runoff discharge (RO) and Traffic count (TR) are independent variables.
Data collected were organized into three groups; namely:

(i) High traffic count (TR) and low runoff discharge (RO) and their combined effect on soil loss (SL) and on gully growth volume (both as dependent variables (Table 1).
(ii) High runoff discharge (RO) and low traffic count (TR) as independent variables and the recorded gully soil loss (SL) and on gully growth volume (GR) (Table 2);
(iii) High runoff discharge (RO) and high traffic count (TR) on gully soil loss (SL) and gully volume growth rate (GR) (Table 3).

The fourth and fifth groups are the mixed magnitudes of independent variables and the point values of each variable. These are too many to be presented here.

Since the gully growth is additive geometric dimension or cumulative morphometric degradation over time, it is essential to relate the variables in cumulative values. Hence, the values in Table 1 – 3 are presented as cumulative magnitudes of the variables.

4.0 DISCUSSION

4.1 Effect of gully growth

Gully growth is the cumulative dislodgement and transportation of soil particles from a location to a deposition at a distance. It is also erosive water effect which erosive water may not be constant in magnitude and force but vary in time and place. As such the infinitesimal or discrete change in morphometric dimension by successive current of erosive water (and or erosive rainfall) and abrasive tractive truck wheels (which grind the soil and enlarge or widen the gully geometry. By the cessation of the rains (i.e. erosive water current productive season), the resultant gully dimensional morphology is a cumulative addition of the geometric of infinitesimal time dimensional increment.

$$\therefore Gully\ volume = \int_{t}^{\square} (L + dt)(w + dw)(D + dd)dt$$

Where n is number of infinitesimal dimensional changes in the period (t) of the season. Thus, the ultimate gully geometry *L.W.D.* = cumulative sum of changes in gully dimension in time interval *dt* under cumulative runoff, etc.

Table 1-3 indicate the cumulative changes (continuous) of the four parameters (RO, TR, SL, GR) occurring within the rainy season. The values reflect the background of prior sand-mining of the road banks and filling of road with subsoils from the sand-

The main difference in the groups is combining soil erosion factors.

4.1.1 Regression relationship (soil loss)

1. High traffic count is a scene occurring under dry earth routes. Runoff is a scene under the threshold period of rainfall and dry season.

The effect of both Cum, RO and Cum.TR on soil loss was tested with a regression relationship, which gave:

$$Cum\,SL = 1.328 - 0.059 cum\,RO + 4.606 \text{cum}\,TR + 3.537 \;@\; R^2 = 99.0\%,\; adj\,R^2 = 98.9\%$$

Where estimated standard error of estimate is the constant 3.5375. (1)

The ANOVA indicated significant change at $P < 0.01$ the R^2 showed significant association of predictors to dependent variable (cum SL) @ $P < 0.01$. The coefficient of TR was also significant in predicting at $P < 0.01$ using t-statistics. The coefficient of the constant and RO were not significant, hence the error in estimation.

Case of high runoff and low traffic count (Table 2):

This scene is usually observed under high rainfall amount in the months of July to October, which condition also reduces the traffic flow of haulage truck, even as constructive and building activities tend to subside.

The regression function relating their regime effect and gully soil loss was obtained as:

$$\text{Cum SL} = 2.479\,\text{cumRO} - 0.060\text{cumTR} - 94.096 + 4.030 \quad (2)$$

@ $R^2 = 88.8\%$, adj $R^2 = 85.6\%$.

Regression coefficient showed significant association @ $P < 0.01$ and significant difference of variance $P < 0.01$ also.

ANOVA show that the null hypothesis of variance homogeneity (of cum RO and cum TR) can be rejected at P<0.01 (Ofo, 2001).

The coefficients for cumRO and cumTR showed significance at P<0.01

The predictive association was obtained as:

$$\text{Cum}GR = 4432.175 cumTR + 79546.954 cumRO - 3629338.062 - 61695.863.$$

@ $R^2 = 99.0\%$; Adj $R^2 = 98.7\%$

ANOVA: The F-ratio shows that we can reject the null hypothesis of the homogeneity of variances of cumRO and cumTr at P<0.01.

The dependence of criteria variable (GR) on the predictors were 92.2% accurate. Only 7.8% of estimate could be said to depend on any other factor. There was a significant difference in the variable variances. The coefficients of the constant and predictors were, however, not significant at P<0.05.

Case of high runoff discharge and high traffic count:

This scene is usually in the post August break period with high intensity rainfall lasting for long hours (2½ -6 hours, AKADEP, 1995). The cumulative variable in regression relationship gave a predictive function as:

$$\text{Cum SL} = 2.348\text{cum RO} + 0.143\text{cum TR} - 89.422 + 2.581. \quad (3)$$

@ R2 = 98.8%, adjusted R2 = 97.3%, which were significant at P<0.01. ANOVA showed insignificance at P<0.01 indicating no homogeneity of variance; hence the variable variance were significantly different at P<0.01.

The accuracy of the relationship was significantly high @ P<0.01.

In general, using the cumulative criterion, the accuracy of the predictive association between the predictors (cumRO and cumTR) and the criterion (dependent) variable (cumSL) was very high and significant at $P < 0.01$.

The predictive association was obtained as:
$CumGR = 4432.175 cumTR - 79546.954 cumRO - 3629338.062 - 61695.863$.
@ $R^2 = 99.0\%$; Adj $R^2 = 98.7\%$
ANOVA: The F-ratio shows that we can reject the null hypothesis of the homogeneity of variances of cumRO and cumTr at $P<0.01$.

Also, the contribution of the constant, and the coefficients of cumRO and cumTR were significant at $P<0.01$, $P = 0.05$ and $P<0.01$ respectively.

4.1.2 Regression relationship (gully volume growth)

The gully volume growth (cum GR) is another criterion variable that depends on the predictor variables (cum RO, cum TR). Specific regimes were observed.

Case of high traffic count and low runoff:
The effect of cumulative high traffic count (cum TR) and cumulative low runoff (cum RO) was established as:

$$\text{cum GR} = 2140\text{cumTR} - 44940.50\text{cumRO} - 397276.450 - 3.2097E5 \quad (4)$$

@ R^2 = 89.9%, adj R^2 = 89.5% at $P<0.01$. ANOVA shows criterion variable and predictors have accurate association significant at $P<0.01$. The coefficient of the constant and cum TR were significant at $P<0.01$ and 0.1 respectively.

Case of high runoff and high traffic counts:
The predictive association was obtained as:

$$\text{cumRG} = 2636997.624\text{cumRD} - 56477.606\text{cumTR} - 450688.340 + 2.10891E6 \quad (5)$$

@ $R^2 = 92.2\%$
The coefficients of the constant and predictors were, however, not significant at $P<0.05$.

The case of high runoff discharged and low traffic count:
The predictive association was obtained as:

$$\text{cumRG} = 4432.175\text{cumTR} - 79546.954\text{cumRO} - 3629338.062 + 61695.863 \quad (6)$$

@ $R^2 = 99.0\%$; Adj $R^2 = 98.7\%$

5. CONCLUSION

Sand mining land use caused the on removal of soil vegetative cover and topsoil to the sublayer depths at a peri-urban sub catchment in Uyo for construction and building projects in adjoining areas. The unplanned and unregulated activity exposed the area and the unpaved haulage road to water and truck traffic erosion.

The gully erosion on unpaved roadside was accelerated by the agency of runoff in splash wash from the road, and high axle sand haulage trucks traffic.

The effect of the Runoff discharge and traffic count, as in dependent variables and in cumulative quantities, on the cumulative soil loss from garged side slope gullies, and

the gully volume growth were very significant at $P<0.01$ generally. Predicative coefficient of determination significant at $P<0.01$, were very perfect at R^2 = 88.8 to 98.9%. Different regimes of association were obtained such as: high runoff and high traffic count; high flow rate and low traffic count, and low runoff and high traffic count for effect and on gully loss and gully volume growth, and they gave accurate and significant relationship.

The case of using mixed magnitudes and point values of variables did not, however, show accuracy and significance R^2 = 12.4%. The growth of gully and its soil loss is really a cumulative addition of geometric changes over time in a given rainy season.

Regulation of sand-mining over a catchment is recommended as it has otherwise destroyed landform and initiated unrestrained gullying.

REFERENCES

AKADEP (1995). Northern Akwa Ibom Swamps Development Study, Akwa Ibom Agricultural Development Project, Ministry of Agriculture and Natural Resources, Uyo, Nigeria.

Michael, M. A. and Ojha, T. P. (2006). Principles of Agricultural Engineering, Volume II. Jain Brothers, New Delhi 110005, 603-613.

Ofo, J. E. (2001). Research methods and statistics, JOJA Educational Research and Publishers Ltd, Ikeja, Lagos, ISBN 978-2477-58-6, 311.

Okon, E. G. (2010). Effect of rainfall intensity on the rate of gully development, B.Sc. Project. Faculty of Engineering, University of Uyo.

Schwabs, G. O., Fangmeier, D. D. Eliot, W. J. and Frevert, R. K., (1993). Soil and water conservation Engineer, Wiley and Sins, 507pp.

Suresh, R. (2006). Soil and water conservation Engineering. Standard Publishers Distributors. Delhi 110 006. pp 404 – 522.

Xu, X. L., Lin, W., Kong, V. P, Zhang, K. L, Yin, Bu and Chen, J. D. (2009). Runoff and water erosion on road sides: Effect of rainfall characteristics and slope length. Transportation Research Part D: Transportation and Environment, 14(7), 497 – 501

Table 1. High Traffic Count And Low Runoff Discharge Effect On Soil Loss And Gully Volume Growth Rate.

S/N	High traffic count (TR)	Low runoff discharge (cumulative) (RO)	Soil loss (SL)
1.	18	1.1	4.25
2.	38	2.0	8.75
3.	90	2.7	12.13
4.	113	3.8	16.76
5.	135	4.4	19.21
6.	159	5.1	23.71
7.	189	5.9	27.21
8.	210	6.8	29.69
9.	245	7.4	32.69
10.	281	7.8	36.59
11.	304	8.6	40.07
12.	328	9.0	44.35
13.	348	9.8	47.70
14.	378	10.7	51.30
15	398	11.6	54.43
16.	435	12.3	58.23
17.	487	13.3	61.81
18.	532	14.1	64.69
19.	563	15.0	67.89
20.	617	16.0	71.44
21.	663	16.5	74.12
22.	699	17.8	76.70
23.	731	18.8	79.13
24.	781	19.6	81.88
25.	832	20.2	83.63
26.	872	20.9	88.26
27.	909	21.6	101.64
28.	937	22.2	106.39
29.	981	23.0	109.69
30.	1033	23.7	112.52
31.	1093	24.7	114.20
32.	1157	24.4	116.83

Table 2. High Runoff Discharge And Low Traffic

High runoff discharge	Low truck traffic count	Soil loss	GV
40.7	1839	143.37	1,295,123
41.8	1867	148.14	1,375,917
42.5	1900	150.59	1,430,777
43.8	1944	158.59	1,584,954
48.3	2128	171.67	1,921,439
48.7	2154	175.95	2,031,056
47.5	2173	179.3	2,121,979
48.4	2201	182.9	2,259,261
49.4	2233	186.03	2,316,669
53.4	2432	203.04	3,003,833

Table 3. High Amplitude Regime

High runoff discharge (Cum RO	High traffic count	Soil loss	Gully growth (Volume)
40.7	1839	143.37	1,295,123
41.8	1867	148.14	1,375,917
42.5	1900	150.59	1,430,777
43.8	1944	158.59	1,584,954
48.3	2128	171.67	1,921,439
48.7	2154	175.95	2,031,056
47.5	2173	179.3	2,121,979
48.4	2201	182.9	2,259,261
49.4	2233	186.03	2,316,669
53.4	2432	203.04	3,003,833
56.1	2567	211.7	3,236,993
55.3	2529	209.3	3,130,949
54.3	2475	206.7	3,003,833

N/B. Cum Ro = Cumulative Runoff Discharge, Cum Tr – Cumulative Vehicular Traffic Count, Cum Sl = Cumulative Soil Loss, Cum Gr = Cumulative Gully Growth Volume (cm^3)

QUALITY ASSESSMENT OF A SPRING FOR DOMESTIC WATER SUPPLY

Ogwuche, Emmanuel Udeh, Bashiri, Istifanus Malami and Eleke, Patience Nkemjika.
Department of Agricultural Engineering, Kaduna Polytechnic, Kaduna, Nigeria.
ogwucheinacada@yahoo.co.uk.(08037005199),mabash60yahoo.com.(08057273567) and patienceeleke@gmail.com.(08037873468).

ABSTRACT

The quality of the spring water used as an alternative water source to the existing boreholes at (ANWASE-ABANDE) Village in Kwande local government area of Benue state was evaluated. The essence of the study was to investigate the quality and portability of the spring using the World Health Organization (WHO) standards for drinking water through chemical and bacteriological analyses of water sample taken from the spring at the Department of Agricultural Engineering laboratory of Kaduna Polytechnic, Kaduna. The results showed potential contamination of the spring as evidenced by the high concentrations of sodium (188mg/l, 198mg/l, 180mg/l, 200mg/l respectively), coliform count (17 cfu/ml, 14 cfu/ml, 24 cfu/ml), calcium (220mg/l, 396mg/l, 316mg/l, 228mg/l, 324mg/l 220mg/l) and magnesium (250mg/l, 220mg/l, 240mg/l) values as compared to W.H.O. standards for safe drinking water. This result suggests that the water might have been contaminated due to human activities and random defecation within the spring area.

Keywords: Spring Water, Dry season, Potential, Contamination, Defecation.

INTRODUCTION

A spring is a location where ground water naturally emerges from the earth subsurface in defined flow and in amount large enough to form a pool or stream, Michael (2001).

A spring, also known as a rising or resurgence, is a component of hydrosphere. It is any natural situation where water flows to the surface of the earth from the underground. Thus, a spring is a site where aquifer surface meets the ground surface. Spring water may be as a result of karst topography where surface water has infiltrated the earth surface (recharge area), becoming part of the ground water. The ground water travels through a network of cracks and fissures opening ranging from the inter-granular spaces to large caves. The water eventually emerges from below the surface in the form of a karst springs. The forcing of the springs to the surface can be as a result of confined aquifer in which the recharge area of the spring water table rests at a higher elevation than that of the outlet, La Moreaux et al (2001).

Most of the water that emerges as the springs is meteoric in nature. This means that it originally fell as rain or snow on the surface of the earth. At the hot springs near active volcanoes, some of the water may have originated from magma, molten rock that also contains dissolved substances such as water. As magma cools and crystallizes in the earth crust, it releases much of this water. Spring water also can be ancient, seawater, although it usually dilute with meteoric water, Michael (2001).

Conceptually, the ground water system associated with springs is simple. The springs consist of three components which include:

- An aquifer or sets of aquifers through which the water flows
- A discharge point where water emerges as a spring, Michael (2001).

The existence of springs requires that below the surface (the area commonly called the subsurface); the infiltration water encounters a low permeability zone and is unable to move downwards as fast as it supplied the surface. As a result, the water spreads laterally until it intersects the land surface where erosion has lowered the topography to the water level (e.g. on the side of a canyon).

A range of geological structures and topographic features can direct water to the surface and from a spring, Michael (2001). Many seeps and small spring are associated with topographic depression where the water table intersects the earth surface. Larger springs are usually formed where geological structures such as faults and fractures or layer of low permeability materials forced large amount of water to the surface, Michael (2001). The use of springs and boreholes fitted with pumps has been a major means of getting water to rural communities.

Rivers and lakes are common sources of community water supply, but they may be made very unfit for drinking if the water source and sewage from the town and cities is allowed to drain into them. Rain water takes up dust and gases from the air and organic matter from the roofs over which it is collected. The long storage in the cistern gives bacteria opportunity to grow large numbers causing the water to be unsafe for drinking purposes. While there are many potential benefits of an improved water supply, improved health remains one of the most important. This can only be achieved if accompanied by appropriate hygienic practices such as safe collection, handling as well as other activities which need good water quality.

STATEMENT OF THE PROBLEM

The community existed a long time ago, but the common sources of water supply are manually operated boreholes provided by the government, shallow wells, rivers and spring. Although the community experienced difficulties during dry seasons where the water table goes down leaving only the boreholes as the only source of water supply, but the development of spring water in the community will alleviate the shortage of water supply during dry season and further enhance the quality of water supply.

AIMS

The aim of this research is to carry out quality assessment for domestic water use.

METHODOLOGY

Anwase-Abande village, Live ward 1 (Ikurav – Ya, Iwarev), along Jato-Aka-Ikyogen Road is located within latitude 10^0 0E, longitude 7047'N, and latitude 8^0 8'E, longitude $6^0$25'N, in Kwande Local Government area of Benue state. The project area is a place featuring tropical climate and beautiful scenery of forest, dissected hills dykes, dozens of fast flowering streams and incised valleys. It is a beautiful place for camping, sight viewing and picnicking and located on Nigeria – Cameroun border stretching to the Obudu in Cross River State – Cameroun range.

Water samples were taken from the spring between the months of January and March when the water table is considered lowest. The samples were taken in plastic containers each of 1.5-litre capacity after being properly washed, cleaned and sterilized using sulphuric acid, and again rinsed with distilled water. At the point of collection, each bottle was half-filled with the water sample, shaken and poured away in order to stimulate the containers before being later filled up and covered. A total number of six samples were taken from randomly located points along the spring length at five meters interval and were properly labeled (A – F) as in table 1, to indicate the sample number and point of collection. The laboratory analyses conducted on the water samples include the pH,

temperature, electrical conductivity, turbidity, odour, taste, hardness, carbonate, bicarbonates, chloride and bacteriological examination.

RESULTS AND DISCUSSION

The results of the chemical and bacteriological analyses are presented in Table 1 below:

Electrical conductivity:
The values obtained for all the samples were ranged between 29µs/cm and 60µmhos/cm. These values are within the W.H.O. standard for drinking water as shown in Table 2, and they also satisfied the Nigeria drinking water standard as shown in Table 3. This implied that electrical conductivity test does not reveal any health hazard in using water from the spring as drinking water.

Total dissolved solids:
The total dissolved solids test showed 1800mg/l, 200mg/l, 1800mg/l, 400mg/l, 1600mg/l and 1000mg/l respectively for samples A to F. The W.H.O. standard allows between 500 and 1500. This then means that water samples taken from points A, C and E are not suitable for drinking and pose health hazard in these areas.

Bicarbonate:
The results obtained gave these values, 38.8mg/l, 16.8mg/l, 32.4mg/l, 31.2mg/l, 36mg/l and 108.4 mg/l for samples A to F respectively. These are within the W.H.O. standard of 90-160 mg/l. Water taken from the spring is free from excessive bicarbonates.

pH:
As can be seen in Table 1, the pH values range from 6.56 to 6.92. The W.H.O. standard recommended a value range of 6.5-8.5. The values obtained fell within this range and hence considered suitable for drinking with respect to pH values.

Sulphate:
Samples A to F, after analysis, gave the values 36.9mg/l, 17.9mg/l, 153.7mg/l, 248.3mg/l, 168.7mg/l and 257.9 mg/l respectively. The W.H.O. recommended a minimum value of 200mg/l and a maximum value of 400mg/l. Since the values obtained are all within the safe limits, there appeared to be no sulphate contamination threat for drinking from the wells.

Iron:
The water sample results showed range of values from 0.09mg/l to 0.20mg/l for samples A to F. The W.H.O. standard gave range of 0.1mg/l to 1mg/l, suggesting that the results obtained are within safe limits for iron.

B.O.D.:
Samples A to F have B.O.D. values of 4.5mg/l, 5.5mg/l, 4.0mg/l,5.6mg/l, 3.8mg/l and 5.2mg/l respectively. These compare well with the W.H.O. standard of 5 to 7 and hence the water is free for drinking.

Coliform count:
The coliform count for the samples gave values of 8cfu/ml, 17cfu/ml, 10cfu/ml, 2cfu/ml, 14cfu/ml and 24cfu/ml for samples A to F respectively. W.H.O. standard gives a range 1 to 10 cfu/ml. Samples B, E and F values fall outside of the given range and therefore water from these points are not suitable for drinking.

Sodium:
Samples A to F give values of 100mg/l, 188mg/l, 198mg/l, 180mg/l, 200mg/l, and 106mg/l respectively. However, the W.H.O. standard recommended a sodium value of between 20mg/l to 150mg/l. It therefore shows that samples B, C, D and E whose values are found higher than the recommended values are not suitable for drinking.

Magnesium:
Sample test results for samples A to F showed 128mg/l, 144mg/l, 256mg/l, 220mg/l, 240mg/l and 144mg/l. W.H.O. recommended a range of 30mg/l to 150 mg/l. It then follows that samples C, D and E are not suitable for drinking.

CONCLUSION AND RECOMMENDATION

The spring water at Anwase-Abande village, Live ward 1 (Ikurav – Ya, Iwarev), along Jato-Aka-Ikyogen in Kwande Local Government Area of Benue State Nigeria, were investigated with a view to determining the suitability of water from the spring for drinking, following the proliferation of public toilets and grazing in the area. The concern has been proved by the presence of excessive concentrations of sodium, magnesium and calcium and high coliform count at some of the sampled points. This agrees with USEPA (1980) that sanitation (indiscriminate defecation) contaminate 1% of a nation's usable aquifers. It is recommended that the State Environmental Protection Agency should keep monitoring this situation before hazardous substances accumulate and cause outbreak of water-related diseases of epidemic dimension.

`The spring site should be fenced at least two (2) meters high around the spring area including the spring box to prevent contamination by animals and people who are unaware of the spring location. Flood diversion works should also be carried out around the spring.

Heavy vehicle traffic over the uphill bearing layer should be avoided in other to prevent compaction that may reduce water flow.

REFERENCES

La Moreaux, P. E. and Tanner, Judy T., ed. [2001], springs and bottle water of the world; Ancient history, source, occurrence, quality and use. Berlin, Heidelberg, New York: Springer – Verlag, ISBN 3-540-61841-4.

Michael, M. [2001], Using Spring to Study Ground Water Flow and Active Geologic Processes. Annual Reviews of Earth and Planetary Sciences, p203-230.

United States Environmental Protection Agency [1980], Planning Workshop to Develop Recommendations for Strategy: Appendices, Washington DC.

World Health Organization [1971], International standard for drinking water, Geneva.

WHO/UNICEF [2000], Global water supply and sanitation assessment Report.

WHO/UNICEF: New York.

World Health Organization [1984], International standard for water.

Table 1: Result of chemical and bacteriological analyses on water samples

Parameters	Units	A	B	C	D	E	F
PH		6.92	6.56	6.61	6.75	6.65	6.79
Electrical conductivity	µmhos/cm	60	34	29	0.47	32	49
Calcium Ca^{2+}	mg/l	220	396	316	228	324	220
Magnesium Mg^{2+}	mg/l	128	144	250	220	240	144
Sodium Na^{+}	mg/l	100	188	198	180	200	106
Potassium K^{+}	mg/l	100	100	98	90	94	102
Bicarbornate HCO_3^{-}	mg/l	38.8	16.8	32.4	31.2	36.8	108.4
Chloride Cl^{-}	mg/l	92.3	92.3	92.3	149.1	120.7	120.1
Sulphate SO_4^{2-}	mg/l	316.9	179.7	153.7	248.3	168.7	257.9
Boron	mg/l	1.7	2.5	1.5	0.90	1.3	1.1
Total hardness	mg/l	372	296	240	260	208	328
Iron Fe	mg/l	0.09	0.15	0.11	0.08	0.08	0.02
Total dissolved solids	mg/l	1800	200	1800	400	1600	1000
Total suspended solids	mg/l	600	600	400	1000	1000	800
Total solids	mg/l	2400	1200	2200	1800	2600	1800
B.O.D	mg/l	45	55	40	5.6	3.8	52
C.O.D	mg/l	84.60	106.4	75.20	105.28	71.44	97.76
Coliform count	cfu/ml	8	17	10	2	14	24

Table 2: W.H.O. International Standards for Drinking Water

Acceptable and allowable concentration of Chemical substances

Parameters	Units	W.H.O Guide level	WHO Maximum Permissible Level
Arsenic	mg/l		
*Alkalinity	mg/l		250
Bicarbonate	mg/l	90	160
*B.O.D	mg/l	5	7
Calcium	mg/l	75	200
Carbonate	mg/l		
*C.O.D	mg/l	25	30
*Colour	HAZEN	1	15
Copper	mg/l	0.05	1.5
*Chloride	mg/l	25	200
*D.O		saturated	saturated
*Electrical Conductivity	Us/cm	400	
*Iron	mg/l	0.1	1
Lead	mg/l		
Magnesium	mg/l	30	150
Manganese	mg/l	0.05	0.5
*Nitrate	mg/l	20	25
Odour	-	unobjectionable	-
*PH		6.5-8.5	6.5-8.5
Sodium	mg/l	20	150
Sulphate	mg/l	200	400
Taste	-	unobjectionable	-
Total Solids	mg/l	500	1500
*Total coliform	Cfu/ml	1/100	10/100
*Temperature	oC	12	25
*Turbidity	NTU	0.4	5

Source: W.H.O 1984* and International standard for drinking water Geneva 1971

Table 3: Nigerian Parameters and Maximum Allowable Limits for Drinking Water Including the Health Impact

Parameter	Unit	Maximum Permitted	Health Impact
Aluminum (Al)	mg/L	0.2	Potential Neuro-degenerative disorders
Chloride (Cl)	mg/L	250	None
Chromium (Cr6+)	mg/L	0.05	Cancer
Conductivity	µS/cm	1000	None
Copper (Cu+2)	mg/L	1	Gastrointestinal disorder,
Cyanide (CN-)	mg/L	0.01	Very toxic to the thyroid and the nervous system
Fluoride (F-)	mg/L	1.5	Fluorosis, Skeletal tissue (bones and teeth) morbidity
Hardness (as CaCO3)	mg/L	150	None
Hydrogen Sulphide (H2S)	mg/L	0.05	None
Iron (Fe+2)	mg/L	0.3	None
Lead (Pb)	mg/L	0.01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems
Magnesium (Mg+2)	mg/L	0.20	Consumer acceptability
Manganese (Mn+2)	mg/L	0.2	Neurological disorder
Mercury (Hg)	mg/L	0.001	Affects the kidney and central nervous system
Nickel (Ni)	mg/L	0.02	Possible carcinogenic
Nitrate (NO3)	mg/L	50	Cyanosis, and asphyxia („blue-baby syndrome") in infants under 3 months syndrome") in infants under 3 months
pH	-	6.5-8.5	None
Sodium (Na)	mg/L	200	None
Sulphate	mg/L	100	None
Total Dissolved Solids	mg/L	500	None
Zinc (Zn)	mg/L	3	None
Total Coliform count	cfu/mL	10	Indication of faecal contamination

ENVIRONMENTAL SUSTAINABILITY: IMPROVEMENT OF WATER DISTRIBUTION NETWORK FOR THE FEDERAL POLYTECHNIC BAUCHI, NIGERIA.

Udusuyi, O. Felix[1] and Ahuchaogu, I. Israel[2]
[1]*Department of Civil Engineering, Federal Polytechnic, Bauchi, Nigeria.*
[2]*Department of Agricultural & Food Engineering, University of Uyo, Nigeria.*

ABSTRACT
The study covers the survey of the pipelines, estimation of water requirement and analysis of the reticulation network using Finite Element Method (FEM) to obtain the discharges at the various nodes within the Federal Polytechnic, Bauchi. The study revealed that the terrain of the Polytechnic slopes from north to the south part of the study area. This nature of the terrain made it possible for water in the pipe to flow under gravity when released from the overhead tank. The population projection for the period (2005 – 2025) using geometric progression is 19,732 persons. The total water requirement was estimated at 1,477,226litres per day. The study revealed that some parts of the Polytechnic experience negative flow. The result obtained from the reticulation analysis shows that the proposed pipe size of 100mm is adequate for the distribution with a maximum member discharge of 9.482E-05(L/S/day) at node 30, and the analysis also reveals that a total of 1,350,000L/d of water currently supplied to the community is inadequate as a result of possible increase in population.

Keywords: Water Supply, Reticulation, Finite Element Method (FEM), Water Requirement, Nodes, Pipes, Discharges.

1.0 INTRODUCTION
The Federal Polytechnic Bauchi was established by the policy statement formulated by the then Federal Military Government led by General Olusegun Obasanjo in July of 1979. With an initial student's population of 245 and staff strength of 138, the Polytechnic can now in (2013) boast of about 11,338 of students' population and about 800 staff strength. As the population grows, there is an attendant growth of social amenities of which the forefront of such amenities is water supply. There was a precarious water supply within the Polytechnic community until 1985 when the situation began to improve with the drilling of two boreholes. A water distribution system connected to the two boreholes was put to use in 1986 bringing continuous tap water to the central administration building, some administrative blocks, workshops and some selected laboratories and hostels (male and female hostels). Toward a further improvement of water supply system, a ground and overhead tank with a capacity of 100,000 gallons (400,000 litres) and 60,000 gallons (240,000 litres) respectively as well as a pumping station were erected and took off within this period. Also two ground water tanks with a capacity of 4,000 gallons (16,000 litres) each were put to use for the two units of two-storey students (male) hostel blocks.

Presently staff and students are being served with water by means of direct lines supply from borehole supplemented by a water tanker. Eight boreholes have been sunk on the campus with a 100,000 gallons (400,000 litres) main water reservoir and 60,000 gallons (240,000 litres) main over-head tank with complete pumping station. Just about 60% of the campus has been reticulated with pipelines.

The water distribution network of the Federal Polytechnic Bauchi community is grossly inadequate, thus this research primary aims at evaluating the water distribution network of the community and suggesting ways of obtaining a more efficient distribution

network to enhance efficient water supply. To achieve this, the Finite Element method for analyzing pipe network is adopted.
The improvement of water distribution network for Federal Polytechnic Bauchi is a unique one as this work have not been design by this method adopted.

2.0 MATERIALS AND METHODS

2.1 Study Area.

The Federal Polytechnic Bauchi is located in Bauchi, the State capital of Bauchi State. The school is 14 kilometers to the south-western part of Bauchi town along Bauchi-Dass road which is about 11km away from Wunti gate. It is located on latitude 030^0 $31^{'}$ $30^{"}$ and longitude 090^{o} $00^{'}$ $00^{"}$. It has an area of about 748 hectares. The location plan of Federal Polytechnic Bauchi is shown in figure 1. It provides all necessary facilities for the smooth running of the Institution and for recreation. As a demonstration of its sincerity to staff and students welfare, the Polytechnic has a medical Centre which offers free medical services to the Polytechnic Community. Other services offered by the Polytechnic include Library services, staff school, Bus Services and sports and Games facilities.

2.2 Design Methods

A pipe network is a set of pipes which are interconnected so that the flow from a given input or a given outlet may come through several different routes. The methods involved in pipe networking include, Newton-Raphson, Linear theory (Larry, 2001), Finite Element (Rajasekkaran, 1990; Vasudeva, 1987; Hassan et al, 1991 and Kutas et al, 1997), Equivalent pipe, Nonlinear and the Hardy Cross (head balance and quantity balance) methods.

2.2.1 Finite element method

Finite element method which represents a newer technique has been used mainly for the analysis of problems in structural engineering. At the present time these methods have not been so widely adopted by hydro-geologists and in water resources engineering. This is possibly due to the fact that the basis of finite elements is more difficult for hydro geologists and others field of engineering to grasp, being based upon unfamiliar concepts such as the principle of minimum energy. The basic data required for the analysis are the pipe size, lengths of pipes, consumption at each nodes and the connectivity of the pipes. The system reach at the nodes and discharges through the elements are the unknown. The network is visualized as a sense of pipe (elements). The method can be approached in two ways; the linear approach which is based on the poisseulli equation for laminar flow which gives a linear relationship between energy loss and discharge or the non- linear approach which is based on Hazen Williams or Darcy-Weisbach formula which describes the turbulent nature of the network flow between two nodes. The study employed the non- linear method because of the assumption of turbulent flow of water and Darcy-Weisbach formula is used in the non-linear method to obtain the value of the network characteristics matrix, k , Hassan et al (1991) and Kutas et al (1997). Below is the formula used for the computation of the element.

$$\begin{Bmatrix} Q_K^{\,i} \\ Q_j^{\,i} \end{Bmatrix} = K^i \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} H_K \\ H_j \end{bmatrix} \quad \text{.....1}$$

Where Q = discharge (ms^{-1}), H = head (m)

The value of the constant k, is obtained using the formula shown below

$$K = \frac{1.73944 D^{2.5}}{f^{0.5} L^{0.5}} \quad \text{.....2}$$

D = pipe diameter (m), L = length of pipe (m), f = frictional factor
and the element matrix equation is obtained as in equation 1 above. Due to the complexity that accompanied solving these equations manually, the equations were evaluated through a computer programme. This was done by employing the results of the survey work, careful linking of the pipe network stating the pipe diameter and the friction factor of the pipe used. Some of the consumptions were made at the nodes and assumed head. The Compac Visual Fortran program developed by Salau (2007) was used to obtain the consumption of water, pipe diameter and pressure required at a particular node. This is achieved by inputting into the software the parameters needed for the program to run. These parameters are the number of nodes, coordinates of the nodes, element connectivity, boundary nodes, loaded nodes and other parameters to obtain the value of k as in equation 2. This will be used to determine the various discharges and consumptions along each distribution element.

2.2.3 Selection of pipe materials

The principal pipe materials recommended for water line are cast iron, galvanized iron, copper, Brass, Asbestos cement, steel coated with bitumen, Reinforced concrete, vitrified clay and wood, polythene and polyvinyl chloride (PVC). The selection of the required pipe materials for this study is based on some important factors such as: Durability, type of liquid to be transmitted, Resistance to corrosion and erosion, strength, cost of pipe, cost of handling and layout, type of joint, its water tightness and assembly, site condition, availability, local material and cost of maintenance. For the purpose of this study PVC pipes are chosen because they are known to be widely used, for urban, suburban and rural water supply network because of their high resistance to corrosion, consequent long life and probably low cost. Under normal conditions, they can be expected to last up to 50years or more. The diameter of pipes used for the distribution network are 100mm, 125mm, 150mm, 200mm and 250mm in diameter. The main pipes diameter lies between 150mm – 250mm while the sub-main diameter ranges from 100mm to 125mm.

2.2.4 Method of population estimate

The population of a given community can be estimated using the different known methods. The methods of forecasting the population includes the graphical, Arithmetic, Geometric, incremental, Uniform percentage, Declining growth, Logistic, Curvilinear/ Comparative, Ratio and Correlation methods. In this study, the geometric method was adopted. The result expected at the end of the chosen method is influenced by economic factors, Development programmes, social facilities, communication links, Tourism, community life, and some unforeseen factors (Punmia, et al 1995 and Basak, 2004). Al-Layla (1978) said in addition to the above factors, Births, Deaths, Migration and Immigration also affects the population of a given community. Other Authors such as Steel (1979) and Kamala (1993), also gave the methods of population estimate. The current population of students and staff as at the time of the study was obtained from the school's records inclusive of the assumed figure to cater for the population of the surrounding communities also depending on the boreholes as source of water.

3.0 RESULTS

From the topographical map of the Polytechnic obtained, it was observed that the terrain of the land sloped from the northern part to the southern part of the school and this signifies that water in the pipes can flow under gravity. The population of the study was obtained using the geometric projection for the period of twenty years. This amount to 19,732 people within the period under study as against 12,138 people currently and an

average of 120l/d was used to estimate the total amount of water required for consumption. From the output obtained after executing the computer programme, it was observed that the water demand for the Polytechnic community is 1,833,484.8litre per day, using a pick factor of 1.5 of daily rate. From the summary of water requirement it was discovered that for effective, efficient and low cost laying of pipes, the number of overhead tanks and boreholes should be increased. The capacity of the overhead tank should double the exiting one in view of the fact that the population of the student is increasing yearly so as to meet the demand at some critical areas such as the boys and girls hostels where the source of water and discharge is both $0.1m^3/s$ or 0.0001l/s, it was found that the discharges at these points are far less than expected. Also the borehole numbers should be increased so that the demand for water at all nooks and crannies of the institution should have water supply. The Polytechnic clinic required 2200l/day but this demand is not met. The Laboratories requires 160,000L/d but this quantity was not attained. The workshops and laboratories were not left out of water shortage such as soil and material laboratory, fluid mechanics laboratory, which requires about 120,00L/d. The residential areas had the worst experience as most of the quarters were not supplied with enough water as the pressures were below the expected values.

The demand of water supply for office requirements were not met as the only school tanker was used to supply water to smaller overhead tanks attached to these buildings. The Polytechnic staff school partially enjoys the water supply with low pressure but not up to the required estimate. The pipe network diagram is shown in Fig 2. And it involves a skeletal system of supplied mains from the water elevated tank to various areas of water consumption within the polytechnic campus. The software used for the analysis of flow in the pipe is the Finite Element Method. The result obtained shows (tables 1 – 3) that there is no flow through the pipes in quarter B as the negative indicates no flow or redirection of flow and the pipe diameter of 250mm gives a better nodal and member discharges. The parameters used for running the Visual Fortran programme are shown in Appendix 1. The result obtained shows a negative flow in the pipe of quarters B, from node 17-21. This situation can be attributed to the high elevation of the area in question which consequently reduced the pressure of flow from the overhead tank.

4.0 DISCUSSION

The study covers the determination of the nodal coordinates from the survey data, computation of the Element Connectivity, computation of system Equations, Continuity Equations, and the Element Matrix Equations ,determination of water lines, population estimates, water requirement of the Polytechnic, design of overhead water tank, design of underground tank, analysis of watersamples, analysis of the reticulation network, using Finite Element Method to obtain the discharges at the various nodes within the Polytechnic. The population projection for the period (2005 - 2025) using geometric progression is 19,743 persons. The total water requirement was estimated as 1,477,226 litres per day.The study revealed that some parts of the Polytechnic experience negative flow. The result obtained from the distribution analysis shows Table 1 – 3, that the proposed pipe size of 100mm is adequate for the distribution with a maximum member discharge of 9.482E-05 (m^3/s) at node 30, and the analysis also reveals that a total of 1,350,000 L/d of water currently supplied to the community is inadequate as a result of possible increase in population.

5.0 CONCLUSION

The findings from the work shows that the distribution system (loop) is considered satisfactory, as water will flow by gravity from the elevated service tank to all the nodes through the proposed reticulation network system, which will cope with

present and future population with adequate implementation.

REFERENCES

Al layla, M.A, Ahmed,S. and Middlebrooks,J.E (1978).Water supply Engineering design, Ann Arbor science publishers.

Basak,N.N(2004). Enviromental Engineering. Second Edition, Tata McGraw-Hill Publishing Company Limited.Pp11-17, 47-52.

Hassan, A.M, Abdel W. H and Isam M.A.M. (1991). Analysis of Pipe Network by the Finite Element Method: Water International, Vol 16 Issue 2 1991. Pp 96 -99.

Kamala, A.(1993). Environmental Engineering. Water Supply, Sanitary Engineering and pollution. Tata .Mc Graw Hill Publishing Company Ltd. New Delhi

Kuta, R. and E. Ciupailaite (1997). The Finite Element Approach for the Analysis of flow in Pipe Network. XIII Polish Conference on Computer method in Mechanics, 5 – 8 May, 1997.

Larry, W. M (2001). Water Resources Engineering First Edition. John Wiley and Sons, New York, N.Y. Pp343-347, 409-468.

Punmia, B.C, Ashok ,J. and Arun, J(1995). Environmental Engineering-1, First Edition, Shri Prem Singh Sankhla Ltd. Pp140-165, 504-535.

Rajasekarans, S(1990). Finite Element Analysis in Engineering Design. S. Chand and company ltd, 7361, Ram Nagar, New Delhi-110055. Pp 2-11.

Salau O.B.E (2007). Compaq Visual Fortran (version 6.0) [Electronic software] Compaq Computer Corporation Houston, Texas.

Steel,E.W.and Terence.J. Mcghee(1999). Water Supply and Sewage, fifth edition, International Student edition, Mc Graw Hill Kogakusha Ltd.

UNECE Technical Information Report.(http://www.unece.org/env/water/test/text protocol.htm)

UNICEF, (1975). Rural Water Supply. Fourth Edition. John Wiley and Sons.

United Nations Environmental Programme. (UNEP).

Vasudeva, B. and Rao (1987). Finite Element Analysis of Flow Networks Engineering Analysis, Volume 4 issue 1 March, 1987 pg 35 – 39.

Wikipidia encyclopedia (2003). http://en.wikipedia.org/

World Bank technical report series No18,1981

World Health Organization Dec. 5 , 2003 http://www.who.org

APPENDIX 1 Element Connectivity

ELEMENT	INITIAL NODE	FINAL NODE	DIAMETER (m)
1	1	2	100
2	2	3	100
3	2	34	100
4	3	33	100
5	3	4	100
6	4	32	100
7	4	5	100
8	5	30	100
9	5	6	100
10	6	28	100
11	6	7	100
12	7	8	100
13	8	9	100
14	28	8	100
15	27	9	100
16	9	10	100
17	10	23	100
18	23	13	100
19	10	11	100
20	11	12	100
21	12	13	100
22	13	14	100
23	24	23	100
24	25	24	100
25	34	33	100
26	33	32	100
27	32	31	100
28	31	20	100
29	31	30	100
30	30	29	100
31	29	28	100
32	28	27	100
33	22	15	100
34	20	21	100
35	25	22	100
36	19	20	100
37	19	18	100
38	18	17	100
39	17	16	100
40	16	15	100
41	21	22	100
42	30	21	100
43	27	26	100
44	27	28	100
45	26	25	100

Table 1: Consumption Of Water Using Polyvinyl Chloride (PVC) Pipe

Node	pipe1 (0.100m)	Pipe2 (0.125m)	pipe3 (0.150m)	pipe4 (0.200m)	pipe5 (0.250m)
1	5.86E-03	2.26E-03	7.70E-04	3.85E-04	5.38E-04
2	5.86E-03	2.26E-03	7.70E-04	3.85E-04	5.38E-04
3	5.96E-03	2.31E-03	8.31E-04	4.41E-04	5.70E-04
4	6.15E-03	2.39E-03	9.40E-04	5.30E-04	6.21E-04
5	6.13E-03	2.46E-03	1.27E-03	9.69E-04	8.18E-04
6	6.16E-03	2.54E-03	1.49E-03	9.15E-04	7.47E-04
7	1.01E-02	3.79E-03	1.97E-03	1.10E-03	8.22E-04
8	1.28E-02	4.62E-03	2.29E-03	1.22E-03	8.73E-04
9	1.97E-02	6.87E-03	3.28E-03	1.67E-03	1.15E-03
11	1.46E-02	5.46E-03	2.88E-03	1.80E-03	1.34E-03
12	1.40E-02	5.29E-03	2.83E-03	1.84E-03	1.37E-03
13	1.22E-02	4.78E-03	2.68E-03	1.83E-03	1.44E-03
14	1.22E-02	4.78E-03	2.68E-03	1.83E-03	1.44E-03
15	5.91E-03	2.78E-03	2.01E-03	1.45E-03	1.48E-03
16	6.49E-03	2.93E-03	1.83E-03	1.13E-03	1.31E-03
17	7.33E-03	3.16E-03	1.90E-03	8.39E-04	1.22E-03
18	7.82E-03	3.29E-03	1.60E-03	5.18E-04	1.04E-03
19	8.26E-03	3.42E-03	1.26E-03	1.97E-04	8.62E-04
20	8.95E-03	3.60E-03	1.23E-03	-1.11E-04	7.22E-04
21	5.68E-03	2.55E-03	1.66E-03	1.67E-03	1.48E-03
22	5.10E-03	2.56E-03	1.94E-03	1.74E-03	1.58E-03
23	9.08E-03	3.87E-03	2.42E-03	1.79E-03	1.57E-03
24	3.75E-03	2.38E-03	2.00E-03	1.84E-03	1.78E-03
25	1.85E-03	1.85E-03	1.85E-03	1.85E-03	1.85E-03
26	1.41E-03	1.41E-03	1.41E-03	1.41E-03	1.41E-03
27	2.50E-05	2.50E-05	2.50E-05	2.50E-05	2.50E-05
28	1.93E-03	7.60E-04	4.32E-04	2.79E-04	2.23E-04
29	4.01E-03	1.64E-03	9.79E-04	7.12E-04	5.83E-04
30	5.61E-03	2.32E-03	1.40E-03	1.05E-03	8.61E-04
31	6.27E-03	2.53E-03	5.07E-04	-5.02E-04	3.63E-04
32	6.24E-03	2.49E-03	7.39E-04	1.47E-06	5.29E-04
33	5.71E-03	2.27E-03	6.34E-04	2.21E-04	4.56E-04
34	5.81E-03	2.32E-03	6.97E-04	2.80E-04	4.90E-04

Table 2: Nodal Discharge Of Water Using Polyvinyl Chloride (PVC) Pipe

Node	pipe1 (0.100m)	pipe2 (0.125m)	pipe3 (0.150m)	pipe4 (0.200m)	pipe5 (0.250m)
1	-3.41E-08	-7.08E-08	9.40E-08	1.86E-07	-2.32E-07
2	-1.69E-05	-3.97E-05	-2.95E-05	-4.19E-05	-6.75E-05
3	-3.28E-05	-5.01E-05	-5.95E-05	-8.70E-05	-1.31E-04
4	7.58E-05	4.86E-05	6.42E-05	9.55E-05	1.15E-04
5	1.49E-06	1.84E-05	4.83E-05	3.77E-04	4.86E-04
6	-9.57E-07	2.43E-05	8.67E-05	6.37E-06	1.63E-05
7	1.04E-06	9.61E-07	8.82E-07	1.08E-06	1.15E-06
8	-4.14E-07	-2.73E-07	3.06E-07	8.90E-07	4.36E-06
10	-4.81E-06	-3.97E-06	-2.90E-06	-1.32E-04	7.90E-06
11	7.33E-07	6.38E-07	4.87E-07	6.35E-05	-1.32E-06
12	2.64E-06	2.30E-06	1.76E-06	1.01E-04	-4.78E-06
13	1.50E-06	1.29E-06	8.70E-07	9.89E-06	-2.94E-06
14	-3.83E-08	-2.71E-08	9.81E-08	-1.19E-07	3.09E-07
15	7.05E-07	5.84E-07	1.16E-04	5.37E-05	1.15E-04
16	-7.97E-07	-6.61E-07	-1.16E-04	-6.08E-05	-1.31E-04
17	1.17E-06	9.72E-07	1.58E-04	9.07E-05	1.82E-04
18	1.97E-07	-2.33E-06	2.06E-05	1.62E-05	2.89E-05
19	-9.25E-07	1.73E-06	-1.20E-04	-7.30E-05	-1.33E-04
20	1.81E-04	1.72E-04	1.95E-05	-3.70E-04	-3.13E-04
21	-4.21E-06	-4.86E-05	-1.89E-05	3.12E-04	3.07E-04
22	6.66E-06	4.87E-05	1.06E-04	2.08E-04	1.21E-04
23	9.24E-07	5.99E-07	3.34E-07	-4.27E-05	-9.05E-07
24	-6.66E-06	-5.84E-06	-4.49E-06	2.47E-06	1.22E-05
25	-2.15E-04	-1.19E-04	2.57E-05	5.34E-04	1.29E-03
26	2.47E-06	4.68E-06	7.83E-06	1.76E-05	3.15E-05
27	-4.96E-04	-5.63E-04	-6.92E-04	-1.22E-03	-1.99E-03
28	-9.97E-06	-1.01E-05	-1.04E-05	-1.77E-05	-2.93E-05
29	8.13E-07	9.08E-07	1.13E-06	2.20E-06	3.69E-06
30	3.20E-06	6.18E-06	3.18E-04	7.72E-04	7.91E-04
31	-4.55E-06	-5.52E-06	-3.95E-04	-1.08E-03	-1.15E-03
32	1.09E-05	8.47E-06	6.19E-05	1.05E-04	2.34E-04
33	-5.24E-05	-4.65E-05	-1.18E-04	-1.85E-04	-3.52E-04
34	1.54E-05	3.75E-05	2.69E-05	3.85E-05	6.16E-05

Table 3: Member Discharge Of Water Using Polyvinyl Chloride (PVC) Pipe

Node	pipe1 (0.100m)	pipe2 (0.125m)	pipe3 (0.150m)	pipe4 (0.200m)	pipe5 (0.250m)
1	-3.41E-08	-7.08E-08	9.40E-08	1.86E-07	-2.32E-07
2	-2.36E-05	-2.69E-05	-5.68E-05	-1.21E-04	-1.59E-04
3	6.65E-06	-1.29E-05	2.74E-05	7.94E-05	9.17E-05
4	1.78E-05	8.84E-06	5.01E-05	1.22E-04	1.50E-04
5	-7.42E-05	-8.58E-05	-1.66E-04	-3.30E-04	-4.41E-04
7	6.19E-06	-2.80E-05	-1.29E-04	-3.48E-04	-3.96E-04
8	1.30E-05	9.79E-06	-1.77E-05	-2.72E-05	-3.63E-05
9	-5.31E-06	-1.93E-05	-6.30E-05	5.63E-05	1.26E-04
10	5.94E-05	6.53E-05	7.92E-05	1.30E-04	2.15E-04
11	-6.56E-05	-6.04E-05	-5.54E-05	-6.77E-05	-7.21E-05
13	-1.81E-04	-1.76E-04	-1.79E-04	-2.50E-04	-3.39E-04
15	-1.96E-04	-1.98E-04	-2.11E-04	-3.12E-04	-4.60E-04
16	1.63E-04	1.43E-04	1.10E-04	-6.04E-05	-2.99E-04
17	9.92E-05	8.76E-05	6.78E-05	-4.57E-05	-1.84E-04
18	-6.40E-05	-5.56E-05	-4.25E-05	-2.76E-05	1.16E-04
19	5.92E-05	5.14E-05	3.93E-05	-1.47E-04	-1.07E-04
20	5.99E-05	5.21E-05	3.98E-05	-8.31E-05	-1.08E-04
21	6.25E-05	5.44E-05	4.15E-05	1.78E-05	-1.13E-04
22	3.83E-08	2.71E-08	-9.81E-08	1.19E-07	-3.09E-07
23	-1.64E-04	-1.44E-04	-1.11E-04	6.08E-05	3.00E-04
24	-1.57E-04	-1.38E-04	-1.06E-04	5.83E-05	2.88E-04
25	2.20E-05	2.46E-05	5.43E-05	1.18E-04	1.53E-04
26	-1.26E-05	-1.31E-05	-1.36E-05	5.44E-05	-4.82E-05
27	-6.33E-06	-1.39E-05	7.50E-05	2.73E-04	2.56E-04
28	-6.90E-05	-7.39E-05	-9.67E-05	-1.50E-04	-2.65E-04
29	5.81E-05	5.45E-05	-2.23E-04	-6.58E-04	-6.31E-04
30	7.80E-05	8.71E-05	1.09E-04	2.11E-04	3.53E-04
31	7.88E-05	8.80E-05	1.10E-04	2.13E-04	3.57E-04
32	1.22E-04	1.30E-04	1.52E-04	2.55E-04	4.08E-04
33	-5.37E-05	-4.45E-05	-3.46E-05	2.06E-04	2.02E-04
34	5.82E-05	5.44E-05	-5.29E-05	-2.87E-04	-3.13E-04
35	-1.11E-04	-8.24E-05	-3.72E-05	9.63E-05	3.17E-04
36	-5.33E-05	-4.42E-05	2.43E-05	2.33E-04	2.65E-04
37	5.24E-05	4.59E-05	-1.44E-04	-3.06E-04	-3.97E-04
38	5.26E-05	4.36E-05	-1.23E-04	-2.89E-04	-3.69E-04
39	5.38E-05	4.46E-05	3.46E-05	-1.99E-04	-1.86E-04
40	5.30E-05	4.39E-05	-8.12E-05	-2.59E-04	-3.17E-04

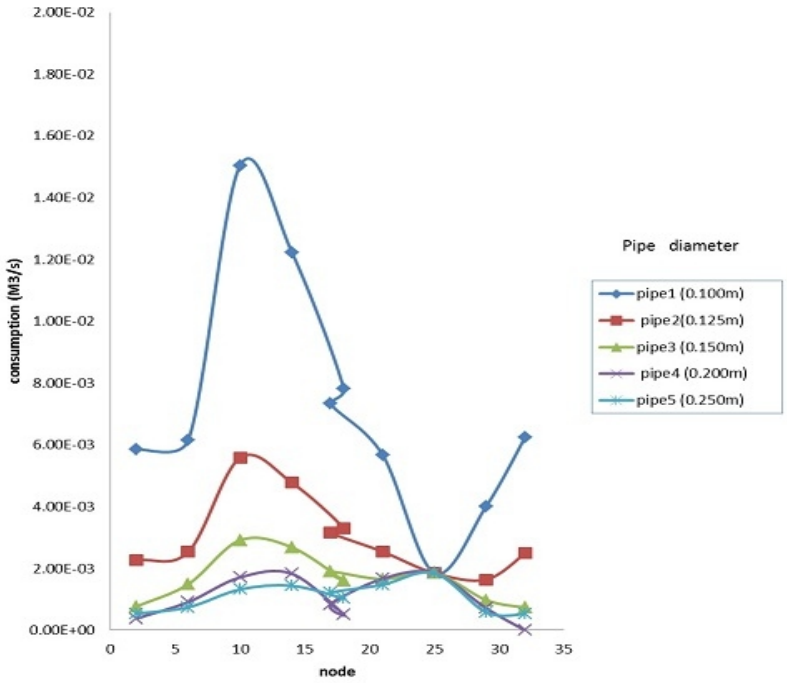


Fig. 3: Nodal Discharge Versus Nodes Using PVC Pipe

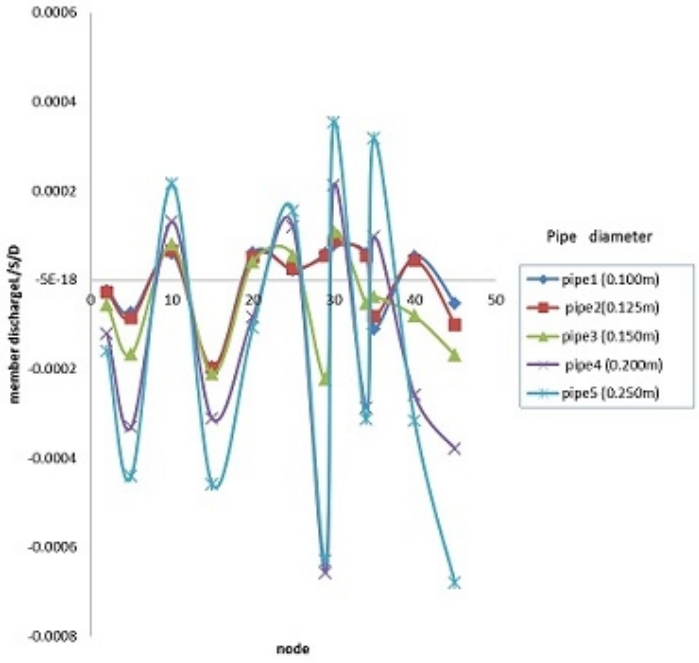


Fig 4: Member Discharge Versus Node For PVC Pipe

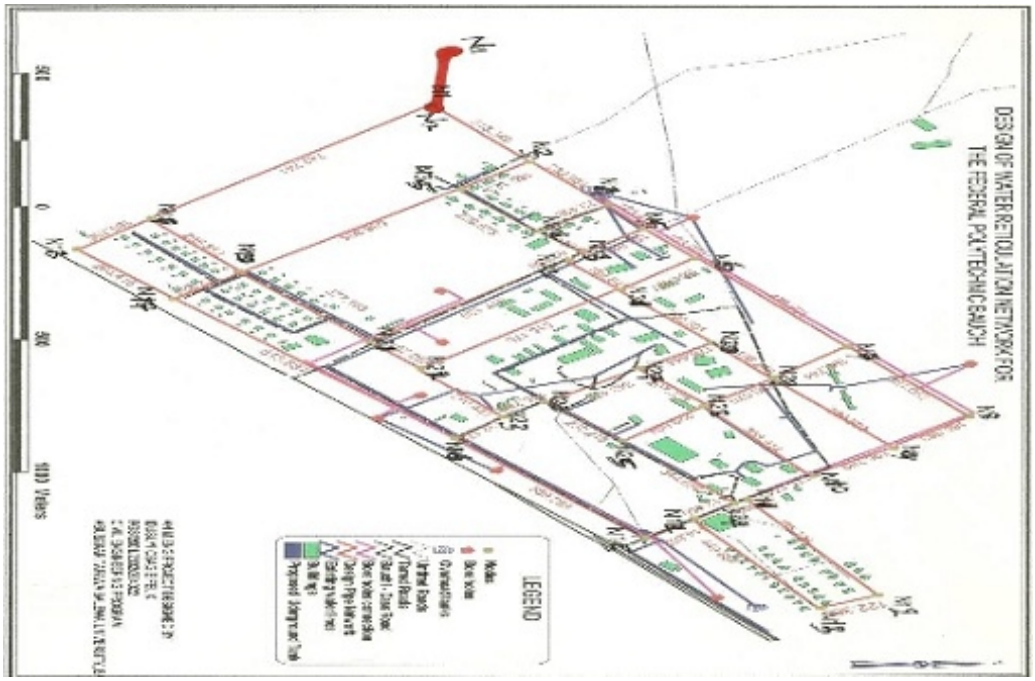


Fig 5: Designed Pipe Network For The Polytechnic Community

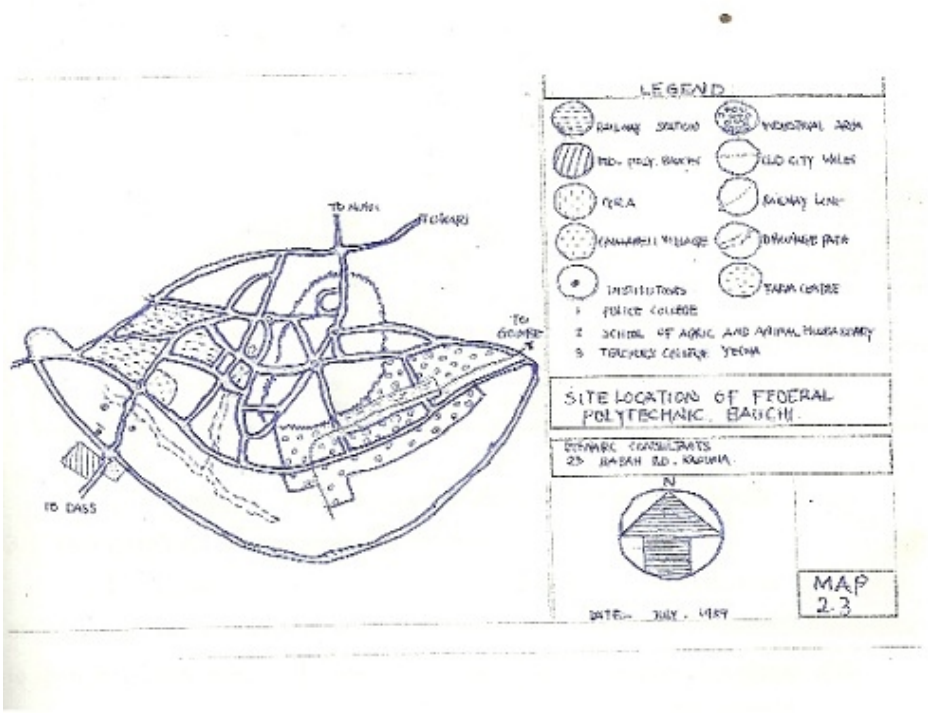


Fig. 2: Topographic Map Of Federal Polytechnic Bauchi

ESTIMATION OF THE VOLUME OF SOIL DISTURBED IN THE CASSAVA TUBER ZONE IN LOAMY SOIL DURING CASSAVA HARVESTING

[1]Ogunjirin, O. A., L. A. S. Agbetoye[2] and O. C. Ademosun[2]
[1]National Centre for Agricultural Mechanization, Ilorin, Nigeria
[2]Federal University of Technology, Akure, Ondo State
ntslola@yahoo.com, 08075508029

ABSTRACT
In the development of a viable harvesting tool, there is the need to know the actual weight that the soil tool would be working against. However, the volume of soil displaced in the soil is cumbersome and difficult to determine. Therefore, an experiment to estimate the volume of soil displaced during cassava tuber uprooting was carried out on a loamy soil at the National Centre for Agricultural Mechanization in the 2012 farming season. The lofting modelling, an important method for 3D object creation was employed for the modelling of the full shape of the cassava tuber to reproduce the hull accurately despite the irregular shape of the cassava tuber and the soil above the tuber. The analysis of the field data using least square regression method generated a model equation with which the volume of the soil displaced could be estimated having known the soil bulk density, soil moisture content, soil shear strength and the volume of cassava tuber harvested.

Keywords: Cassava Tuber, Lofting, Harvesting, Soil Volume, Soil Tool

1.0 INTRODUCTION

Cassava is gaining the desired attention since it became widely known that it possesses the potential to eradicate hunger. In tropical Africa, root and tuber crops still constitute important components in traditional diets. In rural areas, there is usually an adequate supply to meet any local demand from the surplus production of subsistence farmers and by local trade. Roots and tubers are widely grown and consumed as subsistence staples in many parts of Africa, Latin America, Pacific Islands and Asia. However, the production volume is highest in Africa with Nigeria as the world highest producer of cassava and yam. The most produced tuber crop in Nigeria is cassava with annual metric tonnage of 37.5 million followed by yam with annual metric tonnage of 29.2 million (FAOSTAT, 2012).

During manual harvesting of cassava tubers, the stem is cut at about 30 cm from the ground surface. It is with this stem that the cassava tuber is pulled out of the soil. In the course of harvesting, there is a minimum force required to be generated before the soil covering the tuber fails by shearing. This shearing causes some failure lines in the soil covering the tuber. Studies have further revealed that the soil failure path is assumed to be trapezoidal in nature during cassava harvesting (Agbetoye et. al., 2000).

To estimate the soil volume and soil weight disturbed during harvesting had been a very cumbersome exercise. This however had created bottlenecks in the study on profitable, practicable, cost effective and durable cassava lifter. With a suitable methodology to estimate the volume and weight of the disturbed soil in root zone during harvesting in the field, researchers would be properly guided in further studies on the development of cassava lifting coefficient. In order to forge ahead, a modelling procedure for the design of boat was studied for possible application in the study.

Designing boats using solid modelling dated back to the 17th century. Sections were formed by many curves using drawing instruments such as compass. Thereafter, the

designer would employ shifting moulds based on mild section form, so that one set of frame moulds could be used by shifting butts to form all the frames. The use of half-models in lieu of the reduced scale drawing originated in Europe by the early 18th century (Encarta, 2009). It involves carving a model from a solid block of wood for the designing of commercial boatyards and shipyards. The sections required to form the mould shape controlling the hull shape of the boat are obtained by sawing the mould at the designed transverse mould stations and scaling off these sections by drawing ordinates.

Builders developed a model consisting of a blackboard cut to the shape of the hull profile, with the sections formed of a thin plank secured at the desired mould stations. Lofting is an important method for 3D object creation. It creates shape of object to serve as a path using any number of cross-sectional shapes. The path becomes the framework that holds the cross-sections forming the loft object. Lofting consists of drawing the full-size shape of the hull (cassava tuber) on a suitable platform or floor, which are tested by drawing in some longitudinal curves such as the level lines. In making the longitudinal drawing, the profile of the hull is drawn in full size. Lofting has been employed in boat building in the 18th century because it allows design to be reproduced accurately.

Considering the irregular shape of cassava tuber in the soil, it becomes expedient to adapt this lofting technique to model the actual cassava shape with which the volume would be estimated. This procedure would also be applied for the determination of the volume of soil displaced during cassava harvesting in the field having known the path of soil failure.

In order to come up with a viable and cost effective harvester, there is the need to estimate the volume of soil displaced by the cassava tuber. It is the weight of the soil and the weight of the cassava tuber that needed to be overcome before harvesting is effective. There is, therefore, the need to come up with appropriate method of estimating the volume of soil displaced during harvesting of cassava tuber. This has been very difficult to obtain in the field, thus, the application of other scientific methods of determination of the parameters would be a welcome development in the effort to come up with a cost effective cassava tuber harvester. Therefore the objective of this work is to estimate the volume of cassava tuber and estimate the volume of disturbed soil during cassava tuber harvesting.

2.0 METHODOLOGY

The experiment was carried out during the 2012 farming season at the research farm of the National Centre for Agricultural Mechanization (NCAM), Ilorin (826'N430'E). Ahaneku and Ogunjirin (2005) reported that Ilorin lies within the southern Guinea Savannah agro ecological zone of Nigeria and is characterized by a tropical climate with distinct wet and dry seasons and mean annual rainfall of about 1000mm.

The cassava field was established in the 2010 farming season by planting 0581 specie of cassava stem cuttings acquired from Root and Tuber Expansion Programme station in Ajase Ipo, Kwara State after the field was conventionally tilled. Fertilizer (NPK: 20:10:10) was applied on the cassava field at the rate of 200kg/ha. After eighteen months, the field was fully matured for harvesting. It was at this point that the outlined approach was followed to take the cassava tuber and soil failure parameters in the field: -

i). Acquisition and installation of AutoCAD 2010 software which had the lofting feature which was required to form the exact shape of the soil and the cassava tuber shapes during harvesting;

ii). Collection of relevant data for the cassava tuber which were: -

- Height of the cassava tuber at the cross-sectional diameter, "h" in mm
- Corresponding horizontal distance of the cassava relative to the stem of the cassava plant.

iii). Collection of parameters at different sections across the cassava tuber uprooted. This formed the points at which the cassava tubers were modelled using the lofting feature.

iv). Collection of relevant field data for the soil disturbed/sheared during harvesting, which were: -

- The width, height and Corresponding Horizontal Distance, CHD, of the soil disturbed from the woody part where it joined to the stem. Various measurement points during cassava tuber harvesting were taken for soil modelling.
- The diameter at each point where the above readings were taken were also measured and recorded.
- With these data, the soil formation and shape were determined.

v). Estimation of the volumes of the disturbed soil and cassava tubers using the lofting feature of the AutoCAD software.

vi). Calculations of the bulk densities of the soil and cassava tubers.

vii). Estimation of the weights of the disturbed soil and the cassava tubers using the relationship

$$\rho v = m$$

Where: -

m=weight (g)
V=Volume (mm^3)
ρ= density (g/mm^3)

The field measurements were used to obtain the placement cross-sectional diameters and the heights of the cassava tubers in the soil. These points were lofted to give the exact shape of the cassava tuber in the soil when the cassava tuber was pulled out of the soil. For the soil, the data obtained from the field was used to draw the 2-Dimensional shape of the soil. The lines were thereafter converted to polylines which was lofted along the corresponding horizontal distance.

In order to cross-check the accuracy of the procedure the actual weight of the cassava tuber was obtained using digital weighting scale. The percentage error is thereafter calculated using the expression below:

$$\% \text{ error} = \frac{\text{Actual weight of cassava - Estimated weight of cassava}}{\text{Actual weight of cassava}} \subset \text{ع}$$

Also in order to obtain the estimated actual volume of the soil disturbance, the shape of the cassava tuber formed under the soil surface was subtracted from the shape of the modelled soil.

Important assumptions and considerations:

i. The cassava plot soil was left undisturbed to take care of tough field conditions;
ii. The cross-sectional diameter of cassava tuber is circular; and
iii. The soil disturbance is from the centre of height of the cross-sectional diameter of the cassava tuber.

3.0 RESULTS AND DISCUSSION

The laboratory analysis of the soil sample taken from the field revealed that it is a loamy soil. The result of the analysis is as tabulated below.

Data collection and analysis:

The matured cassava field was manually harvested in other to study, identify and take relevant measurement along the line of soil failure. These measurements were taken at different soil moisture content which varied the soil bulk density. The soil and cassava tuber data collected is as detailed in Table 2. Forty nine samples of soil and cassava tubers data were collected at varied soil physical conditions, these were modelled to obtain the appropriate shape and position of the cassava tuber in the soil. It is with this model that the volume of the cassava tuber and soil were obtained using the lofting feature of the AutoCAD 2010 software. The figurative description of the soil and cassava tuber modelled in the soil for the forty nine samples are as represented below.The data were subjected to statistical analysis using least square regression method. From the analysis, volume of soil displaced was significantly influenced by the soil physical properties such as bulk density and soil shear strength, the cassava tuber properties such as moisture content of cassava and the volume of the cassava tuber. This showed that all the factors mentioned contributed to the volume of soil displaced during cassava tuber harvesting.

The coefficient of multiple determination showed that 74.9% of the volume of soil displaced is accounted for by the soil properties and also the cassava tuber been harvested. The analysis of variance (ANOVA), which was utilized to test the acceptability of the model from statistical point of view, was significant at 5% level indicating that the model is adequate.

The coefficient of regression model that defined the individual contribution of the volume of soil displaced, the soil physical properties and cassava tuber physical properties were significant at 5% level implying that the soil and cassava tuber properties have direct contribution to the volume of soil displaced. The model equation for the estimation of volume of soil displaced is:

$$V_{SD} = -9.28\times10^{6} + 1.31\times10^{9} BD_S \times MC_S - 1.46\times10^{6} BD_S \times V_C - 1.33\times10^{4} SS_S \times MC_S + 1.53\times10^{1} SS_S \times V_C - 5.02\times10^{2} MC_S^{\,2} + 5.43\times10^{-1}$$

Where:

V_{SD} = Volume of soil displaced,
BD_S = Bulk density of the soil,
MC_S = Moisture content of soil,
V_C = Volume of cassava, and
SS_S = Soil shear strength.

The graphical illustration in figure 3 below showed the plot of the observed volume of soil displaced and the predicted volume of soil displaced. It is observed that there is little or no visible difference in the observed and the fitted or predicted curve concluding that the model can be utilized to adequately predict the volume of soil displaced using the soil physical properties and the cassava properties.

4.0 CONCLUSION

An experiment to estimate the volume of soil displaced during cassava tuber uprooting was carried out on a loamy soil at the National Centre for Agricultural Mechanization in

the 2012 farming season. The analysis of the field data using least square regression method generated a model equation with which the volume of the soil displaced could be estimated having known the soil bulk density, soil moisture content, soil shear strength and the volume of cassava tuber harvested.

REFERENCES

Agbetoye, L. A. S, J. Dyson and J. Kilgour (2000). Prediction of the Lifting Forces for Cassava Harvesting. Journal of Agricultural Engineering Research. Vol. 75:39-48.

Ahaneku, I. E. and O. A. Ogunjirin (2005). Effect of Tractor Forward Speed on Sandy Loam Soil Physical Conditions during Tillage. Nigerian Journal of Technology. Vol. 24(1):51-57.

FAOSTAT (2012). Food and Agricultural Commodities Production accessed online at http://faostat.fao.org/site/339/default.aspx.

Microsoft Encarta Premium 2009.

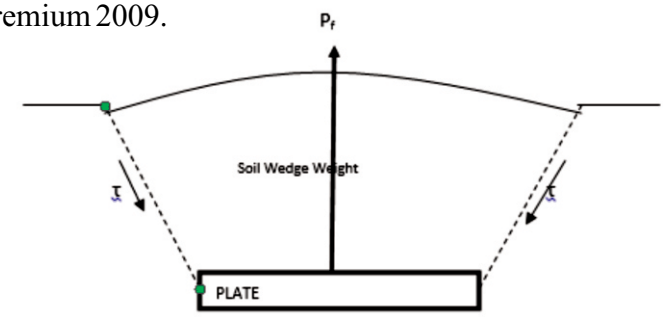


Fig. 1. Qualitative Model As The Plate Is Lifted Out Of The Soil
Source Agbetoye et. al. 2000

Table 1. Soil Sample Analysis Result

S/No	Parameters	Value
1.	pH	5.6
2.	Nitrogen (%)	2.54
3.	Organic Carbon (%)	2.43
4.	Organic Matter (%)	2.63
5.	Sand (%)	82.8
6.	Silt (%)	5.0
7.	Clay (%)	12.2
8.	Texture ($USDA_{std?}$)	Loamy Soil
9.	Calcium (mg/kg)	172.55
10.	Magnesium (mg/kg)	197.43
11.	Sodium (mg/kg)	126.77
12.	Potassium (mg/kg)	149.67
13.	Acidity (mg/kg)	10.1
14.	Phosphorus (mg/kg)	20.33
15.	Cation Exchange Capacity (CEC) (meq/100g)	64.67



Fig. 1. Established Cassava Field

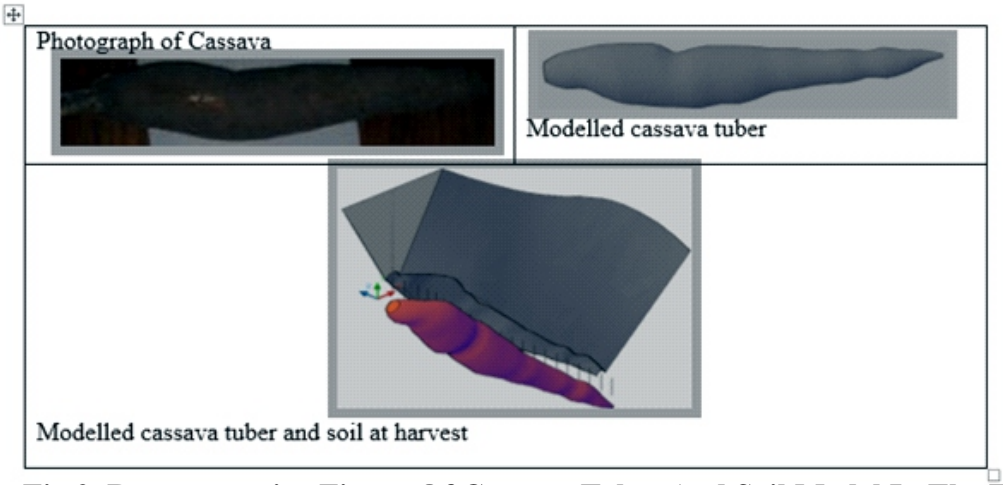


Fig.2. Representative Figure Of Cassava Tuber And Soil Model In The Field

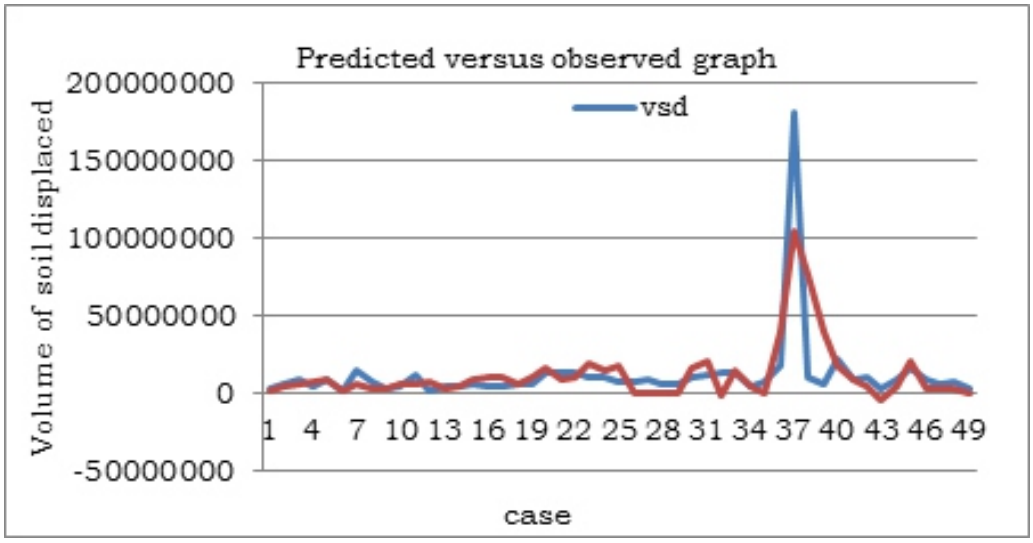


Fig. 3. Graph Of Predicted Volume Of Soil Versus Observed Graph

Table 2. Soil And Cassava Tuber Data Measured In The Field

S/N	SOIL MOISTURE CONTENT @ 0-21 DEPTH (%)	SOIL BULK DENSITY (0-21 DEPTH) (gmm^{-3})	SOIL SHEAR STRESS (0-21 DEPTH) (Nmm^{-2})	SOIL CONE INDEX (0-21 DEPTH)	MASS OF CASSAVA (g)	CASSAVA BULK DENSITY (gmm^{-3})	CALC VOLUME OF CASSAVA (mm^3)	SIMULATED VOLUME OF CASSAVA (mm^3)	PERCENTAGE ERROR (%)	ESTIMATED VOLUME OF SOIL DISPLACED (mm^3)
1	8.82	0.00183	42.90	34.87	1448.96	0.0011347	1.27×10^6	1.36×10^6	6.22	3.58×10^6
2	8.82	0.00183	42.90	34.87	1272.70	0.0011347	1.12×10^6	1.21×10^6	7.54	5.72×10^6
3	8.82	0.00183	42.90	34.87	1184.13	0.0011347	1.04×10^6	1.05×10^6	0.92	8.84×10^6
4	8.82	0.00183	42.90	34.87	602.58	0.0011347	5.31×10^5	4.98×10^5	6.28	4.28×10^6
5	8.82	0.00183	42.90	34.87	708.78	0.0011347	6.25×10^5	6.08×10^5	2.60	8.61×10^6
6	8.81	0.00174	36.90	35.23	359.71	0.0011347	3.17×10^5	2.87×10^5	9.43	2.09×10^6
7	8.81	0.00174	36.90	35.23	628.19	0.0011347	5.54×10^5	5.87×10^5	5.99	1.47×10^7
8	8.81	0.00174	36.90	35.23	1219.70	0.0011347	1.07×10^6	1.12×10^6	4.32	7.05×10^6
9	8.81	0.00174	36.90	35.23	470.60	0.0011347	4.15×10^5	4.74×10^5	14.21	2.95×10^6
10	7.23	0.00165	59.13	57.90	566.75	0.0011347	4.99×10^5	5.07×10^5	1.47	4.06×10^6
11	7.23	0.00165	59.13	57.90	1068.62	0.0011347	9.45×10^5	9.92×10^5	5.42	1.22×10^7
12	7.23	0.00165	59.13	57.90	1030.74	0.0011347	9.08×10^5	9.13×10^5	0.48	1.70×10^6
13	7.23	0.00165	59.13	57.90	1288.54	0.0011347	1.14×10^6	1.23×10^6	7.02	4.48×10^6
14	7.23	0.00165	59.13	57.90	507.20	0.0011347	4.47×10^5	4.89×10^6	9.44	4.33×10^6
15	7.56	0.00171	70.10	67.57	626.60	0.0011347	5.52×10^5	6.15×10^6	11.36	6.05×10^6
16	7.56	0.00171	70.10	67.57	780.80	0.0011347	6.88×10^5	7.51×10^5	9.19	4.56×10^6
17	7.56	0.00171	70.10	67.57	1000.23	0.0011347	8.81×10^5	9.91×10^5	12.43	4.37×10^6
18	5.59	0.00165	127.33	100.00	395.71	0.0011347	3.49×10^5	3.83×10^5	9.72	5.57×10^6
19	5.59	0.00165	127.33	100.00	530.66	0.0011347	4.68×10^5	5.13×10^5	9.59	5.79×10^6
20	5.59	0.00165	127.33	100.00	1240.04	0.0011347	1.09×10^6	1.06×10^6	3.26	1.35×10^7
21	5.59	0.00165	127.33	100.00	460.31	0.0011347	4.05×10^5	4.05×10^5	0.10	1.39×10^7
22	5.59	0.00165	127.33	100.00	545.07	0.0011347	4.80×10^5	5.11×10^5	6.41	1.36×10^7
23	6.40	0.00157	147.67	138.00	1038.87	0.0011347	9.15×10^5	9.63×10^5	5.23	1.09×10^7
24	6.40	0.00157	147.67	138.00	683.64	0.0011347	6.02×10^5	6.51×10^5	8.04	1.03×10^7
25	6.40	0.00157	147.67	138.00	1157.35	0.0011347	1.01×10^6	1.08×10^6	5.78	8.32×10^6
26	1.48	0.00164	193.33	104.89	448.98	0.0011803	3.80×10^5	4.00×10^5	5.22	7.18×10^6
27	1.48	0.00164	193.33	104.89	488.33	0.0011803	4.14×10^5	4.34×10^5	4.85	8.76×10^6
28	1.48	0.00164	193.33	104.89	446.18	0.0011803	3.78×10^5	3.87×10^5	2.44	6.71×10^6
29	1.48	0.00164	193.33	104.89	570.15	0.0011803	4.83×10^5	4.98×10^5	3.24	6.85×10^6
30	1.24	0.00158	129.67	225.33	771.51	0.0011136	6.92×10^5	7.14×10^5	3.14	1.09×10^7
31	1.24	0.00158	129.67	225.33	1114.03	0.0011136	1.00×10^6	1.03×10^6	1.58	1.17×10^7

COMPARISON OF SOME FILTER MEDIA FOR WATER FILTRATION TREATMENT

Tolubanwo, S. E., Ogbuagu, A. E and Kadurumba, C. H.
National Root Crops Research Institute, Umudike, P. M. B. 7006, Umuahia, Abia State, Nigeria.
E-mail: engrtolubanwose@gmail.com Phone: +2348037630702

ABSTRACT
The research paper compares the performance of three local filtration media using charred coconut shell, hard coal and slow sand for respect to water treatment plant. Water samples were collected for water analysis from Otamiri River in Owerri, Imo State prior to the research work and assessed of its microbial qualities. Two approaches were used in carrying out comparison of some filter media for water filtration treatment: specific gravity (Gs) and void ratio (e), and its depth variations from 9cm, 6cm and 2.5cm, 5cm and 7.5cm respectively. Total coliform count, suspended solids and the total dissolved solids were parameters determined on the water samples after passing them through the filtration media with gradual reduction in depths at interval of 0.5cm; that is from 9.0cm to 6.0cm, and gradual increment in depth from 2.5cm, 5.0 to 7.5cm respectively. The results obtained showed higher removal rate of faecal coliform, suspended solids and total dissolved solids for smaller filter media sizes and at higher media depths. The first approach charred coconut shell, hard coal and sand at 6cm depth with void ratio of 0.16 achieved 100%, 97.9% and 89.5%, and total coliform removal rate respectively. The second approach, charred coconut shell, hard coal and sand at 7.5cm depth achieved 0 cfu/ml of faecal coliform and 0.2 cfu/ml total bacteria count, 0.4 cfu/ml of faecal coliform and 19.8 cfu/ml and 1.8 cfu/ml faecal coliform and 24.8 cfu/ml total bacteria count respectively. The results show that charred coconut shell filter gave the best result.

Keywords: Filtration Media, Specific Gravity, Void Ratio, Water Treatment And Microbial Analysis.

1.0 INTRODUCTION
The provision of potable water for drinking and other household uses is very important in any society, particularly in developing nations where large numbers of the population do not have access to regular water supply. The treatment of water to achieve portable water is not an easy task. In Nigeria efforts are being made by Government and individual in the treatment of contaminated water to make it fit for drinking. Different methods have been used by researchers for the treatment of contaminated water. In this work emphasis was placed on water treatment by filtration method using hard coal, slow sand and charred coconut shell as filtration media. The objective of this work is based on comparison of the performances of the three local filter media namely: hard coal, slow sand and charred coconut shell. The use of the filtration media to remove harmful impurities like organic contaminants from water is an appropriate technique for making surface water safe for intended use when surface water is readily available. This is so because surface waters are characterized by high suspended particles which could be readily trapped by the charred coconut shell, slow sand and hard coal beds [1, 3, and 4]. The science and technology behind charred coconut shell, slow sand and activated carbon filters have been exhaustively dealt with several researchers [5, 6, and 7].

Activated carbon is the generic term used to describe a family of carbonaceous adsorbents with a highly amorphous form and extensively developed internal pore structure. [1, 2].

Due to their high carbon content and hardness, coconut shells are an excellent raw material source to produce activated carbon. Activated carbons that are produced using coconut shells as the raw material are often sourced in geographic regions where coconuts are harvested, including India, Malaysia, Sri Lanka, and the Philippines [9]. Activated carbon is extremely porous with a very large surface area, which makes it an effective adsorbent material. This large surface area relative to the size of the actual carbon particle makes it easy to remove large amounts of impurities in a relatively small enclosed space.

The purification of water by physical method has been based on sand and sometimes on combination of sand and activated carbon. Contaminated water can be treated by the process of clarification (screening, aeration, flocculation, sedimentation) and filtration. In contaminated water, some of the bacteria present in water are harmless to man, while others are pathogenic or disease producing. Epidemics of typhoid fever, dysentery and cholera are caused frequently by contaminated drinking water. There is every need therefore to treat our water before use.

2.0 MATERIALS AND METHODS

Activated carbon is produced from coconut shells in a two-step process.

The first step in activation is to carbonize the shells to drive about two-thirds of the volatiles out of the shells, creating a carbonaceous mass full of tiny pores.

In the second stage, this carbonized base material is activated at high temperature (1,100°C/2,012°F) in steam. Activation temperature and the amount of activation time are important to create the internal pore networks and to impart certain surface chemistries (functional group) inside each particle. In essence, the total activation process gives carbon its unique adsorption characteristics.

2.1 Preparation Of The Coconut Shell Charcoal

The process of carbonization is to convert coconut shells to char or charcoal.

The charring process (the making of charcoal) is known as pyrolysis, which is the chemical decomposition of the shell by heating in the absence of oxygen During the carbonization of coconut shells, volatiles amounting to 70 percent of the mass of the coconut shells are released into the atmosphere, yielding 30 percent of the coconut shell mass as charcoal. The volatiles released during the carbonization process are methane, CO_2, water vapour and a wide range of organic vapours, [7, and 9]. Coconut shells are carbonized in an age-old process commonly known as the open-pit method. In this process, earth is used as an insulator and to heat the shells in the absence of oxygen. The pit charcoaling cycle consists of three stages:

1. Pyrolysis phase. Over 12 hours long, when gases are released.
2. Pacification phase. When the pit is closed and the char is cooled for 12 hours.
3. Unloading. Final step where charcoal is unloaded and fresh shells are loaded for the next production cycle.

The temperature maintained in the process is vital for complete pyrolysis. Experiments have shown that the charcoal yield is directly proportional to the temperature in the pits. In addition, the amount of methane released into the atmosphere is directly related to the temperature in the pit.

By and large, pits yield 30 percent char, which means they maintain a temperature of 500°C (932°F). Several experiments have been conducted to measure the amount of gases released; on average, one million ton (MT) of coconut shells releases about 12 to

15 Kg of methane into the atmosphere [10]
Mechanically in a standard sieving machine. The machine was made up of close-fitting receiving pans and cover. Its operation is in a rotary horizontal and vertical direction by tapping on the hard surface until sieving is practically completed.

2.2 The Preparation of Hard Coal Particulates

The hard coal is a hard, non brittle, coarse black substance. The coal was collected directly from Enugu coal station at Okpara Rom location. Coal was formed from the vegetation of the carboniferous era which was protected from complete decay by overlying water washed earth deposits [11].

For the filtration process, the hard coal was crushed into smaller particulates in order to have smaller sizes. The crushed coal was sieved with the aid of mechanical sieve until particulate size of about D_{90} was obtained. The sieved coal was collected and enclosed in one of the cylindrical container as shown fig 2.1

2.3 The Preparation of Filtration Sand

The slow sand was collected from management Board, Umuahia. The sand was coarse with diverse colours from light brown to dark sand and of various sizes. However, the sand was mechanically sieved in order to obtain a uniform size of D_{90} meant for the filtration treatment of water as shown in fig 2.1.

2.4 Test Procedure

The raw water to be filtered was initially analyzed to determine the level of the following contaminates: Faecal coliform count, total bacteria c total dissolved solids and suspended solids contained in the water. This was used to determine the filtration medium that will be most effective in filtering/treating the water by comparing their initial values with their respective values at the end of the filtration.

2.4.1 Determination of the values of the contaminants

The method by which the values of the contaminants were determined is as follows:

2.4.2 The Filtration experiment

The reservoir was placed on a table of 100cm height so that the water can flow by gravity into the filtration compartment which was also placed on a table of 50cm height as shown in fig 2.1. With the aid of the 12.7mm T- joint and 12.7mm elbow, the 12.7mm PVC pipes which served as distributors were connected from the reservoir to the filtration chamber. The stop valve was used to regulate the outflow of the water from the reservoir into the filtration chamber. With the aid of 3nos. 12,7mm elbow, the water from the reservoir was connected to the filtration chambers via the 7,5cm, 7cm, 6.5cm, and 6cm respectively as well as 2.5cm, 5cm and 7.5cm respectively. Note that two approaches where used in the text. The first approach was the use of depths of 9cm down to 6cm by squeezing (compacting) the filtration medium to determine the void ratio. While the second approach of depths variations of 2.5cm, 5.0cm and 7.5cm without squeezing (compacting) the filtration medium was used. The filtrates were collected below the filter media in the same chamber using well sterilized containers.

2.4.3 Determination of void ratio, e of the filter materials

All the containers used were first of all calibrated in thickness as well as volume so that both the depths and the volume can be read off. The filter materials (Sand, Charred coconut shell and coal) were weighed and filled in the 3nos of the 7liters containers to the depth of 9cm or $3x10^{-3}$ m^3 with the aid of filter cloth. At this level, water was passed through it from the water tank and the filtrates collected. This same depth of the filter

materials were reduced to 8.5cm or $2.83x10^{-3}m^3$ by squeezing the filter cloth. This is way of compacting the filter materials to reduce the air spaces. At this depth water was passed through it and the filtrates collected. The same process was repeated at 8cm, 7.5cm, 7cm, 6.5cm and 6cm or $2x10^{-3}m^3$. The filtrates collected were analyzed at the UNICEF IMO STATE office.

2.4.4 Determination of specific gravity of the filter materials

A 25cm3 volumetric flask was weighed empty with the cap on. The various filter materials were separately put in the flask and their weights were recorded. The flask was than washed to remove all the particles. Distilled water was introduced into the flask to the 25cm3 mark and allowed to stand for one hour and the weight recorded. The distilled water was removed from the flask and a sample of sand was re-introduced into the volumetric flask mark. Distilled water was then introduced into the sand gradually and allowed to seep until the sand was fully saturated. This was left to stand for one hour and the weight was recorded. The same process as repeated for hard coal and charred coconut shell.

3.0 RESULTS AND DISCUSSIONS

The results obtained from the experiment are shown in tables 2 and 3. These tables consists of the filtration of contaminated water at various depths and determinations of filters void ratio e, While table 4 consist of the microbial test results of the raw water and the filtered water.

In table 2, charred coconut shell filter at 6cm removed the faecal coliform from 19cfu/ml to 0cfu/ml, while hard coal filter reduced the faecal coliform from 19cfu/ml to 0.4cfu/ml and sand filter from 19cfu/ml to 2cfu/ml. From that same table 2, charred coconut shell at 6cm removed suspended solids from 7mg/l to 2.5mg/l while hard coal reduced it to 28mg/l and sand reduced it to 3.7mg/l.

The total dissolved solids of charred coconut shell, hard coal and sand filtrate at 6cm are 20mg/l, 21.5mg/l and 28mg/l respectively. These results fell within the WHO limit. Table 3 showed the determination of void ratio, e of charred coconut shell filter, hard coal filter and slow sand filter respectively. From the table, it be seen that charred coconut shell filter and hard coal filter have approximately the same void ratio altogether which is 0.16, while that of sand filter is 0.28. The formula used to calculate the void ratio:

$\mathbf{e} = Gs\,(1+w)\,p_{w/}p$

e = void ratio, Gs =Specific gravity of filter materials, w = water content (%)

P_w = Density of water ($1000kg/m^3$), bulk density (kg/m^3)

In the second test, the filter depths were adjusted from 2.5cm to 5.0cm and finally to 7.5cm with the filtration media directly added to the filtration chamber at the required level, with no force exerted on the media. The depth adjustment enables us know the significance of depth of filter material in the purification of water without compaction. Table 4 shows that charred coconut shell filter at 7.5cm removed the coliform count from 19.2cfu/ml to 0cfu/ml, with bacteria count from 89.6cfu/ml 0.2cfu/ml. Table 5 shows that hard coal filter at 7.5cm reduced faecal coliform count from 19.2cfu/ml to 0.4cfu/ml with bacteria count from 89.6cfu/ml to 19.8cfu/ml. comparing results in tables 4 and 5 shows that the filtrate from charred coconut shell filtration medium contains less f. coliform and total bacteria count than the hard coal. The results obtained, shown in table 6 with f. coliform count of 1.8cfu/ml and total bacteria count of 24.8cfu/ml, at 7.5cm depth, sand as a filtration medium is less effective and cannot produce clean water that meets WHO limit. This implies that the higher the height of a filtration medium, the more effective the purification process becomes because the adsorption of impurities increases with increase in the surface area.

4.0 CONCLUSION

Based on the results obtained in the experiment, charred coconut shell filter removed 97 to100% of the contaminants found in the raw water and therefore it is a good filtration medium. Also, charred coconut shell removed 100% the microbial contaminants more when compared with hard coal and filtration sand filters. With all these, it is concluded that;

1. Charred coconut shell is an effective water filtration treatment medium looking at the WHO water treatment.
2. Although both hard coal and slow sand may be used for filtration, they require addition of some chemicals, such as chlorine to meet WHO water treatment. The physical and chemical analysis was carried out but could not be included in this paper as a result of space.
3. This equipment can be used for water filtration with any of the filtration media at a depth of 7.5cm or more and void ratio of 0.16.

REFERENCES

Andy Krause. 2012. Coconut shell on steroid. New GE water filters using carbon from burnt coconut shell filters meds from tap water.

Dike, B.U. 2009. Coliform and turbidity removal using slow low cost sand filters by official journal of Nigeria society of engineer, Owerri branch. Volume 4, no.2.

Dr. P.A Shankar. 2012. Coconut shell based activated carbon with no g4reen house gas emission. OEC-201204/ Environmental issues.

Federal Republic of Nigeria. 2004. National water policy. Federal Ministry of Water Resources, Abuja.

Michigan State University Extension. 1997. Home water treatment using Activated carbon.

Theodore, L. B and L. H. Eugene Jr. 1998. Chemistry, the central prentice hall Englewood cliffs new jersey.

Utah Division of wildlife Resource, Effect of sand size on filtration of triactinomyxons (Tams), Utah, 2000.

www.activatwedcarbonxk.com/product-knowledge/coconut-shell-based-activated-carbon-application.html

www.water.siemens.com/sitecollectiondocuments/product-line/westates-carbon/brounchures/coconutvscoal.pdf

Table 1: Determination of contaminants

S/NO	Contaminants	Method of determination
1	Faecal coliform count	McCaskey broth
2	Total dissolved solids	Evaporation and weighing
3	Suspended solids	Titration

Table 2: Results Of Filtration Treatment Of Contaminated Water At Various Depths

Contami Nants	Filter materials	Value of contaminant Before	Value of contaminants after treatment at depths of						
			9cm		8.5cm 6.5cm	8cm	7.5cm 6cm		7cm
Faecal Coliform	1.Filtration Sand	19 (cfu/ml)	6.5	5.3	4.2	3.8	2.75	2.25	2.0
	2.Charred Coconut Shell	19 (cfu/ml)	3.6	2.7	1.7	1.0	0.5	0.2	0.0
	3.Hard coal	19 (cfu/ml)	40	3.4	2.5	1.3	1.0	0.52	0.4
Suspended Solids	1.Filtration Sand	7 (mg/l)	5.5	5.1	4.6	4.2	4.0	3.8	3.5
	2.Charred Coconut Shell	7 (mg/l)	3.8	3.4	3.1	2.9	2.7	2.6	2.5
	3.Hard Coal	7 (mg/l)	4.1	3.7	3.5	3.17	3.0	2.87	2.8
Total dissolved solids	1.Filtration Sand	48 (mg/l)	40	36.7	35	33	30	28.8	28
	2.Charred Coconut shell	48 (mg/l)	30	25	23	22.8	21.5	20.5	20
	3.Hard Coal	48 (mg/l)	32	28	25	24	23	22	21.5

Table 3: Determination Of Filters Void Ratio, E
a. Slow Sand Filter

Filter depth (cm)	Vol. of sand, v ($x10^{-3}$)	Mass of dry sand M_d(kg)	Mass of wet sand M_w(kg)	Water content (W)	Specific gravity (Gs)	Bulk density (P) (kg/m^3)	Void ratio, e
9.0	3.00	4.30	4.65	0.081	2.76	1550	0.93
8.5	2.83	4.30	4.65	0.081	2.76	1643.11	0.82
8.0	2.66	4.30	4.65	0.081	2.76	1748.12	0.71
7.5	2.49	4.30	4.65	0.081	2.76	1867.47	0.60
7.0	2.33	4.30	4.65	0.081	2.76	1995.71	0.50
6.5	2.16	4.30	4.65	0.081	2.76	2152.78	0.39
6.0	2.00	4.30	4.65	0.081	2.76	2325	0.20

b. For Charred Coconut Shell Filter (CCSF)

Filter depth (cm)	Vol. of CCSF (V) ($x10^{-3}$)	Mass of dry CCSF, M_d (kg)	Mass of wet CCSF M_w (kg)	Water content (W)	Specific Gravity (Gs)	Bulk density (P) (kg/m^3)	Void ratio, e
9.0	3.00	2.10	2.27	0.295	1.22	906.67	0.74
8.5	2.83	2.10	2.27	0.295	1.22	961.13	0.64
8.0	2.66	2.10	2.27	0.295	1.22	1022.56	0.55
7.5	2.49	2.10	2.27	0.295	1.22	1092.37	0.45
7.0	2.33	2.10	2.27	0.295	1.22	1167.38	0.35
6.5	2.16	2.10	2.27	0.295	1.22	1259.26	0.26
6.0	2.00	2.10	2.27	0.295	1.22	1360	0.16

c. For Hard Coal Filter

Filter depth (cm)	Vol. of HCF (V) ($x10^{-3}$)	Mass of dry HCF, M_d (kg)	Mass of wet HCF M_w (kg)	Water content (W)	Specific Gravity (Gs)	Bulk density (P) (kg/m^3)	Void ratio, e
9.0	3.00	2.20	2.83	0.286	1.28	943.33	0.75
8.5	2.83	2.20	2.83	0.286	1.28	1000	0.65
8.0	2.66	2.20	2.83	0.286	1.28	1063.91	0.55
7.5	2.49	2.20	2.83	0.286	1.28	1136.55	0.45
7.0	2.33	2.20	2.83	0.286	1.28	1214.59	0.36
6.5	2.16	2.20	2.83	0.286	1.28	1310.19	0.26
6.0	2.00	2.20	2.83	0.286	1.28	1415	0.16

Table 4 : Microbial Test Result Of The Charred Coconut Shell Filtrate

Test No.	Faecal Coliform count (cfu/ml) Depth of filter (cm)			Total bacteria count (cfu/ml) Depth of filter (cm)		
	2.5	5.0	7.5	2.5	5.0	7.5
1	05	0	0	40	10	0
2	04	0	0	39	10	0
3	05	01	0	39	11	01
4	05	01	0	40	9	0
5	0	0	0	40	10	0
Average	3.8	0.4	0	39.6	10	0.2

Table 5: Micobial Test Result Of The Hard Coal Filtrate

Test No.	Faecal Coliform count (cfu/ml) Depth of filter (cm)			Total bacteria count (cfu/ml) Depth of filter (cm)		
	2.5	5.0	7.5	2.5	5.0	7.5
1	08	05	0	51	30	20
2	08	06	0	50	31	19
3	09	05	01	51	31	20
4	08	05	01	51	30	20
5	09	05	0	49	30	20
Average	8.4	5.2	0.4	50.4	30.4	19.8

Table 6 :microbial Test Result Of Slow Sand Filtrate

Test No.	Faecal Coliform count (cfu/ml)			Total bacteria count (cfu/ml)		
	Depth of filter (cm)			Depth of filter (cm)		
	2.5	5.0	7.5	2.5	5.0	7.5
1	06	03	02	58	50	25
2	05	03	02	57	50	24
3	06	04	01	59	51	25
4	06	04	03	58	50	26
5	07	03	01	58	50	24
Average	06	3.4	1.8	58	50.2	24.8

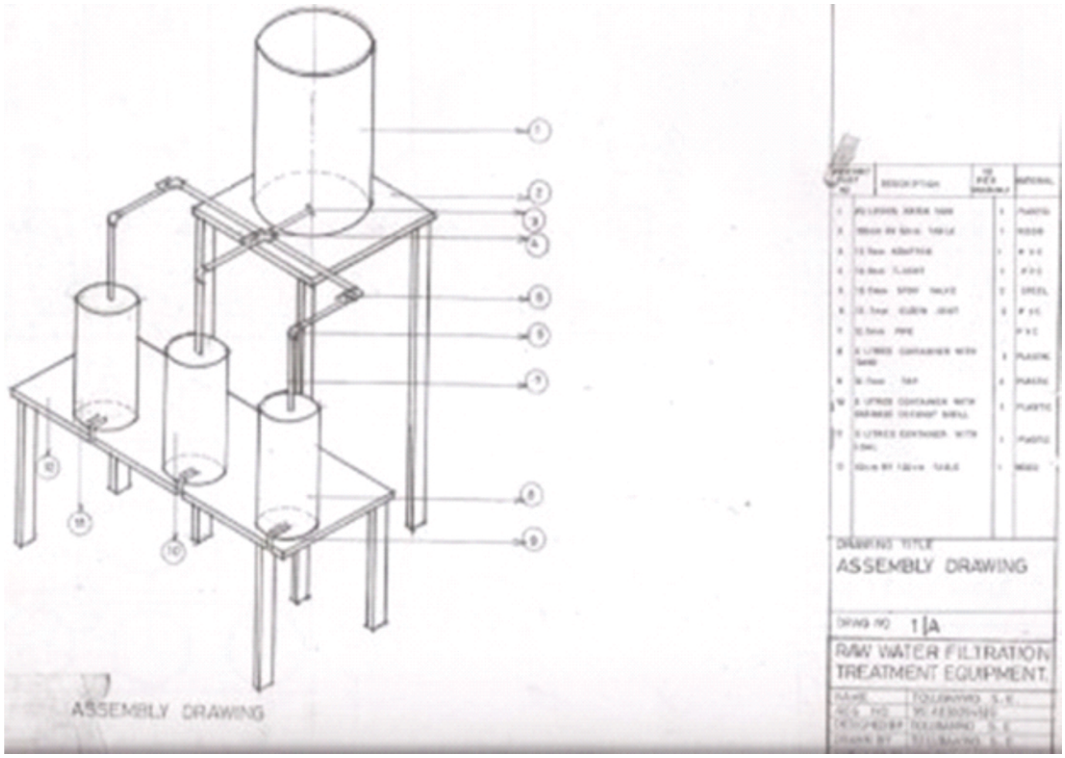


Fig 2.1: Assembly Drawing Of Raw Water Filtration Treatment Equipment

DEVELOPMENTS OF SELF PURIFYING CASSAVA PRODUCTION SYSTEM IN THE IMPROVEMENT OF WATER BUDGETING PRACTICES IN NIGERIA

EWEMOJE Temitayo Abayomi and OMOTOSHO Olayinka Akinola
Agricultural and Environmental Engineering Department, Faculty of Technology, University of Ibadan, Ibadan
ta.ewemoje@mail.ui.edu.ngtayo_ewemoje@yahoo.co.uk
akintoshforever@yahoo.com

ABSTRACT
The study reported the volume of water employed in processing cassava through fermentation process to be 1,525l/ton while that for non-fermentation process is 965l/ton. Total annual water use for cassava processing was examined using three scenarios in the ratio of fermentation to non-fermentation processes i.e. 30:70, 50:50, 70:30 respectively. Total water use for first, second and third scenarios were 104,951.36 million litres, 100,195.20 million litres and 95,639.04 million litres respectively. After treatment process of 8hrs, a comparison of quality characteristics of treated wastewater was made with FEPA interim standard on discharge for all classes of industry and also standards for irrigation water. The outcome indicate that after adsorption, all the parameters considered met minimum requirements for safe discharge with the exception of suspended solids; this was however further treated with incorporation of a sedimentation tank after adsorption chambers to separate the suspended particles. Treated water also met the standard for irrigation use for agricultural purposes. Based on the tested physical parameters, the treatment method can be well suited for the treatment of cassava industry effluent. The study concludes that if self-purifying processing technology is used, substantial volume of water could be conserved for other uses such as irrigation and groundwater recharge thereby improving water budget.

Keywords: Water Budget, Cassava Waste-water Treatment, Activated Carbon, Self-Purification Technology.

1.0 INTRODUCTION
One of the most common staple food crops in most tropical countries, including Nigeria is cassava (*Manihot esculenta* Crantz). Ugwu and Odo (2008) stated that it is the 7th most important food crop in the world and constitutes a staple food for about 12.50% of the world population. According to Nwaogwu *et.al*, (2011) the annual cassava production is about 84 million tonnes. According to Obadina *et.al*, (2006), cassava peels account for up to 10 % of the wet weight of cassava tubers. However, some authors (Jekayinfa and Olajide, 2007; Kniper et al., 2007) have reported that with hand peeling which is common among subsistence farmers, volume of the peels could be as high as 20% of the total weight of the tuber. Considering the above information on cassava production in Nigeria this implies that with hand peeling process which is predominantly used, annual cassava peel production could be as high as 16.8 million tonnes of cassava peels. This large volume of waste could be a source of problem especially in cassava processing communities; however recent research (Omotosho, 2012) shows that this cassava peels can be processed into activated carbon and further used in the effective treatment of wastewater from the same industry.

Water is very essential for survival and balance of ecosystem on planet earth. The earth's surface is covered by 70% of water of which 97.5% are from oceans and seas which are usually regarded as being too salty for consumption and agricultural purposes. It is also observed that of the remaining 2.5% of water, 68.7% exists as glaciers and ice-caps, 30.1% is ground water, 0.43% is permafrost thus leaving about just 0.77% fresh water for consumption and agricultural use (Czarra, 2003). Water is also a vital resource, which human activities depended upon in the areas such as agriculture, industry, transportation, domestic uses etc. (Awomeso, 2010). However, water represents the most abused, poorly managed and polluted resource by human activities (Fakayode, 2005).

Nigeria is adjudged the most populous country in Africa with an estimated population of over 140 million. The country is endowed with generous water resource. The span of water bodies within the country is estimated at 900 km^2 (Ekiye and Luo, 2010).

1.1 Rainfall, Agricultural Production and Water Resources for Irrigation

Going by FAO (2001) statistics between year 1970-2000, the area of land under irrigation increased from less than 200 million ha to more than 270 million ha worldwide. Out of Nigeria's total land mass of about 923,768 km^2, survey by Japan International Cooperation Agency (JICA) in the 1980s showed that 39% (360,269.52km^2) of the Nigerian land mass is potentially suitable for agriculture, of this land mass, between 4.0 and 4.5 million ha (approximately 4.5 to 5.0% of the land) are adjudged suitable for irrigated agriculture.

According to Omogbai (2010), when considering water requirement by various crops, rainy days appears to be relatively more important than the amount. However the number of rainy days have increasingly become erratic due to global warming phenomenon (Julius *et.al,* 2012) thus making rainfall prediction unreliable there is therefore urgent need to salvage as much of this resource as possible and use it wisely.

1.2 Wastewater Production and Disposal Issues

Wastewaters are unavoidable by-products of any processing activity. Whatever processing procedures are used for preparing products, there will always be an aqueous liquid as by-product (Asia and Akporhonor, 2007). According to Al-Rekabi *et.al,* (2007) wastewater can be classified into four major types namely; Domestic, Industrial, Storm Water and Infiltration/Inflow.

One of the byproducts of cassava processing is the effluent. Cassava effluent if allowed to move freely within the soil contaminates surface water as it percolates into underground water and sub soil with serious adverse effect on human, fauna and flora (Ogundola and Laiasu, 2007). The recent encouragement by Nigerian government in the area of cultivation of cassava for industrial, export and domestic purposes has resulted in corresponding increase in production and processing thereby increasing the amount of cassava effluent and its discharge to the environment. It has been observed that clean water demand and supply is one major problem of concern in most parts of the world especially in Africa (Ahiablame *et al.* 2011; Behr, 2008). Research showed that even though Africa has 5 trillion m^3 of fresh water resources available annually, only 3.8% of this supply has been developed, leaving 300 million African people without access to safe drinking water (Ford, 2008). This situation has been noted to be endemic in most parts of sub Saharan Africa particularly, Sudan, Chad, Niger and Nigeria where majority of their populations are resident in the rural areas and are dependent on seasonal water supply sources such as rivers, streams and ponds. It is therefore important to protect available fresh water from contamination because once ground water becomes contaminated; it can take years or decades for it to clean itself naturally. Hence, there is need to take care of

effluent discharge from cassava processing operations in order to prevent pollution of both surface and groundwater sources which have been observed to be major sources of water supply in most Nigerian communities.

1.3 Self-Purifying Cassava Production System

Waste treatment is generally classified into four levels: primary, secondary, tertiary, and quaternary treatment with each treatment level aimed at removing a more specific class of contaminants (Okonko *et al*., 2006). The self-purifying treatment system (figure 1) is that in which the waste from a production system is used as a precursor in treatment of other form of waste thereby reducing the production process net environmental effect. Self-purifying cassava production system do not only takes care of the effluent discharge but also takes care of the solid waste problem as seen in Plate 1. Proper management with the provision of solid waste and wastewater treatment facility may therefore be a way forward.

2.0 MATERIALS AND METHODS

2.1 Pilot Scale Study of Self Purifying Cassava Treatment Process

A pilot scale experiment of the self-purifying cassava treatment process was set up in the soil and water conservation laboratory of the Department of Agricultural and Environmental Engineering Department of the University of Ibadan. Cassava peels and its wastewater were collected from a cassava processing industry in Ibadan. The cassava peels were inspected, washed and sundried to a moisture content of between 8-11% dry-basis. Dried cassava peels were carbonized using a muffle furnace (Carbolite, England Model AAF 11/18) at 420^{0}C for 90mins and then allowed overnight cooling under inert conditions.

The cassava peel carbon (CPC) as seen in Plate 2 size was reduced to 500μm. The reduced carbon was pre-washed to remove any form of dirt that may have been attached during size reduction process and later dried in the oven at 120^{0}C for 8hrs. Three samples of the CPC were activated using $ZnCl_2$ at activation ratios of 1:3, 2:3 and 1:1.

Added to the wastewater sample collected was 0.5M NaOH until the pH was 10.0 and Hydrogen peroxide at 50% concentration was then added at a dose of 0.5 grams H_2O_2 per gram of CN^- oxidized. Wastewater was left for 2hrs to ensure a reasonable level of oxidation and cyanide destruction before filtration was done in an intermediate sand filter column.

Oxidized wastewater was released simultaneously into four adsorption columns containing the CPC (0:1) in one column and Cassava Peel Activated Carbon (CPAC) at activation levels 1:3, 2:3 and 1:1 in the other three columns at the rate of 0.378 l/hr. Water samples were strained from the adsorption columns after a period of 2, 4, 6 and 8hrs. The discharged effluent was then compared with FEPA interim standard on discharge for all classes of industry and also standards for irrigation water.

2.2 Estimation of Water Use in Cassava Production Process

This research compares the estimated volume of effluent discharge from cassava processing activities within the country with the country's annual fresh water availability data by measuring water usage characteristics from selected cassava processing plants within Ibadan metropolis of Oyo state in Nigeria. Water use pattern was recorded for the soaking (fermentation) and the non-soaking method as practiced in these cassava processing industries. Average water use per ton was multiplied by the value of estimated

cassava production in the country and used as a basis for obtaining the estimated total water usage.

Three main scenarios were considered in the combination of fermentation and non-fermentation cassava processing techniques, these scenarios were: Scenario 1 (60:40% Soaking: Non-soaking); Scenario 2 (50:50% Soaking: Non-soaking); Scenario 3 (40:60% Soaking: Non-soaking) processes. The use of these scenario analyses is due to the varying dietary constitution of the country as well as the recent government policies concerning cassava production and processing.

3.0 RESULTS AND DISCUSSION

3.1 Efficacy of Self-Purifying Cassava Treatment Process

After the treatment process a comparison of the characteristics of treated wastewater effluent was made with FEPA interim standard on discharge for all classes of industry and also standards for irrigation water (Table 1). The outcome showed that after adsorption all the parameters considered met the requirement for discharge with the exception of suspended solids, this was however countered with the incorporation of a sedimentation tank after adsorption chambers to separate the suspended particles. The effluent also met the standard for use as irrigation water for agricultural purposes. This result shows that based on the tested physical parameters, the treatment method can be well suited for the treatment of cassava industry effluent. This means that valuable water resource can be effectively conserved through this recycling process. It is also important to note here that the treatment process was able to reduce the weight of peels by about 61% while the volume reduction was as high as 80% thereby leading to a more efficient utilization of space and easier waste handling.

3.2 Cassava Processing and Water Budget

The water budget under cassava production can be classified into two which are;

i. internal water budget
ii. external water budget

Internal water budget relates to the water requirements in within the production process, cassava processing can either be by soaking (fermentation) or the non-soaking methods of processing and water usage differs distinctly with each process as shown in table 2.

3.3 Scenario Analysis of Estimated Water Use in Cassava Processing

Water estimate was analyzed with the aid of a 3-Scenario system based on the percentage composition of two processing methods (soaking and non-soaking). Based on 84 million ton annual cassava production capacity of the nation, Scenario1 estimate showed that water requirement for fermentation process was 76,860 million litres while non-fermentation process accounts for 32,256 million litres process water. Scenario 2 estimate showed that 64,050 million litres of water are used. Under scenario3, a total of 51,240 million litres of water was used in fermentation process method while 48,384 million litres was used in non-fermentation process (table 3).

The scenario analysis makes use of the estimate of 1,525 litres of water per tonne for fermentation process and used for fermentation process while the non-fermentation process will use 40,320 million litres of process water. 960 litres of water per tonne for non-fermentation process of cassava processing. The total estimated wastewater discharge from scenarios 1, 2 and 3 were 104,751.36, 100,195.20 and 95,639.04 million

litres respectively. This shows that the system would be able to recycle 104,751.36, 100,195.20 and 95,639.04 million litres of wastewater respectively from the three scenarios when passed through the self-purifying cassava treatment system. A quantitative analysis of water use within each of the scenarios shows that within scenario1 fermentation process consumed 70.4% of the total water use while non-fermentation process consumed 29.6% of the total use, under scenario 2 fermentation process accounted for 61.4% of total water use while non-fermentation process was 38.6% finally the scenario3 showed 51.4% total water use for fermentation while non-fermentation used 48.6% of the total water use as shown in figure 2.
The table 2 shows the average water demand these values included water requirements for sanitation activities during processing. Based on the three scenarios considered in table 3, it was observed that the estimated water usage in the soaking processing is inversely proportional to the non-soaking processing with the use of self-purifying technology.

4.0 CONCLUSION AND RECOMMENDATIONS

The study showed that annual water usage in the cassava processing industry in Nigeria is of substantial quantity, this wastewater could be harnessed for irrigative purposes thereby helping to boost food production. The system also has the advantage of taking care of both solid and effluent waste which could have been a problem if discharged carelessly. In the event of discharge to water course, the system would prevent pollution of adjacent water bodies which would take a long time to dilute to safe level due to its high polluting strength. Such discharge could also pollute groundwater sources rendering such sources unfit for abstraction. Since most cassava processing plants within the country are still making use of wells, springs and other shallow groundwater sources, groundwater budget is usually affected due to pumping; thus the adoption of this treatment method will assist in the safe recharge of groundwater thereby improving yield from wells in such areas both in quality and quantity.

It is therefore recommended that the self-purifying method of waste treatment in cassava production be adopted as opposed to the current indiscriminate solid and effluent disposal. Processing of cassava is usually done all year round therefore the recycled water from the system could be utilised during the dry season for irrigation farming with the aim of increasing food production.

The FAO has listed Nigeria among nations with economic water scarcity i.e. that are technically unable to meet their food needs from rain fed production at low level of inputs, between 2000 and 2025 therefore more efforts should be made at increasing food production through irrigation, to this end investment in irrigation to supplement rain fed agriculture has become necessary to alleviate food insecurity for the teeming population of Nigeria.

REFERENCES

Al-Rekabi S., Wissam., He Qiang and Wei Wu Qiang (2007) Improvements in Wastewater Treatment Technology. *Pakistan Journal of Nutrition* 6(2): 104-110.

Asia I. O. and Akporhonor, E. E. (2007) Characteristics and Physciochemical Treatment of wastewater from Robber Processing Factory. *International Journal of Applied Science Research* 4(4): 397-402.
Awomeso, J.A., Taiwo, A.M., Gbadebo, A.M. and Adenowo, J.A, (2010) Studies on the

Pollution of Water body by Textile Industry Effluents in Lagos, Nigeria. 354, *Journal of Applied Sciences in Environmental Sanitation,* 5 (4): 353-359.

Behr, P. (2008) Looming Water Crisis, *CQ Global Researcher*, 2: 27-56.

Czarra, F. (2003). Fresh water: Enough for me and you? *Occasional papers from The American Forum for Global Education*, 147: 1-15.

Ekiye, E. and Luo, Z. (2010) Water quality monitoring in Nigeria; Case Study of Nigeria's industrial cities. *Journal of American Science*, 6(4): 46-53.

Fakayode S. O., (2005). Impact of industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria, Ajeam-Ragee, 10: 1-13.

FAO (2001) AQUASTAT FAO's Information system on water and agriculture http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastatweb/main/html/background.htm [Geo-2-119] accessed July 2012.

Ford, N. (2008) Seeking water solutions for Africa. *African Business*, p. 30. http://www.allbusiness.com/government/ international-organizations/8888959-1.html. Accessed September 2010.

Jekayinfa S.O. and Olajide J. O. (2007) Analysis of energy usage in the production of three selected cassava-based foods in Nigeria. *J. Food Eng.* 82: 217-226.

Julius M. H. , Josephine K. W., Ngaira, Harun O. O. and Nelly M. (2012) The changing rainfall pattern and the associated impacts on subsistence agriculture in Laikipia East District, Kenya, *Journal of Geography and Regional Planning* . 5(7): 198-206

Kniper L, Ekmekci B, Hamelinck C, Hetinga W, Meyer S and Koop K (2007) Bio-ethanol from cassava. *Ecofys Netherlands BV.* 3: 22-30.

Ahiablame. L, Ohlemiller, J., Stein, E., Noel, S. and Engel, B. (2011) Bringing clean water to rural communities in developing countries: A well for the community in Agrippa Todzi, Togo, *Journal of Rural and Community Development* 6 (2): pp. 124–134.

Nwaogwu, L. A., Agha, N. C., Alisi, C. S. and Ihejirika, C. E. (2011) Investigation on the effect of cassava effluent-polluted soil on germination, emergence and oxidative stress parameters of *Telferia occidentalis*. *Journal of Biodiversity and Environmental Sciences* (JBES) 1(6): 104-111.

Obadina, A. O., Oyewole, O. B., Sanni, L. O. and Abiola, S. S. (2006) Fungal enrichment of cassava peels protens. *African Journal of Biotechnology*. 5(3): 302-304.

Ogundola, A. F. and Laiasu, M. O. (2007) Herbicidal effects of effluent from processed cassava on growth performances of *chromolana odorata* weeds population. *Afri. J. Biotech.* 6: 685-690.

Okafor, N. (1992) Commercialization of fermented foods in Sub-Saharan Africa. In Application of Biotechnology to traditional fermented foods. pp. 165-169. National

Academy press, USA

Okonko, I.O, Olabode, O. P. and Okeleji, O. S. (2006) The role of biotechnology in the socioeconomic advancement and national development: An Overview. *African J. Biotechnology 5*(19):2354-2366.

Omogbai, B. E. (2010) Rain Days and their predictability in south-western region of Nigeria. *J. Hum. Ecol*, 31(3): 185-195.

Omotosho, O. A. (2012) Production and Utilization of Cassava Peel Activated Carbon in Treatment of Effluent from Cassava Processing Industry; an Unpublished M.Sc. thesis in the Department of Agricultural and Environmental Engineering University of Ibadan, Ibadan, Nigeria, pp. 50-72.

Ugwu, F. M. and Odo, M. O. (2008) Effect of cassava variety on the quality and shelf stability of Soy-Garri, *Pakistan Journal of Nutrition* 7 (2): 381-384.

Table 1: Treatment After 8hrs Contact Time Compared With Fepa Interim Discharge Standards

	Activation Ratio			
Parameters	**0:1**	**1:3**	**2:3**	**1:1**
Temperature	?	?	?	?
Colour (Lovibond Units)	**X**	**X**	?	?
Total Dissolved Solids (TDS)	?	?	?	?
Total Suspended Solids (TSS)	**X**	**X**	**X**	**x**
pH	?	?	?	?
BOD_5	**X**	**X**	?	?
S^{2-}	?	?	?	?
CN^-	?	?	?	?
SO_4^{2-}	?	?	?	?
NO_3^-	?	?	?	?
Fe^{3+}	?	?	?	?
PO_4^{3-}	**X**	**X**	?	?
Mn^{2+}	?	?	?	?
Phenol	**?**	**?**	**?**	**?**
Cl^-	?	?	?	?
Cd^{2+}	?	?	?	?
Hg	?	?	?	?
Ni^{2+}	?	?	?	?
Mg^{2+}	?	?	?	?
Ca^+	?	?	?	?
Zn^{2+}	?	?	?	?

? : Meets FEPA discharge standard

x : Does not meet FEPA discharge standard

?: Not detected in wastewater sample

*Fermentation process **values obtained from cumulative process observations

Table 2: Estimated Water Budget For Cassava Processing

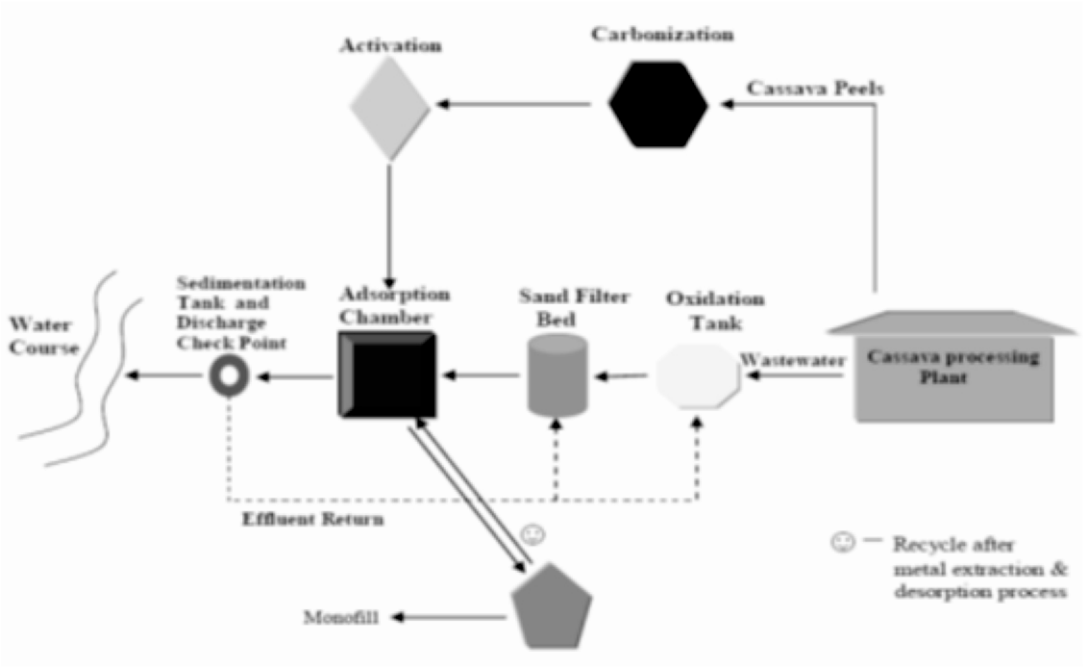
Process Method	[Ġ■**
Soaking*	1,525
Non Soaking	965

*Fermentation process **values obtained from cumulative process observations

Table 3: Estimate Of Water Budget For The Different Cassava Processing Scenarios

	Annual Production (Tonnes)	Process	Estimated Water Usage(L/tonne)	Estimated Water Usage(L)	Estimated Water Loss(L)*	Estimated Total Annual Water Usage (L)
Scenario 1	84 x10^6	Soaking	1,525.0	76,860 x 10^6	3,074.40 x 10^6	**104,751.36 x 10^6**
		Non Soaking	960.0	32,256 x 10^6	1,290.24 x 10^6	
Scenario 2	84 x10^6	Soaking	1,525.0	64,050 x 10^6	2,564.00 x 10^6	**100,195.20 x 10^6**
		Non Soaking	960.0	40,320 x 10^6	1,612.80 x 10^6	
Scenario 3	84 x10^6	Soaking	1,525.0	51,240 x 10^6	2,049.60 x 10^6	**95,639.04 x 10^6**
		Non Soaking	960.0	48,384 x 10^6	1,935.36 x 10^6	

ŏĂĠš'n■ℓℓ ℓ ĊĂ╢ś■ Ăℓ ى□ ◘źśℓĠ▒ĂĠšŕ ŏĂĠš'nĵ ℓĂ╢ś



Source: Omotosho,(2012)

Fig. 1: Schematic Diagram of the Self Purifying Cassava Treatment Facility

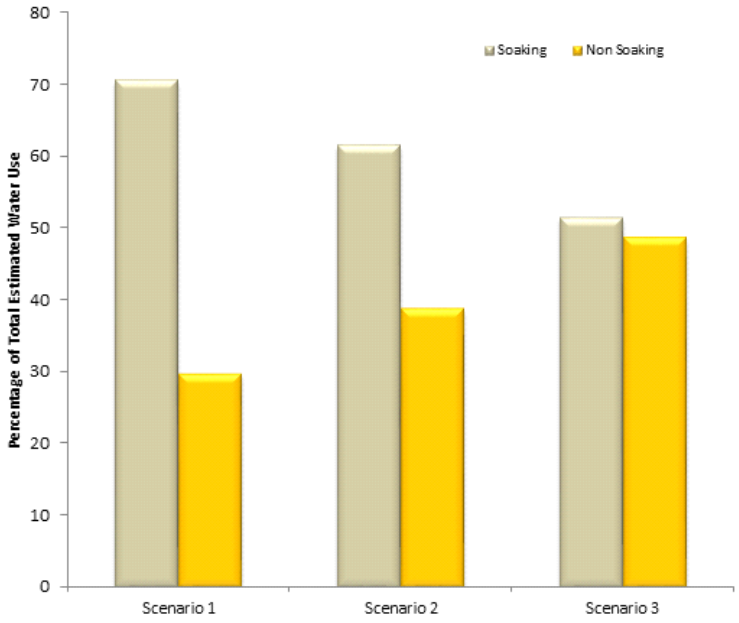


Figure 2: Analysis Of Water Use Within Scenarios



Plate 1: Pollution of Surface Water by Cassava Production Processes



Plate 2: Cassava Peel Carbon (CPC)

TREATMENT OF WASTE WATER FOR IRRIGATION PURPOSES (A CASE STUDY OF NIGERIAN BREWERIES PLC AMAEKE NGWO, ENUGU)

P. C. Eze, H. U. Offiah And C. N. Eze
Agricultural and Bioresource Engineering,Enugu State University of Science and Technology, Enugu. (Ezepaul2@Yahoo.Com)

ABSTRACT
Effluent discharge affects our environment negatively and also creates chemical imbalance in the surrounding soil it comes in contact with. However, these effluents (wastewater) can be treated to be useful for agricultural purposes (irrigation). Samples of both treated and untreated wastewater was collected from the study area; Nigerian Breweries, Amaeke Ngwo, in Enugu, and were analyzed using standard equipment. The analysis of physical, chemical and biological properties immediately shows that wastewater from the brewery cannot be used directly for irrigation as it can affect the soil or crop it mixes with. Results obtained from the analysis reveal that some of the quality parameters like pH = 8.30 units, total dissolved solids = 114.80 Mg/l, total suspended solids = 95 Mg/l, chlorides = 35.45 Mg/l, iron, sulphates = 60.95 Mg/l, calcium = 125 Mg/l, copper = 0.2 Mg/l, magnesium ion = 8.16 Mg/l and sodium = 3.57 Mg/l conformed to international standards for agricultural use while some parameters like turbidity = 115 units, total hardness = 152.20 Mg/l, nitrate = 8.32 Mg/l, silica = 18 Mg/l, oil and grease = 0.26 Mg/l etc, are not available in international standards for agricultural use but were also analyzed. Also the Sodium Adsorption Ratio (SAR) which is the measure of the suitability of wastewater used for irrigation shows that the treated water is sodium free, therefore the treated water can be used for irrigation purposes. It was, therefore recommended that more research is required to determine the actual effect of the effluents on the immediate environment since some of the constituent's standards were not available.

Keywords: Wastewater, Physical, Chemical and Biological Parameters.

1.0 INTRODUCTION

With increasing industrial development, safe disposal of industrial wastewater is one of the major ecological challenges. Therefore, environmental degradation has now become a global problem and maintaining ecosystem's health is a serious issue being confronted by the environmentalist. Due to lack of effluent treatment facilities and proper disposal system of wastewater, water bodies are getting polluted by the day and causing adverse effects on soil, water bodies, agriculture, flora and fauna, because of presence of toxic and persistence chemicals. Disposal of industrial effluents into fresh water bodies affects water quality, which is necessary to sustain aquatic life, primary productivity and food chain (Eze, P. C. and Eje, B. E. 2008). In many parts of the world, economic, social and political problems have risen following rapid industrial development and urbanization, resulting in adverse effects on the quality of life. Owing to this, there is great need for the effluents from our industries to be treated before discharging to the

Legend stout etc, and of course a large amount of wastewater is being generated by their various means of production. This wastewater consists of suspended colloidal and dissolved (mineral and organic) solids, excessive acid or excessive alkaline, toxic materials, pathogenic bacteria and so many other substances. This effluent if not properly treated before disposal to the environment can create a lot of hazards both for human, water bodies, aquatic lives and the environment in general. This study was performed to analyze the physical, chemical and biological properties of wastewater obtained from Nigerian Breweries Ama-eke Ngwo Enugu. To determine from the analysis the suitability of the wastewater for irrigation purposes and to treat this wastewater to a standard level so that it will not be a pollutant in our environment.

2.0 MATERIALS AND METHODS

The wastewater sample was collected in the morning from the auto sampler of the influent pump pit of Nigerian Breweries' wastewater treatment plant using a plastic bottle of 1000 ml and taken to the laboratory for analysis.

2.1 Sample Analysis and Equipment

The sample was analyzed to determine the physical, chemical and bacteriological qualities of wastewater. The following equipments and Reagents were used during the laboratory analysis:– filter photometer, filter 20 – 50 covets, distilled water, turbid meter card, conductivity meter with different disks, indicators (phenol red, chlorophenol red, biomethynol blue), pH meter, burettes, graduated cylinder, conical flask, pipette, acid washed glass wares, measuring cylinder, water bath, nester tubes, evaporating dish, sterilization equipment, sterilized glass wares, incubator, automatic pipette, test tube and Durham tubes, buffer solution, indicator such as eriochrome black 'T' dye, standard EDTA, Titrant 0.01N, ammonium purpurate, potassium chromate, standard silver nitrate, titrant 0.02N, Thioglycollic acid, phenathrolin solution, phenoldisulphonic acid, 10% ammonia, barium chloride, nutrient agar (28g/L) and macConkey broth.

2.2 Physical Analysis

2.2.1 Turbidity

The materials used for the analysis are filter photometer, filter 20 – 50 covet, turbidity card, wastewater sample, distilled water. The photometer was switched on and the zero error corrected using distilled water. The covet containing distilled water was then replaced with the waste water samples one after the order. Each time the sample was allowed to stabilize and the reading taken.

2.2.2 Electrical conductivity (E.C.)

The electrical conductivity was determined using conductivity meter with electrode glass wares and distilled water. The electrode of the conductivity meter was placed in a beaker containing distilled water and the conductivity value was taken as a reference value. The electrode was then placed in the beaker containing wastewater samples and the conductivity values taken and recorded for each of the samples.

2.3.3 Total dissolved solids (T.D.S)

The TDS was obtained by calculation using the formular TDS = E.C. x 0.56 (Metcalf 1979). Where E.C. is the electrical conductivity value of the sample.

2.2.4 Color

The following equipments were used for colour analysis: - Filter photometer, filter 20 –

55 covets distilled water. The filter photometer was switched on and then the zero error corrected using distilled water as blank sample. The covet containing distilled water was replaced with the wastewater sample and placed in the photometer. The sample was allowed to stabilize and the values recorded.

2.3 Chemical Analysis

2.3.1 pH value

The pH value of the wastewater was determined using comparators with different discs, distilled water, indicator (Biomethynol blue, phenol red or chlorophenol red). The samples were added to the left covet and right covet up to 10ml mark. Biomethynol blue indicator was added to the right covet and compared with the biomethynol blue disk.

2.3.2 Total hardness and calcium hardness (EDTA titrimetric method)

Total hardness and calcium hardness were determined using the Ethylene diamine tetra acetate (EDTA) titrimetric method while the magnesium hardness was obtained from the difference between the total hardness and calcium hardness (Mackenzie et al 1998)

2.3.3 Magnesium hardness (by calculation method)

Magnesium hardness was obtained by calculating as follows:
Magnesium hardness = total hardness – calcium hardness.

2.3.4 Sulphates (barium sulphate method)

sulphates were analysed using turbidity meter, barium chloride salt, measuring spoon, stirrer, conditioning reagent. 1ml of the conditioning reagent was first added to 50ml of sample of the raw water. This was stirred for two minutes and then used to correct the zero error of the turbidimeter. Further, a spoon of barium chloride salt was added to sample solution and stirred. The sample solution was then inserted into the turbidity meter and its reading was taken.

2.3.5 Total iron (eisen phenanthroline method)

Total Iron was determined using Spectrophotometer, glass wares, hydroxyaminehydrochloride, ammonium acetate buffer, phenanthroline, heating mantle. 100ml sample was pipette into conical flask and 1ml of hydroxyaminehydrochloride was added and boiled to half the volume to ensure complete reduction of ferric iron to ferrous iron. It was then allowed to cool and transferred to 100ml volumetric flask. 1ml of phenanthroline was added to 100ml of ammonia acetate buffer. Allow for ten minutes for full color development. Read the transmittance at 510nm wavelength in a spectrophotometer.

2.3.6 Manganese (periodate method)

Manganese was analyzed using Spectrophotometer, glass wares, phosphoric acid, sodium periodate. To a 25ml of sample, 5 drops of phosphoric acid was added. A pillow of sodium periodiate was added and allowed to stand in a water bath (warm). A permanganate color will be observed in the sample if it contains manganese. Measurement was performed with spectrophotometer at wavelength of 525nm.

2.3.7 Chloride as NaCl (calculation method)

Chloride as NaCl was determined mathematically as

Cl mg / l x 1.65 (Anon, 2012)

2.3.8 Heavy metals

All heavy metals are determined by filter photometric method. The filter

inserted. The corvette holder of the instrument and the wavelength control Nob was used to set the scale reading to zero. The distilled water was removed and replaced with the prepared sample or control experiment. The wavelength disc for the parameter under determination was inserted and the instrument was powered and the value of the metal under study was read on the scale board of the instrument.

2.4 Biological Analysis

2.4.1 Plate or colony count

By means of sterile pipette, 1ml of raw water sample was delivered into a sterile perish dish. 20ml of nutrient agar, which has been melted and cooled to 45^0C, was poured into dish. The content (water sample and nutrient agar) of the dish were carefully mixed together. The mixture was allowed to set (solidify). Further, the petri dish was incubated at 35^0C for 24 hours. Finally, the number of colonies of bacteria were counted using colony counter.

2.4.2 Total coliform or presumptive coliform test

The media (Mac Conkey) were distributed into culture tubes containing inverted Durham tubes each containing 10ml of the media double or single strength. The tubes with media were covered with cotton wool and sterilized in an autoclave at 121^0C for 15 minutes. Five tubes each containing 10ml of double strength broth and 2sets of five tubes each containing 10ml of single strength were each inoculated with 10ml, 5ml and 1ml of water sample. The mixture of the sample and media were incubated for 48hours. At the end, the culture tubes were examined for gas or evidence of fermentation. The tubes in the gas or evidence of fermentation occurred were noted and marked as positive (+ve), while negative (-ve) were marked for no gas formation.

2.4.3 E.coli

After 48 hours in the above experiment (Total Coliform experiment), the fermented tubes are calculated and the same portion of the fermented culture are poured into fresh culture and placed in a water bath at a constant temperature of $44.4^0\text{C} \pm 0.2^0$C for 24 hours. If the fermentation occurs and there are gases observed in the Durham tubes, then there is E.coli in the sample.

3.0 RESULTS AND DISCUSSION

Based on the research that has been done so far certain characteristics of the brewery wastewater were analyzed and their qualities were divided into; physical characteristics, chemical characteristics and biological characteristics.

Physical characteristics: It was discovered that there were a lot of physical sediments present in the wastewater sample, this of course will affect the purposes of the water for irrigation. They include the taste and colour, which when analysed, showed that the taste and colour of the wastewater sample were offensive and this perhaps can create hazards for both the crops and the environment as a whole if used for irrigation purpose depending on the Sodium adsorption ratio of the water. The total suspended solid was far above the normal range and the total dissolved solid was below the normal range when compared with the (C.C.M.E. 1999) water quality guidelines for agricultural uses (irrigation) as shown in Table 1. This can be very detrimental to crops if used for irrigation purposes.

Chemical characteristics: These were tested to detect the chemical substances which are present in the wastewater sample and also determine their ranges. The substances and

properties which affect the portability and suitability of water include iron = 0.42 Mg/l, calcium hardness = 125 Mg/l, sulphates = 60.95 Mg/l, total hardness = 152.20Mg/l, total alkalinity = 379.60 Mg/l, chlorides = 35.45 Mg/l, etc. While large amount of manganese in water can lead to toxicity in crops if used for irrigation. Excess iron in water can lead to acidification and death of plants, where excess chlorides in irrigation water can lead to excessive necrosis (dead tissues)

Bacteriological characteristics: the biological quality of any wastewater is determined by the presence of disease producing organisms but the result of the laboratory analysis showed no presence of E.coli but there was coliform .
In relation to (C.C.M.E. 1999) water quality guidelines for agricultural uses (irrigation) as contained in table 1, it was found that some of the parameters of the sample analyzed were within the C.C.M.E. standard, some did not reach, some exceeded while some were not available. Based on these, the brewery wastewater needs some treatment to make it suitable for irrigation purposes.

Treatment result:
From the results, some of the variables were within the (C.C.M.E. 1999) water quality guidelines for agricultural uses (irrigation). Some were outside the standard but majority of the standard parameters are not available for comparison with the wastewater treatment results. Hence the Sodium Adsorption Ratio (SAR) which is the measure of the suitability of wastewater used for irrigation as determined shows that the treated water is sodium free, therefore the treated water can be used for irrigation purposes.

4.0 CONCLUSION

Based on the results of the research work carried out on the waste water from Nigerian Breweries Plc, Amaeke Ngwo in Enugu State, the wastewater has a very offensive smell and dark color. It also showed that some parameters were above the normal range, some were below the normal range while some others were not available on the Canadian Standard for Ministers of the Environment (C.C.M.E. 1999) water quality guidelines for agricultural uses (irrigation). This led to the treatment of the brewery effluent
After the treatment of the wastewater sample, some parameters increased while some decreased thereby conforming to the Canadian Standard for Ministers of the Environment (C.C.M.E. 1999) water quality guidelines for agricultural uses.
The basic determinant of wastewater suitability is the Sodium Adsorption Ratio (SAR) which was deficient in the treatment result thereby indicates that the water is sodium free which is the most important characteristic of water used for irrigation purposes.
Finally the brewery effluent from Nigerian Breweries PLC, Ama was treated to an extent that will provide little or no harm to crops if used for irrigation purpose. Therefore wastewater from Nigerian Breweries Plc, Ama should not be used directly for irrigation purposes unless treated.

5.0 RECOMMENDATION AND LIMITATIONS

- More research is required to determine the actual effect of the effluents on the immediate environment since some of the constituent's standards were not available.
- Effluent discharge can be treated in situ and in this case pumped directly to the source of use (close by farms). This will promote practical applications of the results of this project.

- Due to the fact that Empirical analysis was performed on the sample taken for treatment because larger samples couldn't be obtained, it is recommended that future analysis should have larger samples with more mechanized treatment equipment which have improved procedures within the overall treatment process .
- The result of this research is applicable to farmlands and compared with normal irrigation water to see if there are any effects on the crops. Due to the time frame of the research this could not be done to see if the treated water has any adverse effect on crops.
- These effluent parameter tests should be reviewed at regular intervals and compared with operating standards so that corrective actions can be taken by the appropriate authorities.

REFERENCES

Anon, (2012). Wastewater – Standard method of examination of water and wastewater. http://en.wikipedia.org/wiki/Wastewater. Accessed on 19th August, 2013.

Brauer J. (2006). Wastewater treatment, Back to basics. Brewers Guardian, pp 135.

Brown, N. (1997). Health Hazard Manual. Wastewater Treatment Plant and Sewer Workers. New York: Cornell University ILL School.

Eze, P. C. and Eje, B. E. (2008). Wastewater Management in Enugu Metropolis (A case study of Central Bank of Nigeria Quarters, Enugu), A Conference Paper Presentation, NIAE (SE) 1st Regional Conference, 2008, Pp: 116-122.

FEPA, (1991). Guidelines and Standards for Environmental Pollution Control in Nigeria, FEPA Lagos pp.238

Gordon, M.F. (1971). Elements of Water Supply and Waste Water Disposal. 2nd Edition, John Willey and Sons Inc. London pp.115 – 120.

Haimes, Y.Y. (1977). Hierarchical Analysis of Water Resources Systems. McGraw-Hill Inc. USA pp. 97 – 98.

Karen Manel (2003). Waste Water Treatment Principles and Regulations. Ohio State University Extension Fact. Sheet Ohio.

Mackenize L. Davis and David A. Cornwell (1998). Introduction to Environmental Engineering. Third Edition. McGraw Hills pp. 131 – 457

Metcalf and Eddy (1979). Waste Water Engineering Treatment, Disposal, Reuse. 2nd edition, McGraw- Hill Inc. USA. pp 104 – 112.

Wagner, E.G. and Lanoix, J.N. (1959). Water Supply for Rural Area and Small Communities. WHO Geneva publication, pp. 35, 46 – 53, 57 – 64.

Table 1: Wastewater Sample Analyses And Water Quality Guidelines For Agricultural Uses (Canadian Council Of Ministers Of The Environment (C.C.M.E. 1999)

S/N	PARAMETERS	UNITS	TEST RESULTS	C.C.M.E STANDARD (1999)
1	Turbidity	N.T.U.	105	Not Available
2	Colour	Unit	85 units	Not available
3	Temperature	^{0}C	28^{0}C	Narrative
4	Ph value		07.60	6.5 – 8.5
5	Electrical conductivity	dS/m	0.15	<1.0
6	T.D.S	Mg/l	84	>100 – <2000
7	T.S.S	Mg/l	720	<100
8	Total solids	Mg/l	804	Not available
9	Chlorides	Mg/l	36.87	<100
10	Chlorides as NaCl	Mg/l	60.83	Not available
11	Total hardness	Mg/l	95.50	Not available
12	Calcium hardness	Mg/l	68.70	Not available
13	Magnesium hardness	Mg/l	26.8	Not available
14	Total alkalinity	Mg/l	120.30	Not available
15	Iron (fe)	Mg/l	01.50	5
16	Sulphates	Mg/l	00.80	5 – 2000
17	Nitrate (NO_3)	Mg/l	00.20	Not available
18	Silica	Mg/l	20.30	Not available
19	Calcium ion	Mg/l	27.48	50 – 800
20	Magnesium ion	Mg/l	8.04	0 -120
21	Manganese	Mg/l	ND	0.2
22	Copper	Mg/l	00.20	0.2
23	Oil and grease	Mg/l	2.42	Not available
24	DO	Mg/l	02.66	Not available

Table 2: Wastewater Treatment Results

S/N	PARAMETERS	UNITS	TEST RESULTS	TREATMENT RESULTS	C.C.M.E. STANDARD (1999)
1	Turbidity	NTU	105 units	115 units	Not Available
2	Colour	Units	85 units	80	Not available
3	Temperature	^{0}C	28^{0}C	28	Narrative
4	pH value	Units	07.60	08.30	6.5 – 8.5
5	Electrical conductivity		0.15	0.25	<1.0
6	T.D.S	Mg/l	84	114.80	>100– <2000
7	T.S.S	Mg/l	720	95	<100
8	Total solids	Mg/l	804	379.80	Not available
9	Chlorides	Mg/l	36.87	35.45	<100
10	Chlorides as Nacl	Mg/l	60.83	58.49	Not available
11	Total hardness	Mg/l	95.50	152.20	Not available
12	Calcium hardness	Mg/l	68.70	125	Not available
13	Magnesium hardness	Mg/l	26.8	27.20	Not available
14	Total alkalinity	Mg/l	120.30	379.60	Not available
15	Iron (fe)	Mg/l	01.50	00.42	5
16	Sulphates	Mg/l	00.80	60.95	5 – 2000
17	Nitrate (NO_3)	Mg/l	00.20	08.32	Not available
18	Silica	Mg/l	20.30	18	Not available
19	Calcium ion	Mg/l	27.48	50	50 -800
20	Magnesium ion	Mg/l	8.04	08.16	0 -120
21	Manganese	Mg/l	ND	ND	0.2
22	Copper	Mg/l	00.20	00	0.2
23	Oil and grease	Mg/l	2.42	00.26	Not available
24	DO	Mg/l	02.66	04.37	Not available

WATER INTAKE CHARACTERISTICS OF SOILS IN JAMILA VILLA FARM, MINNA, NORTHERN NIGERIA

Popoola, A. S* and A. A. Balami**
*Department of Forestry Technology, Federal College of Forestry Jos, Plateau State, Nigeria. **Department of Agric. & Bioresources Engineering, Federal University of technology Minna, Niger state, Nigeria.
Corresponding Author: Popoola A. Stephen – adrom835@yahoo.com, 07030648406.

ABSTRACT
The water intake characteristics of soils under different soil management conditions were studied in Jamila Villa farm; Minna, Niger State.The aim was to understand how management conditions affect water intake characteristics. The infiltration test was carried out in three different condition of the soil, tilled, untilled and Tractor tracked soil. Double ring infiltrometer was used to study the infiltration characteristics of the soil on farm. Horton's equation was adopted for the data analysis. From the analysis, the soil characteristics constant K obtained were 0.038, 0.020, and 0.023. The soil intake characteristic equation for all the three soil conditions were expressed as $F=9.0t + 2921.05[1- e^{-0.038t}]$, $F=1.56t + 3702[1- e^{-0.020t}]$, $F=4.44t+1335.65[1- e^{-0.023t}]$. The result shows that Tilled land had the highest average infiltration of 120cm/hr while Compacted land experienced the least average rate of 38 cm/hr. This study enables the comparison of the parameters obtained from all the soil conditions of the location. These results will guide farmers in designing a good and workable irrigation system in the future.

Keywords: Infiltration Capacity, Infiltration Rates, Soils, Infiltrometer, Horton.

1.0 INTRODUCTION
The soil is an integral component of the hydrological cycle, directly influencing infiltration, storm runoff, evapotranspiration, interflow, and aquifer recharge. Understanding the nature of water movement in the soil and its quantification is essential to solving a variety of problems like prediction of runoff from given precipitation events for the purposes of erosion control; sediment transport and flood control and estimation of water availability for plant growth. It is also relevant in the estimation of water recharge to the underlying aquifer and assessment of the potential for aquifer contamination due to migration of water soluble chemicals present in the soil (EPA, 1998). Consequently, the study of soil-water movement has interested scientists from diverse disciplines such as soil science, hydrology, agriculture, civil engineering, and the environmental sciences for several years. In an attempt to address this problem Breckenridge *et al.* (1994), explained the techniques for characterizing soils for their chemical, physical, and hydraulic properties.

Infiltration rate is the velocity at which water seeps into the soil profile, it is a measure of the rate at which soil is able to absorb rainfall or irrigation, measured in inches per hour or millimeters per hour; it decreases as the soil becomes saturated (Osuji, 1984). The rate of infiltration can be measured using an infiltrometer, a relatively simple and accurate method (Barrow, 1987). The movement of water into the soil by infiltration may be limited by any restriction to the flow of water through the soil profile, the major factors affecting the infiltration of water into the soil are the initial moisture content, condition of the soil surface, hydraulic conductivity of the soil profile, texture, porosity, degree of

swelling of soil colloids and organic matter, vegetative cover, duration of ponding water, irrigation or rainfall and viscosity of water, it is affected by ease of entry, storage capacity, soil texture; soil structure, vegetation types , water content of the soil, soil temperature, and rainfall intensity, all play a role in controlling infiltration rate and capacity. (Saxton *et al*., 1982; Sharma, 2007).

Infiltration capacity is the maximum rate at which water can enter a particular soil; different soil types have different Infiltration capacities. If the arrival of the water at the soil surface is less than the infiltration capacity, all of the water will infiltrate. It is a known fact that the use of heavy machines on soil leads to soil compaction; compacted soils tend to have low infiltration rates and thus encourage high run off (Chancellor, 1977). If rainfall intensity at the soil surface occurs at a rate that exceeds the infiltration capacity, ponding begins and is followed by runoff over the ground surface, once depression storage is filled. This runoff is called Horton overland flow. High infiltration capacities will reduce run off and risks of water logging; any practice that degrades the structure of the soil will have an adverse effect on infiltration. Therefore, monitoring infiltration rates under different soil management regimes is a good indicator of how the practice will influence the rate at which water can move into the soil (Oosterbaan *et al*., 1994). Infiltration rates are generally lower in soils of heavy texture than on soils of light texture. The influence of water depth over soil on infiltration rate was investigated by many workers. It has been established by Horton's (1940) and Green and Ampt (1911) that in surface irrigation, increased depth increases initial infiltration slightly but the head has negligible effect on prolonged irrigation. The purpose of this study is to develop the intake characteristics equation for the soils under conditions of tilled, non – tilled and tractor tracked soils using the Horton's equation.

2.0 MATERIALS AND METHODS

2.1 Study Site

This experiment was carried out in Jamila Villa farm Niger State, during the dry season, December, 2009. The area lies between latitude 9^0 26"N and longitude 6^0 38"E, it has a sub-humid tropical climate with annual rainfall of 1200mm, temperature rarely falls below 22^0C, wet season temperature averages about 28^0C, the peak is 40^0C (March) and 22^0C (December) (Edoga and Suzzy, 2008). The site is located in the Sudan guinea savannah region and has basically the rainy, harmattan and dry season weather. The site is characterised by reduced tillage and intercopping system. The type of soil found in this area was loamy clay soil. It is blackish grey in colour with a sticky nature and it has boulders and cracks after high moisture loss. It has a high percentage of clay and it is water retaining type of soil.

2.2 Field Experimentation

The infiltration experiment was carried out using double ring infiltrometer. A double ring infiltrometer of 30cm inner diameter and 60cm outer diameter was locally constructed and used with a thickness of 0.15cm. Plots for the experiments were leveled by removing grasses and debris just at the surface. Care was taken to ensure that the surface structure of the plot was not destroyed. The double ring infiltrometer was placed on the selected plot. First the inner ring was placed on the soil. The ring was then inserted into the soil by placing a plank across the ring and taped gently until the ring had gone into the soil at depth of 150mm. The inner ring had a ruler attached to the inner side, this allowed for the reading of the water level as infiltration progresses. The the outer ring was also installed in the same manner. The depth was re-checked with a ruler to ensure a perfect level before commencing the experiment. A small quantity of grass was placed in

ring of the infiltrometer to avoid puddling when pouring water in the rings. The inner ring was filled with water up to a level of 20cm reading on the ruler in the inner cylinder. This implies that 20cm of the ruler was used as the reference point. Readings were taken every 2minutes on the tilled plot due to its high infiltration rate of the loosed soil. For the non tilled and compacted soil the reading were taken every 5minutes. The readings vary depending on the type of soils and moisture content. At the expiration of every reference time, a reading was taken and the rings were filled back to the reference water level taking cognizance of the inner ring. The experiment continues for some time until when a constant reading value was obtained for about 3 to 5 times. For every experiment, infiltration rate reading was no less than an hour but not more than 2hours 30minutes. After every experiment, the rings were removed and taken to another plot. Three infiltrometer tests were carried out on each of the plots and the data obtained were used to evaluate the soil characteristics constant K, infiltration rate and cumulative infiltration depth equations for the different conditions of the soils as described by Bertrand (1965).

2.3 Soil Sampling and Analysis

The containers for the collection of the soil samples were thoroughly washed and dried. This was done to maintain its moisture content. Three samples at three different depths were taken for each of the plots; tilled, non-tilled and tractor tracked respectively. The samples designated as T (Tilled soil samples - T_1, T_2, T_3), NT (Non-tilled soil samples - NT_1, NT_2, NT_3), TT (Tractor tracked soil samples - TT_1, TT_2, TT_3) and the points as A, B and C. Soil Auger was used to collect the soil samples at 30m apart between points on each plot. The soil auger has a diameter of 6.5cm, radius of 3.25cm and height as 6.4cm; it was used for the whole experiment. The containers were covered and labeled after collection and then taken to the Agricultural and Bioresources Engineering Laboratory, FUT Minna for analysis. The moisture depth was carried out at a depth of 0-15cm, 15-30cm, 30-45cm; the volume of the sample cup used is 212.37cm^3. The soil moisture, texture and other properties varies at different plots under different conditions, the condition of the soil vary due to the history and cultural practices on the soil. The soil samples were weighed with digital weighing machine and oven dried for 24 hours at a constant temperature of 105^0. The soil porosity, bulk density and moisture content were determined.

3.0 RESULTS AND DISCUSSIONS

The graph for the Average infiltration rate versus ponding time and accumulated depth versus ponding time for all the plots (Tilled, Non-tilled and Compaction soils) were given in figure 1 and 2. The soil characteristic constant k of the farm were; 0.038, 0.020, 0.023. The infiltration depth rate equation for the tilled, non-tilled and compacted soils respectively are given below;

$$f = 9.0 + 111e^{-0.038t}, \quad 1$$

$$f = 1.56 + 74.04\,e^{-0.020t}, \quad 2$$

$$f = 4.44 + 30.72\,e^{-0.023t}, \quad 3$$

The cummulative infiltration depth equation for tilled, non-tilled and compacted soil were;

$$F = 9.0t + 2921.05[1 - e^{-0.038t}] \quad 4$$

$$F = 1.56t + 3702[1 - e^{-0.020t}], \quad 5$$

$$F = 4.44t + 1335.65[1 - e^{-0.023t}] \quad 6$$

The Soil moisture, Bulk density and Porosity were determined at different depth as shown in Tables 1, 2 and 3. The average moisture content are; 12.70, 12.17 and 12.31% respectively. The soil moisture increases with an increase in the difference in weight obtained from the fresh and dry weight of soil samples. The average bulk density are;

0.64, 0.59 and 0.59g/cm$^{3.}$ The average bulk density obtained increases with decrease in the average moisture percentage. The average porosity are; 75.97, 77.74 and 77.61% respectively. The average porosity is observed to increase as the bulk density decreases.
The results of the measured infiltration rates showed that the infiltration rate is higher in tilled soil than the non-tilled soil or compacted (tractor tacked) soils . This is attributed to the loose nature of the tilled soil and void spaces being created, the undisturbed nature of soil in the untilled soil and the increased soil strength in compacted soil. This will affect the water that will infiltrate into the soil at a given time, the rate of runoff will be high in soil of low infiltration and hence proper drainage is needed to curtail water logging problems. The infiltration rate equations, as given in equation 1-3 could be used to estimate the inflow of water into the give period (time, t) on the farm. Similally, total depth of infiltrated water on the farm for the three soil conditions (Tilled, Non-tilled and Compaction soils) could be determined at any period (time, t) using equations 4-6. There was a significant difference in the derived equations.

The results showed that the infiltration rate is higher in tilled soil with average infiltration of 120cm/hr than the non-tilled soil (76cm/hr) and tractor tack (38cm/hr) soils. This is attributed to the loose nature of the tilled soil and void spaces being created, the undisturbed nature of soil in the untilled soil and the increased soil strength in compacted soil. This will affect the water that will infiltrate into the soil at a given time, the rate of runoff will be high in soil of low infiltration and hence proper drainage is needed to curtail water logging problems. This result agrees with a similar work done by Osuji et. al., (2010) that textural difference affects infiltration rates but even in soils of the same texture, other factor can interplay to cause significant difference in infiltration rates. The graphs of average infiltration rate versus ponding time at different conditions have their points scattered, a curved slope is obtained in this graph. From this graph it is observed that the scattered point is due to the difference in the soil bulk density, porosity and moisture. The value of the graphs for the tilled soil is higher than that of non-tilled and compacted soil. The graphs of the infiltration rate versus accumulated depth have the same pattern but different values. This is due to the difference in moisture percentage bulk density and the different texture of soil. The physical properties and chemical properties of soil also vary. The high clay content of the soil makes the infiltration rate low.

4.0 CONCLUSIONS

The result shows that different land use practices affect water intake characteristic due to the effect on the intrinsic properties of the soil, from the characteristic equations derived, the design of any irrigation system on the farm should consider these equations, before implementing the design. Soil characteristic equations should be derived for other soils before it is considered for any irrigation operation.

REFERENCES

Barrow, C.,(1987). Water Resources and Agricultural and Development in the Tropics. Longman, UK.Pp:539-579

Bertrand, A.R.(1965). Rate of water intake in the field.In:methods of Soil analysis . Part1, 1st ed.Eds., C.A. Black *et al*. Agron. Monogr. 9. ASA-SSSA, Madison, W.I., pp: 197-209.

Breckenridge, R.P., J.F. Keck and J.R. Williams (1994). Characterizing of Soils for Hazardous Waste Site Assessment. Environmental Monitoring and Assessment. *US Environmental Protection Agency, Washington D, C.* 30 (1):113-138.

Chancellor,W.J.,(1977).Compaction of soils by Agricultural equipment. Division of Agric.Science, University of California, Richmond, CA, California.

Edoga R. N and A. B. U. Suzzy (2008). Effects of temperature changes on Evapotranspiration in Minna, Niger State. *Journal of Engineering and Applied Sciences* 3(6): 482 – 486, 2008.

Green, W.H. and G.A. Ampt. (1911). Studies in soil physics. I. Flow of air and water through soils. *Journal of Agricultural Sciences,* 3(4):1-24

Horton, R.E., (1940). An approach towards a physical meaning of infiltration capacity. *Soil Science Society of Americal Journal,* 5:399-417

Osuji,G.E., 1984.Water storage, water use and maize yield for tillage systems on a tropical Nigeria.Soil and Tillage Res.4:339-579.

Osuji G. E., M. A. Okon, M. C. Chukwuma and I. I. Nwarie (2010). Infiltration Characteristics of Soils under selected Land use practices in Owerri, Southern Nigeria. *World Journal of Agricultural Sciences* 6(3): 322- 326, 2010.

Oosterbaan R. J and Nijland H. J (1994). Determination of Saturated Hydraulic Conductivity. In: HP Ritzema (ed). Drainage Principle and applications, ILPI Publication 16, p.435-476.

Saxton,K.E.,W.L. Rawls,J.S. Rosenberger (1986). Estimating generalized soil water Analysis characteristics from texture. Soil Sci.Soc 50:1031-1036

Sharma R. K and Sharma T. K. (2007). Irrigation Engineering (including Hydrology). S Chand and Company Ltd, Ram Nagar, New Delhi – 110 055. Pp 20-32.

U.S. EPA, (1998). Estimation of Infiltration rate in the Vadose Zone: Compilation of simple Mathematical Models. U.S EPA Subsurface Protection and Remediation Division, National Risk Management Research Laboratory Ada, OK 74820. 1-3 EPA/600/R-97/128a, February 1998.

Table 1: Bulk Density, Porosity And Moisture Content Of The Soil For Plot A (tilled Soil).

Depth (cm)	Bulk Density (g/cm^3)	Porosity (%)	Moisture content (%
0 – 15	ي ه	ي ي	و ي
30- ي و	ي ه	23 ي	و و
45 – ه ى	ي ه	ي و ي	
! õś'ŋĂ┼ś	0.64	75.97	12.7

Table 2: Bulk Density, Porosity And Moisture Content Of The Soil For Plot B (non-tilled Soil)

Depth (cm)	Bulk Density (g/cm^3)	Porosity (%)	Moisture content (%
0 – 15	ھ ي8	ى و ي ي	ى و
ي و-30	ھ ي ب	ي ى ي ي	ي ى و و
ى ھ – 45	ھ ي ى	ي ى ي ي	ي و و و
! ōś’mĂ┼ś	0.59	77.74	12.17

Table 3: Bulk Density, Porosity And Moisture Content Of The Soil For Plot C (Compacted Soil)

Depth (cm)	Bulk Density (g/cm^3)	Porosity (%)	Moisture content (%
0 – 15	ھ ي ى	ى و ي ي	ى ى و
ي و-30	ھ ي ي	ي و لا ي	ي ي و و
ى ھ – 45	ھ ي و	ي ي ي ي	ي ي ھ و
! ōś’mĂ┼ś	0.59	77.61	12.31

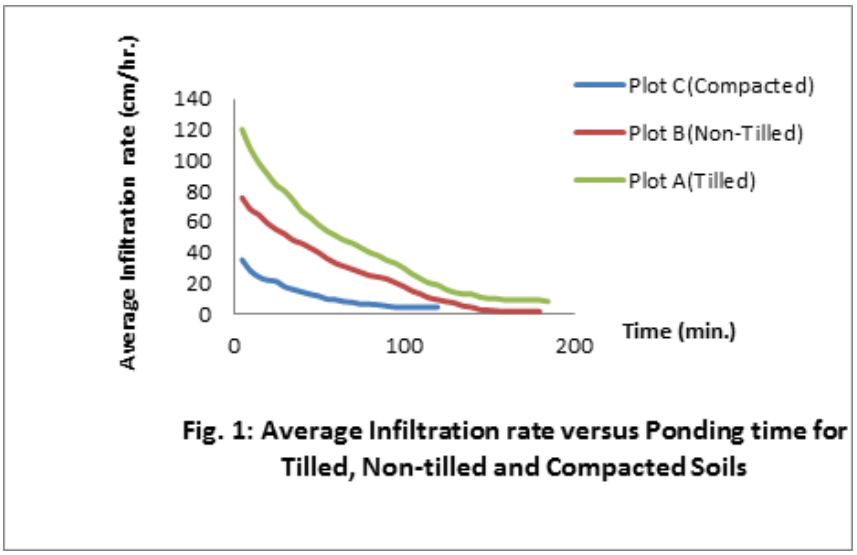


Fig. 1: Average Infiltration rate versus Ponding time for Tilled, Non-tilled and Compacted Soils

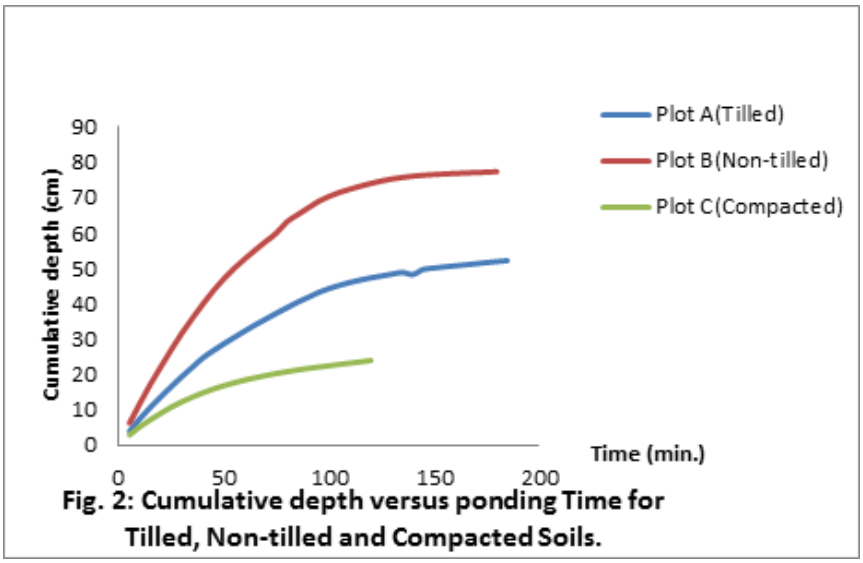


Fig. 2: Cumulative depth versus ponding Time for Tilled, Non-tilled and Compacted Soils.

TREATMENT OF WASTEWATER TREATMENT USING *MORINGA OLEIFERA* SEED SOLUTION IN MAIDUGURI, NIGERIA

[1] A.Y. Arku*, [2] S. M. Musa and [3]I. I. Ahuchaogu
[1]Agricultural and Environmental Resources Engineering Department, University of Maiduguri, Borno State, Nigeria.
*Corresponding author: adarku2001@yahoo.com ; +234(0)7039574213
[2]Agricultural and Bioresources Engineering Programme, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria. shbmusa@yahoo.com
[3]Agricultural and Food Engineering Department, University of Uyo, Akwa Ibom State, Nigeria
israelahuchaogu@uniuyo.edu.ng.

ABSTRACT
Moringa oleifera seed has been identified as one of the most effective primary coagulants and disinfectants for wastewater treatment. In this presentation, *Moringa oleifera* seeds were processed into powdered form. A stock solution was prepared using one gramme of the powder per litre of tap water. Moringa seed solution concentrations of 0.1, 0.2, 0.3 and 0.4 g/L (with untreated wastewater as control) were then prepared per one litre stock solution earlier prepared for treating wastewaters sampled from University hostel (W_1), main Abattoir (W_2) and Nigerian Bottling Company, NBC (W_3) all in Maiduguri metropolis. Results obtained show higher reduction in coliform count (CC_r) from 1000, 1420, 920 to 120, 124, 80 cells/100 mL turbidity (TB_r) from 14, 16, 11 to 2, 3, 1.5 NTU for W_1, W_2 and W_3 respectively. It was therefore suggested that the treated waters at 0.4g/L concentration are suitable for domestic (such as laundry) while those treated at 0.1 to 0.4 g/L could be used for irrigation purposes.

Keywords: Antimicrobial, Coagulant, Irrigation, Quality, Health

1.0 INTRODUCTION
The increasing world population is placing immense pressure on freshwater and challenges in water availability for agriculture. Many farmers in developing countries do not treat wastewaters before application on their farms. Use of chemicals for wastewater treatment has tendencies for causing cardiovascular diseases, cancers and birth defects (Arbuckle *et al.*, 2002; Bove *et al.*, 2002 and Woo *et al.*, 2002) which call for attention. Hence, the use of coagulants and disinfectants of plant origin are suggested to be better alternatives.

Natural materials have not been able to compete favourably with the commonly used chemicals due to insufficient knowledge about them (Kalibbala, 2007). Recently, coagulants of plant origin such as nirmali seeds (Tripathi *et al.,* 1976), *Cactus latifaira* and *Prosopis juliflora* (Diaz *et al*., 1999), tannin from valonia (Özacar and Sengil, 2000), apricot, peach kernel and beans (Jahn, 2001) and maize (Raghuwanshi *et al*., 2002) were discovered. Bhole (1995) noted that maize and rice are good coagulants. Chitosan is a coagulant (Pan *et al*., 1999; Divakaran and Pillai, 2001) with antimicrobial properties (Liu *et al*., 2000; Fuglie and Olivier, 2008). Al-Samawi and Shokrala (1996) estimated that use of okra could save 50-90% of alum requirement.

Moringa oleifera (Zogale in Hausa and Drumstick in English) has origin from India and found in Africa, Asia and America (Olsen, 1987; and Sauveur and Peprah, 2006). It has multiple uses and drought-resistant. Its seeds (Figure 1) are round with a brownish semi-permeable seed hull. Foidl *et al.*, (2001) estimated a moringa tree to produce 15,000 to 25,000 seeds/year and an average seed weighs 0.3 g (Makkar and Becker, 1997). Many researchers have discovered that *Moringa oleifera* is antimicrobial and a coagulant Olsen (1987), Muyibi (2006), Fuglie and Olivier (2008), Muyibi and Evison (1995), Babu (2000), Folklard and Sutherland (2001), Folklard, (2006) and Nwaiwu and Ligmu, 2011). Water treatment plants that use *Moringa oleifera* in Sudan, Malawi and Nicaragua save a lot of foreign currency. *Moringa oleifera* seed does not significantly affect pH of the treated water (Foidl *et al.*, 2001). It also softens hard water and treats heavy metals in wastewater (Doerr, 2005 and Muyibi, 2006). *Moringa oleifera* seed actions are due to water soluble, positively-charged protein (Folklard and Sutherland, 2001). Its coagulating activity could be either due to cationic polypeptides (Tauscher, 1994) or a non-proteineous compound (Okuda *et al.*, 2000). Such seed extracts are capable of bacterial aggregation and removal, with efficacy similar to that of aluminium salts and other related agents (Madsen *et al.*, 1987).
Schwarz (2000) recommended a dosage for wastewater treatment (Table 1) and volume of wastewater (V_w) to be treated. The report however cautioned that *Moringa oleifera* does not guarantee completely (100%) free of pathogens for highly polluted waters. Similarly, Doerr (2005) recommended dosage in same Table 1. This is slightly higher when compared with Schwarz's recommendations.

1.1 Objectives of the Study.

The general objective of this research was to investigate the use of *Moringa oleifera* seed solution in treating wastewater. The specific objectives were to characterize and standardize the *Moringa oleifera* seed, and to evaluate the effectiveness of the *Moringa oleifera* seed solution in treating domestic, agricultural and industrial wastewaters.

2.0 MATERIALS AND METHODS

2.1 The Study Area and Wastewater Sources.

The research was conducted in Maiduguri, capital of Borno state in North-eastern Nigeria lies between latitude 11° 51' N and longitude 13° 05' E at an altitude of 354 m above sea level. The city is known for its dryness, with annual rainfall of about 300 mm. Its average daily temperature ranges from 22 – 35 °C, sometimes with mean of the daily maximum temperature exceeding 40 °C between March and June before the onset of rains in July to September. It has mainly sandy loam soils. The wastewaters were from the University Hostel (W_1), main Abattoir (W_2) and the Nigerian Bottling Company, NBC (W_3) all in Maiduguri as shown in Figure 2. The wastewaters are used for irrigation by the locals in the area. The Garmin's GPS (76 S Model) was used to determine the ordinates of the wastewater sources in Table 2.

2.2 Wastewater Sampling Methods.

W astewater generated in the bathroom (W_1)by students was discharged through a 25 mm PVC pipe. For the agricultural wastewater (W_2), samples were collected from one of the points in the pool of discharge wastewater where farmers pumped water to their farms. Wastewater from the NBC plant (W_3) is treated before discharge to an earth pond reservoir outside the company premises. Sampling was done at a fixed point to minimize

variations. For the agricultural (W_2) and industrial (W_3) wastewaters, samples were collected from the top 100 mm depth. In each case, samples were collected in one litre plastic bottles after being screened with a 0.1 mm stainless screen to prevent sediments. Hand gloves were used as protection against any contamination. Water quality analysis was done in the Geology Departmental Laboratory, University of Maiduguri at room temperature of 25-30^{o}C.

2.3 Sources of Moringa Oleifera Seed. *Moringa oleifera* seeds were collected from households and surroundings in Maiduguri metropolis during the 2009 and 2010 dry seasons.

2.4 Chemical Characterization of Moringa Oleifera Seed. The chemical constituents of the *Moringa oleifera* seed were obtained using the following procedure:

(a) Seeds removed from the pods were dehusked, milled and ground into powder using a local grinding machine. The powder was passed through a 0.1 mm stainless steel sieve to remove bigger particles present.

(b) One gramme (g) of the fine powdered moringa seed was added to one litre of tap water in a plastic bottle at room temperature of 25-30^{o}C. The level of chlorine in the tap water was negligible to have any significant effect.

(c) Solution obtained in (b) was allowed to stand for one hour before filtering the suspended particles. The chemical composition of the solution was analyzed using methods as in Table 3.

2.5 Standardization of Moringa Oleifera Seed Solution. The moringa seed solution was standardized using the following steps:

(a) The solution obtained in 2.4(b) was added to one litre of wastewater and allowed to stand for an hour and then tested to evaluate its quality.

(b) Stock solution of the moringa seed solution concentration (MOSC) was prepared in proportion to the desired quantity of wastewater. Repeated jar tests were conducted to obtain appropriate concentrations based on the turbidity levels initially obtained in the wastewaters using recommendations of Schwarz (2000) and Doerr (2005). Hence, concentrations of 0.1, 0.2, 0.3 and 0.4 g/L were established as appropriate and prepared in plastic bottles with volume of wastewater (V_w) in each case determined. Table 4 shows the moringa seed solution concentrations starting from 0, 0.1, 0.2, 0.3 and 0.4 g/L to compute the volume moringa solution (V_m) for any desired volume of wastewater.

2.6 Water Quality Evaluation.

Samples of treated wastewaters using the moringa seed solution concentrations prepared in 2.5 (b) based on the jar test using five bottles for the selected concentration levels were evaluated using methods in Table 5. When the Moringa seed solution concentration was introduced in each bottle, the moringa treatment mechanism takes place. For coagulation, the anions in turbid wastewater were attracted to the polypetide cations to stick together. In the case of flocculation, polypeptide proteins agglomerate the colloidal particles thereby condensing them and sedimenting under the influence of gravity. As microorganisms are packed in the sediments, the polypeptide proteins get absorbed into the microbial cell membranes thereby killing them.

2. 7 Water Treatment Efficiency.

Water treatment efficiencies were calculated based on turbidity reduction (TB_r) and coliform count reduction (CC_r) as follows:

2.7.1 Turbidity reduction.

$$Tb_r = \frac{TB_o - TB_c}{TB_o} x_{\text{ууу}} \quad (1)$$

where:

TB_r = Turbidity reduction, %

TB_o = Initial turbidity, NTU

TB_c= Turbidity after treatment, NTU

2.7.2 Coliform count reduction.

$$CC_r = \frac{CC_o - CC_c}{CC_o} x100 \quad (2)$$

where:

CC_r = Coliform count reduction, %

CC_o = Initial coliform count, cells/100 mL

CC_c= Coliform count after treatment, cells/100 mL

3.0 RESULTS AND DISCUSSION

3.1 Measured Chemical Characteristics of Moringa Oleifera Seed.

Table 6 shows the major and useful chemical composition of the *Moringa oleifera* seed powder. The results have slight variations when compared with those of Foidl *et al.*, (2001) and Anwar *et al.*, (2006) possibly due to regional and specie variations. Calcium (Ca)**,** Magnesium (Mg) and Sodium (Na) determine its Sodium Adsorption Ratio (SAR). The iodine might have contributed to the disinfecting properties of the plant alongside the influence of polypeptide protein. However, crude protein (30.28 %) obtained was quite high.

3.2 Measured Water Quality Characteristics.

The waste waters evaluated before and after treatment with *Moringa oleifera* seeds resulted to the following***:***

3.2.1 Turbidity reduction.

The reduction values of turbidity (Figure 3) in domestic wastewater (W_1) was from 14 NTU to 2 NTU, agricultural wastewater (W_2) from 16 NTU to 3 NTU while it reduced from 11 NTU to 1.5 NTU in industrial wastewater (W_3) at 0 and 0.4g/L respectively. From Table 7, the highest reductions in turbidity were obtained at 0.4 g/L MOSC while lower values were obtained at 0.1 g/L MOSC levels for all the samples. These agree with the views of Sarpong and Richardson (2010). However, organic matter in treated water increases with moringa dose and may pose water quality problems with storage of treated water (Ndacigengesere *et al*., 1995). The efficiency of *Moringa oleifera* might decrease with increase in storage duration due its high biodegradable nature resulting to a short shelf life (Katayon *et al.*, 2004, 2006a and 2006b).

Figures 4(a) and 4(b) represent the reduction in TDS and TSS for domestic,

and industrial wastewaters before and after treatment respectively. For domestic wastewater, there was a sharp reduction in TDS from 0 to 0.1 g/L but the rate was low from 0.1 to 0.4 g/L. In the case of TSS, there was a steady decrease. For agricultural wastewater, the TDS reduction was steady from 1.5 mg/L at 0 MOSC to 1.2 mg/L at 0.4 g/L. In contrast, both TDS and TSS reductions in industrial wastewater were steady.

3.2.2 Reduction in chemical characteristics.

Figure 5 shows the sodium adsorption ratios (SAR) for the three wastewaters. It could be observed that agricultural wastewater was higher in SAR values than domestic and industrial wastewaters even after treatment with moringa solution and could be harmful to some crops. In Figure 6, electrical conductivity values reduced from 0.78 to 0.71 dS/m, 1.96 to 1.32 dS/m and 1.23 to 0.72 dS/m for domestic, agricultural and industrial wastewaters respectively. pH values (Figure 7) slightly increased from 8.56 to 8.73, 5.6 to 7.2 and 6.98 to 7.90 for domestic, agricultural and industrial wastewaters from 0.1 to 0.4 MOSC respectively. This is in conformity to WHO (2006) standards and in agreement with the views of Foidl *et al*., (2001). In Figure 8(a), for domestic wastewater, there was increase in Boron (B) content from 0.44 mg/L at 0 MOSC to 0.52 mg/L at 0.4 MOSC. In contrast, Chlorine (Cl) reduced from 10.42 to 8.61 mg/L while Bicarbonate (HCO_3) reduced from 7.98 to 7.01 mg/L at 0 and 0.4 g/L MOSC levels respectively. For Phosphate (PO_4), there was a change from 0.3 to 0.36 mg/L at 0 and 0.4 g/L MOSC respectively. In Figure 8(b), Aluminium (Al) content reduced from 0.56 to 0.50 mg/L. Similarly, Cadmium (Cd) values were 0.03 and 0.01 mg/L. For agricultural wastewater in Figure 9(a), Boron (B) increased from 1.8 mg/L to 2.4 mg/L. Chlorine (Cl) reduced from 10.9 to 8.39 mg/L. Bicarbonate (HCO_3) increased from 7.6 to 9.1 mg/L. Phosphate (PO_4) reduced from 0.39 to 0.32 g/L. Nitrogen with higher values reduced from 10.81 mg/L to 4.95 mg/L. Similarly, in the case Aluminium (Figure 9b), it reduced from 1.56 to 1.01 mg/L. Higher levels of Cadmium (Cd) and Lead (Pb) were measured when compared with the corresponding values in domestic wastewater. Cadmium (Cd) reduced from 0.21 to 0.12 mg/L while Lead (Pb) reduced from 1.96 to 1.40 mg/L. Figure 10 shows the chemical characteristics of treated industrial wastewater. In Figure 10(a), Boron (B) slightly increased from 0.39 to 0.50 mg/L, Chlorine also reduced from 6.2 to 3.9 mg/L while Phosphate (PO_4) reduced from 0.13 to 0.12 but later increased to 0.21mg/L at MOSC levels considered. In the case of Bicarbonate (HCO_3), the values increased from 6.41 to 7.31 mg/L.

The untreated agricultural wastewater had Nitrogen as high as 10.70 mg/L and reduced to 4.93 mg/L when treated with 0.4 g/L MOSC. For Aluminium (Al) in Figure 10(b), the reduction was from 0.55 to 0.45 mg/L while Cadmium (Cd) reduced from 0.06 to 0.02 mg/L and Lead (Pb) levels were 0.03 to 0.01 mg/L. This is quite high and therefore in support of the findings of Doerr (2005) and Muyibi (2006). Generally, there were slight variations in the effect of moringa in the chemical characteristics of the wastewaters. The treated water obtained is good for unrestricted irrigation based on Ayers and Westcot (1976) and Ayers and Westcot (1985) recommendations. The effects of *Moringa oleifera* can address health concerns earlier reported (Arbuckle *et al*., 2002, Bove *et al*., 2002 and Woo *et al*., 2002).

3.2.3 Coliform count removal. Results of coliform count show in domestic wastewater (W_1), coliform count reduced from 1000 to 120 cells/100 mL (Figure 11). For agricultural wastewater (W_2), it reduced from 1420 to 124 cells/100 mL while coliform count in industrial wastewater (W_3) reduced from 920 cells/100 mL to 80 cells/100 mL at 0 and 4.0 g/L respectively. Hence, coliform count is directly proportional to the MOSC

concentration levels in the samples as shown in Table 8. However, reductions in coliform count were slightly higher when compared to that of turbidity. This may mean that the moringa seed solution had more disinfecting power than that of coagulation. It forms channels in bacterial cell membranes, leading to cell death (Zasloff, 2002). Also, algal and bacterial growths at lateral nodes can be minimized and reduce biological clogging (Oliver et al., 2012).

4.0 CONCLUSION

Dry mature *Moringa oleifera* seeds were processed into powdered form and analyzed. The *Moringa oleifera* seed solution concentration (MOSC) was prepared and used to treat domestic, agricultural and industrial wastewaters. Results show that *Moringa oleifera* can be used as coagulant and disinfectant and the treated water can be used for domestic (such as laundry) and irrigation purposes.

REFERENCES

Al-Samawi, A. A. & Shokrala, E. M. 1996. An investigation into an indigenous natural coagulant. *Enviro. Sci. Health. A31 (8)*: 1881 – 1897.

Anwar, F., Zafar, S. N. & Rashid, U. (2006). Characterization of *Moringa oleifera* seed oil from drought and irrigated regions of Punjab, Pakistan. *GRASAS Y ACEITES, 57(2)*, ABRIL-JUNIO, 160-168, 2006.

Arbuckle, T. E., Hrudey, S. E., Krasner, S. W., Nuckols, J. R., Richardson, S. D., Singer, P., Mendola, P., Dodds, L., Weisel, C., Ashley, D. L., Froese, K. L., Pegram, R. A., Schultz, I. R., Reif, J., Bachand, A. M., Benoit, F. M., Lynberg, M. I., Poole, C. & K. Waller. 2002. Assessing exposure in epidemiologic studies to disinfection by-products in drinking water: report from an international workshop. *Environ. Health Perspect. 110(Suppl 1)*:53–60

Ayers, R. S. & Westcot, D. W. 1976. Water Quality for Agriculture. Food and Agriculture (FAO). *Irrigation and Drainage Paper* No. 29. FAO, Rome.

Ayers, R. S. & Westcot, D. W. 1985. Water quality for agriculture. FAO Publication. *Irrigation and Drainage Paper.* 163-171.

Babu, S. C. 2000. Rural nutrition interventions of Vitamin A deficiency with indigenous plant foods. Case study of Malawi. *Biotechnol. Agron. Soc. Environ. 2000 4(3)*: 169-179.

Bhole, A. G. 1995. Relative evaluation of a few natural coagulants. *Journal SRT – Aqua. 44(6)*: 284 – 290.

Bove, F., Shim, Y. & Zeitz, P. 2002. Drinking water contaminants and adverse pregnancy outcomes: a review. *Environ. Health Perspect. 110 (Suppl 1)*:61–74.

Divakaran, R. & Pillai, V. N. S. 2001. Flocculation of kaolinite suspension in water by chitosan. *Wat. Res. 35 (16)*: 3904 – 3908.

Diaz, A., Rincon, N., Escorihuela, A., Fernandez, N., Chacin, E. & Forster, C. F. 1999. A preliminary evaluation of turbidity removal by natural coagulants indigenous to Venezuela. *Process Biochemistry*, *35 (3)*: 391 – 395.

Doerr, B. 2005. Moringa Water Treatment (An ECHO Technical Note). Educational Concerns for Hunger Organization (ECHO). *Trees of Life Journal.*

Foidl, N., Makkar, H. P. S. & Becker, K. 2001. The potential of *Moringa oleifera* for agricultural and industrial uses. In: "The Miracle Tree/The Multiple Attributes of Moringa" (Ed. Lowell, J. Fuglie). CTA. USA.
Folklard, G. 2006. Personal communication on November 15, 2006.

Folklard, G. & Sutherland, J. 2001. The use of *Moringa oleifera* seed as a natural coagulant for water and wastewater treatment. SIMPÓSIO INTERNACIONAL SOBRE TECNOLOGIASDE APOIO ÀGESTÃO DE RECURSOS HÍDRICOS Centro de Educação Empreendedora do SEBRAE João Pessoa/PB 10 a 13 de julho de 2001.

Fuglie, L. J. & Olivier, C. 2008. Illustrated brochure on water treatment with Moringa. Retrieved December 15, 2008, from: http://www. moringanews. org/doc./WaterGB.

Ghebremichael, K. A. 2004. Moringa Seed and Pumice as alternative natural materials for drinking water treatment. *Ph.D Thesis submitted to KTH Royal Institute of Technology, Land and Water Resources Engineering, Sweden.*

Jahn, S. A. A. 2001. Drinking water from Chinese river: challenges of clarification. *J. Water SRT – Aqua. 50*: 15-27.

Kalibbala, H. M. 2007. Application of indigenous materials in drinking water treatment. *Ph.D Thesis submitted to KTH Royal Institute of Technology, and Water Resources Engineering, Sweden.*

Katayon, S., Magat Mohd Noor, M. J., Asma, M., Thamer, A. M., Liew Abdullah, A. G., Idris, A. Suleyman, A.M., Aminuddin, M.B. & B. C. Khor. 2004. Effect of storage duration and temperature of *Moringa oleifera* stock solution on its performance in coagulation. *Int. J. Eng. Technol. 1*: 146 – 151.

Katayon, S., Magat Mohd Noor, M. J., Asma, M., Abdul Ghani, L. A., Thamer, A. M., Azni, I., Ahmad. J, Khor, B. C. & A. M. Suleyman. 2006. Effect of storage conditions of *Moringa oleifera* seed on its performance in coagulation. *Bioresour. Technol. 97*: 1455 – 1460.

Katayon, S. Ng. S. C., Magat Johari, M. M. N. & Abdul Ghani, L. A. 2006. Preservation of coagulation efficiency of *Moringa oleifera*, a natural coagulant. *Biotech. Bioprocess Eng.* 11: 489 – 495.

Liu, X. F., Guan, Y. L., Yang, D. Z., Li, Z. & Yao, K. D. 2000. Antibacterial action of chitosan and carbomethylated chitosan. *Journal of Applied Polymer Science, 79 (07)*: 1324 – 1335.

Madsen, M., Schlundt, J. & Omer, E. F. 1987. Effect of water coagulation by seeds of

Moringa oleifera on bacterial concentrations. *J. Trop. Med. Hyg. 90*: 101–109.

Makkar, H. P. S. & Becker, K. 1997. The potential of *Moringa oleifera* for agricultural and industrial uses.

Muyibi, A. S. 2006. *Satiating thirst of millions in Nigeria. Application of processed Moringa oleifera seeds in drinking water treatment. 16th Public Lecture delivered at Abubakar Tafawa Balewa University, Bauchi, Nigeria on 3rd August, 2006.*

Muyibi, A. S. & L. M. Evison. 1995. *Moringa oleifera* Seeds for Softening Hardwater. *Wat. Res. Elsevier Science Ltd. Printed in Great Britain. Vol. 29, No. 4*, pp. 1099-1105.

Ndacigengesere, A., Narasiah, K. S. & Talbot, B. G. 1995. Active agents and mechanism of coagulation of turbid water using *Moringa oleifera. Wat. Res*. *29(2)*: 703-710.

Nwaiwu, N. E. & Ligmu, B. 2011. Studies on the effect of settling time on coliform reduction using *Moringa oleifera* seed powder. *Journ. of Appl. Sci. and Sanitation. Vol. 6 (3):*

Okuda, T., Baes, A., Nishijima, W. & Okada, M. 2000. Isolation and characterization of salt solution extracted active component from *Moringa oleifera* seed. *Water Res. 34*:405–410.

Oliver, M., M. H., Hewa, G. A. & Pezzaniti, D. 2012. Subsurface drip irrigation with reclaimed water: issues we must think now. *Paper presented at the 4th International Conference on Sustainable Irrigation held at University of South Australia, Adelaide from 11-13th December, 2012*.

Olsen, A. 1987. Low technology water purification by bentonite clay and *Moringa oleifera* seed flocculation as performed in Sudanese village: effects on *Schistosoma masoni cercariae*. *Wat. Res. 21(5)*:517 – 522.

Özacar, M. & Sengil, I. A. 2000. Effectiveness of tannins obtained from valonia as a coagulant aid for dewatering sludge. *Wat. Res. 34 (4)*: 1407 – 1412.

Pan, J. R., Huang, C., Chen, S. & Chung, Y. C. 1999. Evaluation of modified chitosan biopolymer for coagulation of colloidal particles. *Colloidal and Corrosive Surfaces: Physiochemical and engineering aspects. 147*: 359 – 364.

Raghuwanshi, P. K., Mandloi, M., Sharma, A. J., Malviya, H. S. & Chaudhari, S. 2002. Improving filtrate quality using agrobased materials as coagulant aid. *Water Quality Research of Canada. 37 (4)*:745 – 756.

Sarpong, G. & Richardson, C. P. 2010. Coagulation efficiency of *Moringa oleifera* for removal of turbidity and reduction of total coliform as compared to Aluminum Sulfate. *African Journal of Agricultural Research. Vol. 5(21)*, pp. 2939-2944.

Sauveur, A. S & Peprah, J. J. G.2006. Moringa News. Retrieved December 15, 2006, from: http://www.jatropha.de/expellers/.

Schwarz, D. 2000. Water Clarification using *Moringa oleifera*. Gate Information Service**,**

Eschborn, Germany.

Tauscher, B. 1994. Water treatment by flocculant compounds of higher plants. *Plant Res. Dev. 40*:56–70.

Tripathi, P. N., Chaudhuri, M. & Bokil, S. D. 1976. Nirmali seeds – a natural occurring coagulant. *Indian Journal of Environmental Health. 18 (04)*: 272 – 281.

Woo, Y.T., Lai McLain, D., Manibusan, J. L. & Dellarco, M. K. V. 2002. Use of mechanism-based structure–activity relationships analysis in carcino-genic potential ranking for drinking water disinfection by-products. *Environ. Health Perspect. 110 (Suppl 1)*:75–87.

World Health Organization (WHO).2006. Guideline for drinking water quality. Vol. 1, 3rd edition. http://www.who.int/water_sanitation_health/dwq/gdwq

Zasloff, M. 2002. Antimicrobial peptides of multicellular organisms. *Nature*. *415*:389–395.

Table 1. Recommended Dosage Of Moringa Seed Powder For Wastewater Treatment

	NTU	Dosage (1) mg/L	NTU	Dosage Seeds	(2) V_w, L
Low turbidity	< 50	10-50	< 50	1	4.0
Medium turbidity	50-150	30-100	50-150	1	2.0
High turbidity	>150	50-200	150-250	1	1.0
Extreme turbidity	-	-	>250	2	1.0

Source: [1]Schwarz (2000), [2]Doerr (2005)

Table 2. Types And Sources Of Wastewaters Sampled

Type	Code	Wastewater source	Latitude	Longitude
Domestic	W_1	University Hostel	11° 48' 15.3" N	13° 12' 10.4" E
Agricultural	W_2	Abattoir	11° 51' 24.6" N	13° 10' 47.0" E
Industrial	W_3	Nigerian Bottling Company	11° 50' 58.7" N	13° 05' 38.9" E

Table 3. Method/equipment For Determining Chemical Composition Of The Moringa Seed Powder

Constituents	Method/Equipment
Calcium (Ca), mg/L	ICPOES Optima 2000DV model (Perkin Elmer)
Potassium (K), mg/L	ICPOES
Sodium (Na), mg/L	ICPOES
Magnesium (Mg), mg/L	ICPOES
Phosphorus (P), mg/L	ICPOES
Nitrogen (N). mg/L	Proximate Analysis
Iodine value (I), mg/L	AAS model 400 (Perkin Elmer product)
Crude Protein (%)	Proximate Analysis

Table 4. Standardized Concentrations With Equivalent Volumes Of Wastewater Treated

MOSC (g/L)	Vol. of wastewater treated (V_w), L	Vol. of moringa solution (V_m), L
0 (Control)	1	0
0.1		0.1
	0.9	
0.2		0.2
	0.8	
0.3		0.3
	0.7	
0.4		0.4
	0.6	

Table 5. Methods/Equipment Used For Evaluating Wastewater Characteristics

Characteristics	Method/Equipment of Evaluation
A. Physical	
Total Suspended Solids (TSS), mg/L	Filtration
Total Dissolved Solids(TDS), mg/L	TDS/Salt meter (HDS 1024 Model)
Turbidity (TB), NTU	Turbidity meter (Hach model 2001A)
B. Chemical	
Electrical Conductivity (EC), dS/m	Combo Combined Electronic meter
Sodium Adsorption Ratio (SAR)	ICPOES
Boron (B), mg/L	AAS
Phosphate (PO_4), mg/L	Proximate Analysis
pH	Combo Combined Electronic meter
Chlorine (Cl), mg/L	Titration using standard Silver Nitrate
Nitrogen (N). mg/L	Proximate Analysis
Aluminium (Al), mg/L	ICPOES
Cadmium (Cd), mg/L	ICPOES
Lead (Pb), mg/L	ICPOES
C. Biological	
Coliform count	Most Probable Number (MPN)

Table 6. Chemical Composition Of The Moringa Seed Powder

Elements	Value
Calcium (Ca), mg/L	22.68
Potassium (K), mg/L	10.59
Sodium (Na), mg/L	2.91
Magnesium (Mg), mg/L	0.16
Phosphorus (P), mg/L	2.29
Iodine value (I), mg/L	62.7
Crude Protein (%)	30.28

Table 7. Turbidity Reduction In The Treated Wastewaters

MOSC, g/L	Turbidity reduction (%)		
	W_1	W_2	W_3
0.1	35.71	31.25	27.27
0.2	57.14	56.25	54.55
0.3	64.29	73.44	72.73
0.4	85.71	81.25	86.36

Table 8. Coliform Count Reduction (%) In Treated Wastewaters

MOSC, g/L	Coliform count reduction (%)		
	W_1	W_2	W_3
0.1	48.00	61.21	56.52
0.2	62.00	75.35	63.91
0.3	75.40	82.39	73.59
0.4	88.00	91.27	91.30



Figure 1. Parts Of Moringa Tree

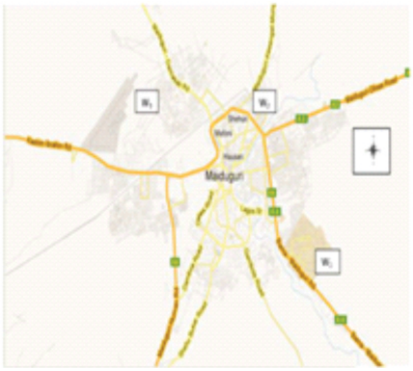


Figure 2. Location Of The Wastewaters

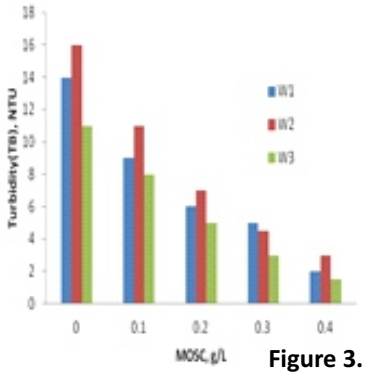
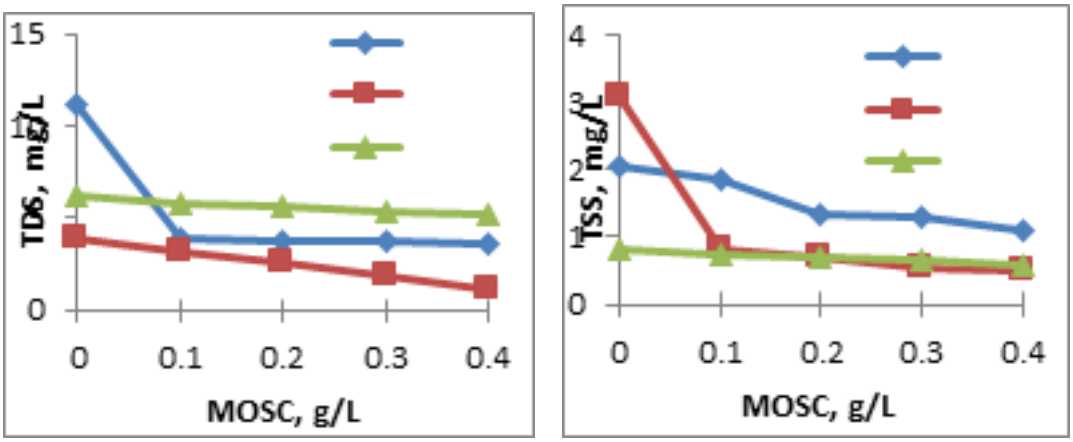


Figure 3. Turbidity Reduction In Treated Wastewaters



(a)Total Dissolved Solids (TDS) (b) Total Suspended Solids (TSS)

Figure 4. TDS and TSS of the Treated Wastewaters

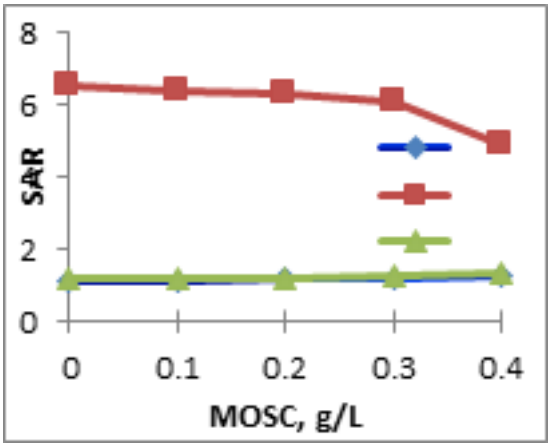


Figure 5. SAR of Treated Wastewaters

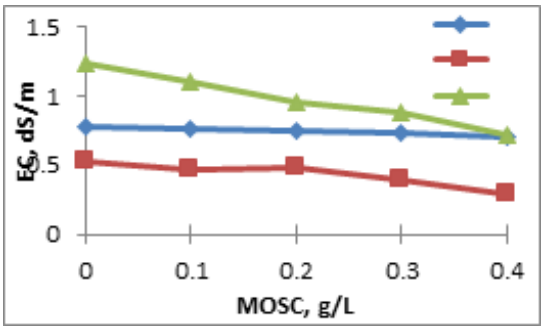


Figure 6. EC of Treated Wastewaters

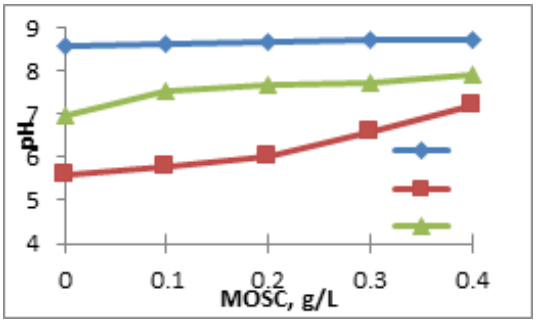


Figure 7. pH of Treated Wastewaters

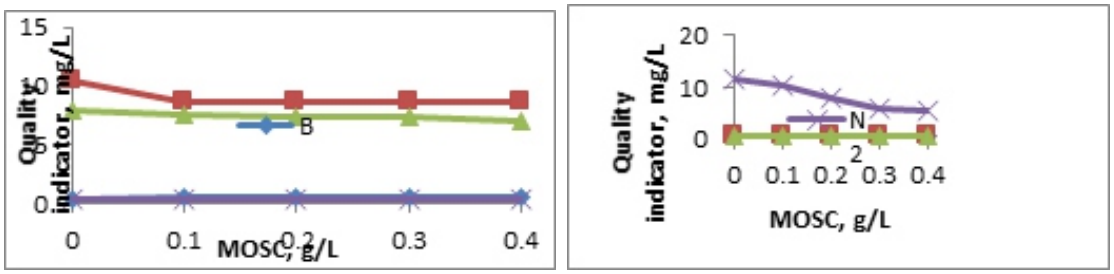
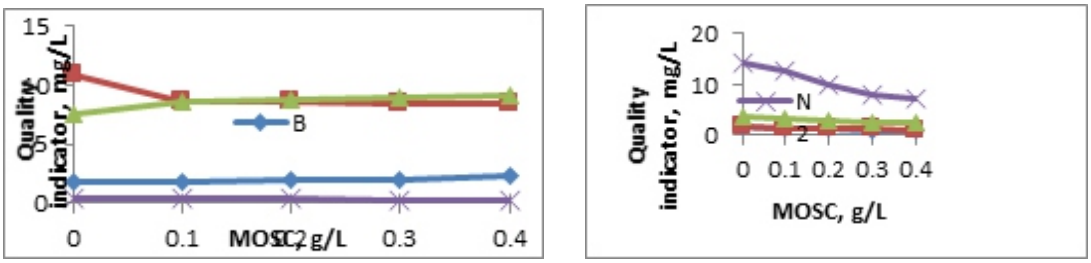
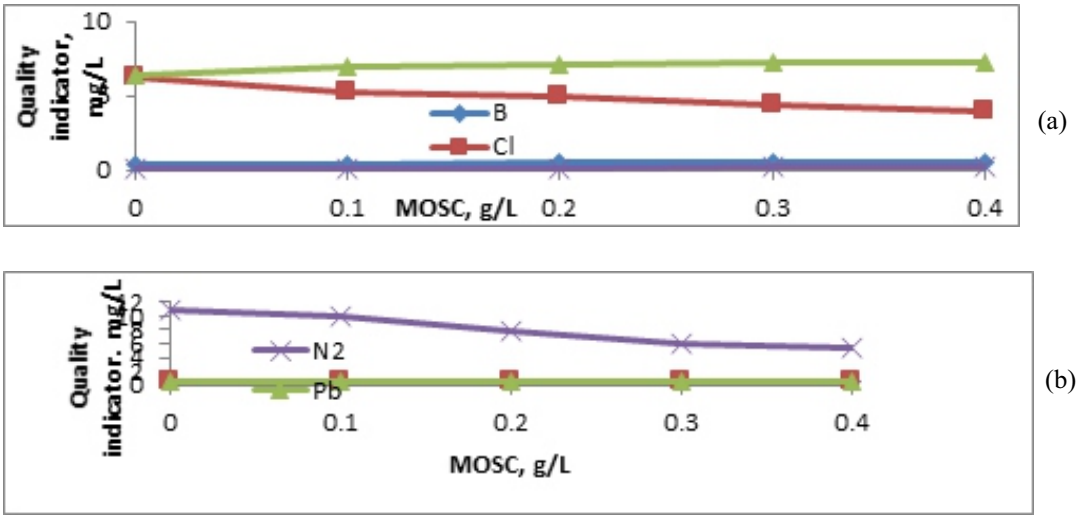


Figure 8. Measured Quality Indicators Of Treated Domestic Wastewater At Varied MOSC



(a) (b)

Figure 9. Measured Quality Indicators Of Treated Agricultural Wastewater At Varied MOSC



(a)

(b)

Figure 10. Measured Quality Indicators Of Treated Industrial Wastewater At Varied MOSC

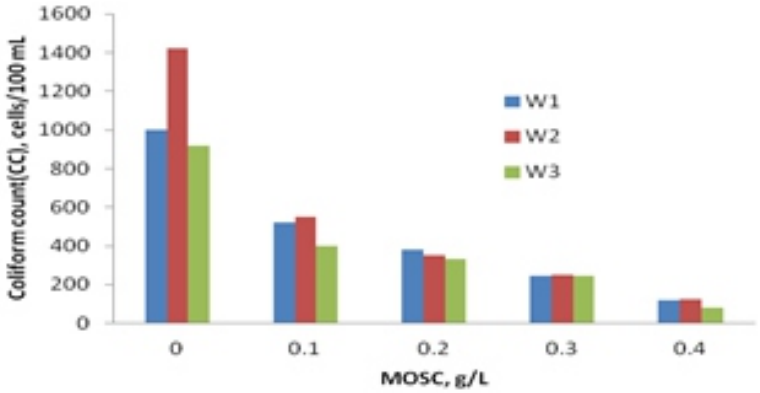


Figure 11. Coliform Count Reduction In Wastewaters At Varied MOSC

Note: AAS Atomic Absorption Spectrometer Icpoes Inductively-coupled Plasma Optical Emission Spectrometer

WATER QUALITY ANALYSIS OF A RECIRCULATORY AQUACULTURE SYSTEM

Ogunlela A.O and Ala A.I
Department of Agricultural and Biosystems Engineering
University of Ilorin, Ilorin, Nigeria.

ABSTRACT
An analysis was carried out to determine the efficiency of aquaculture reuse system in the purification of waste water. The treatment involves biological filtration, mechanical filtration and ultraviolet irradiation. The results indicated a pH value of 7.96. Dissolved Oxygen (DO) of 8.20mg/l and a Biochemical Oxygen Demand (BOD) of 10.20mg/ l- for the cultured system.

Keywords: Recirculatory Aquaculture System (RAS), Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Bacterial Count, Fungal Count.

1.0 INTRODUCTION
Aquaculture is the raising of aquatic organisms such as fishes, molluscs, crustaceans and aquatic plants. In recent times, aquacultural developments have received increased attention. Tilapia, common carp and catfish are the most selected species for a cultured environment (F.A.O, , 2006).

Recirculatory aquaculture system (RAS) is basically a system of aquaculture in which waste water is filtered, cleaned and recycled back for reuse by the aquatic organisms.

Aquaculture differs from most other methods of animal keeping in that the waste accumulates in the cultured environment. This can be hazardous to the organism, it is therefore highly expedient that the culture units are carefully managed to ensure that the water quality does not depreciate up to a point of harming the cultured organisms. Recirculatory Aquaculture System (RAS) ensures that water is conserved and that harmful waste materials are not released into the environment. Efficiency of this system in the purification of waste water needs to be determined by evaluating the quality of water produced after recirculation. Parameters of primary concern are ammonia, nitrite, oxygen, carbon dioxide, nitrogen and solids. It is important to note that it is not only the individual components that needs to be monitored, but the aggregate of all the water quality components which affects the growth and health of fishes (Meade,1989). The recirculated water must be of adequate quality and quantity to maintain acceptable growth and health of the organisms being cultured. This study was conducted to determine the effectiveness of a recirculatory aquaculture system in wastewater purification.

2.0 MATERIALS AND METHODS
A Recirculatory Aquaculture System (RAS), located behind the Agricultural and Biosystems Engineering Departmentof the University of Ilorin, Ilorin, Nigeria, was used for this study. Ilorin (longirtude 4^0 35' E, latitude 8^0 30'N) is characterized by two seasons : wet (March- October) and dry (November - February).

Components of the Recirculatory Aquaculture System were the culture tank, sedimentation tank, pumping machine, ultraviolet irradiation unit and biofilter tank. The biofiltration unit and sedimentation tank are shown in Plates 1 and 2, respectively.

The system was arranged in such a way that the water flowed from the culture tank to the sedimentation tank, then passes through the pump and sterilization unit before entering the biofilter tank and back to the culture tank. Placed on top of the sedimentation tank was the ultraviolet light lamp which was the source of ultraviolet irradiation to kill germs in the water.

2.1 Stocking Of The Culture Tank

The culture tank was stocked with catfish of various sizes and minimum quantity of water per weight of fish. The general rule is that 5 gallons (18.92) of water is needed for every pound (0.45kg) of fish (IFAS, 2012).

2.2 Recirculation Rate

The recirculation rate (R_r) is the amount of water exchanged per unit time (Helfrich and Libey, 2011).

Rr = total volume that can be pumped by the pump in a day/tank capacity ---- 1

2.3 Parameter Estimation

i. pH determination

The pH level was determined using the pH meter (Clida instrument).

ii. Dissolved oxygen (DO) estimation

Winkler titration method was used in the determination of the dissolved oxygen content of the water sample. (U.S. EPA, 1983).

iii. Biochemical oxygen demand (BOD) estimation

The biochemical oxygen demand was determined using standard method (U.S. EPA, 1983).

iv. Bacterial count determination

The standard plate count method was used (Reynolds and Farinha, 2005**).**

v. Fungal count determination

The modified standard plate count method was employed in fungal count determination,

3.0 RESULTS AND DISCUSSION

The laboratory test result of the source water is shown in Table 1 while the temperatures of the cultured tank water are shown in Table 2. The results for the various water quality parameters are shown in Figures 1 to 5, including those with the addition of the ultraviolet light and the biofilter. Table 3 shows the standard values for water quality parameters.

Water samples analyzed were those obtained from the culture tank, ultraviolet treatment unit and biofilter unit using oyster shells and lava stones for six consecutive weeks. It was observed that the pH of the source water (5.33), was relatively low, indicating acidic conditions. The initial acidic conditions were neutralized by the system, shifting towards alkalinity as the weeks progressed (Figure 1). The initial high values in dissolved oxygen (DO) are attributable to the source water. The decline in DO at the end of the second week is due to the oxygen consumption from the metabolism of the fishes and other organisms in the system. Incorporation of the ultraviolet and biofilter units improved the dissolved oxygen status of the system (Figure 2). The source water was responsible for the high Biochemical Oxygen Demand (BOD) in the first week, which

dropped in the second week (Figure 3). The bacterial and fungal counts decreased with the incorporation of the ultraviolet and biofilter units (Figures 4 and 5), indicating their effectiveness in deactivating the pathogens in the system.

SUMMARY AND CONCLUSIONS

Recirculatory aquaculture system is especially desirable in water- scarce regions. It requires proper monitoring and good management skills. Water quality is an essential attribute to monitor since poor water quality poses a great danger to the health of the fishes. Incorporation of ultraviolet and biofilter units improved the quality of water in the system.

REFERENCES

APHA Standard Methods for the Examination of Water and Waste Water 20th Edition. Method 5210B

Bocioc, E., Cristea, V., Patriche, N., Grecul, I., Coada, M.T., T.I Ionescul 2011. Water Quality Monitoring in a Recirculatory Aquaculture System for Intensive Rearing of Carp *(Cyprinis carpio*) juveniles fed with probiotes supplement. Lucrari stiintifice volume 55.

Food and Agriculture Organization (FAO) 2006. Status of the World Aquaculture 2006. FAO Fisheries Technical paper. Rome.

Helfrich , L.A., and G.Libey. 2011. Fish Farming in Recirculatory Aquaculture Systems (RAS). Department of Fisheries and Wildlife Sciences. Virginia tech

IFAS Publication (2012): Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations. http://tal.ifas.ufl.edu/publications.html (SRAC 451)

Losordo, T.M., Maser, M.P., and J. Rakocy.(1998) Recirculating Aquaculture Tank Production Systems. A review of components options. – SRAC Publications NO.453

Maser, M.P., Rakocy, J., T.M. Losordo(1999). Recirculating Aquaculture Tank Production Systems. Management of Recirculating Systems.

Meade, J.W. (1989) Aquaculture Management. Van Nostrand Reinhold, New York.

Methods of Chemical Analysis of Water and Wastes. EPA- 600/4-79-020, USEPA, Method 405.1

http://www.in.gov/dnr/fishwild/files/Methods_Analysis_Water_Wastes_USEPA_March1983.pdf

Steicke, C.R., Jegatheesan, V., C.Zeng.(2011) Recirculatory Aquaculture System – A Review, School of Engineering, James Cook University, Townsville, QLD 4811, Austria.

Table 1: Laboratory Test Result Of The Source Water

Parameter	Value
pH	5.33
DO(mg/l)	40.20
BOD(mg/l)	37.60
Bacterial count	14.7
Fungal count	5.5

Table 2. Temperatures Of The Culture Tank Water

Day	Morning(7:00am)	Evening(6:00pm)
Day 1 (28/05/2012)	26^0C	28°C
Day 2 (29/05/2012)	26^0C	26°C
Day 3 (30/05/2012)	27^0C	26°C
Day 4 (31/05/2012)	24^0C	28°C
Day 5 (01/06/2012)	26^0C	28°C
Day 6 (02/06/2012)	24^0C	27°C
Day 7 (03/06/2012)	25^0C	27°C

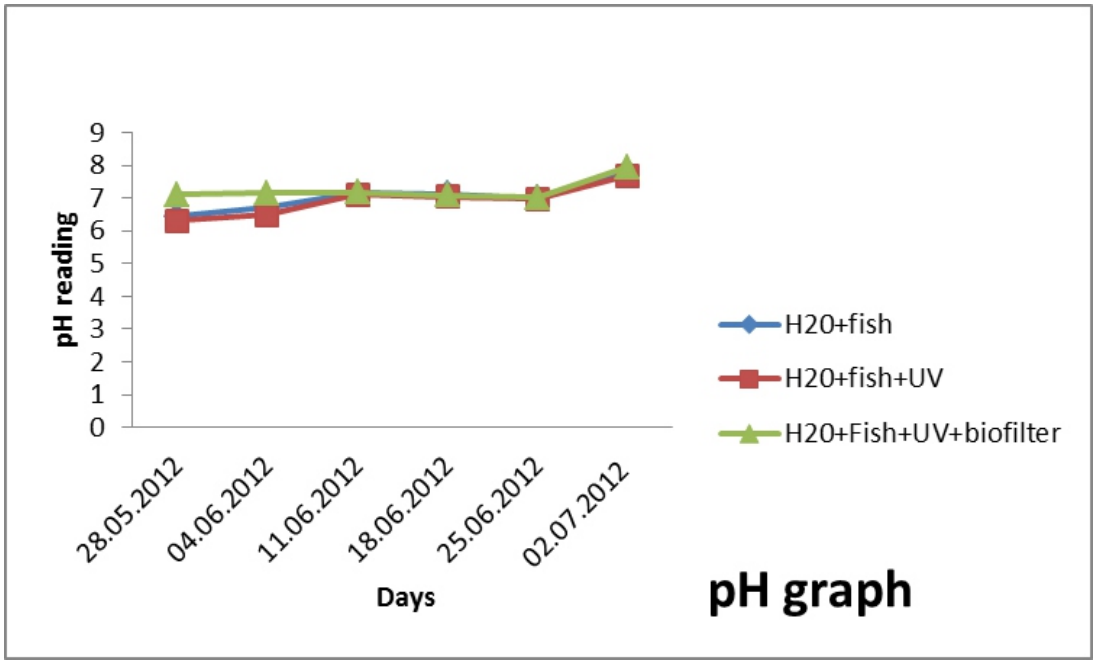


Figure 1: pH Graph

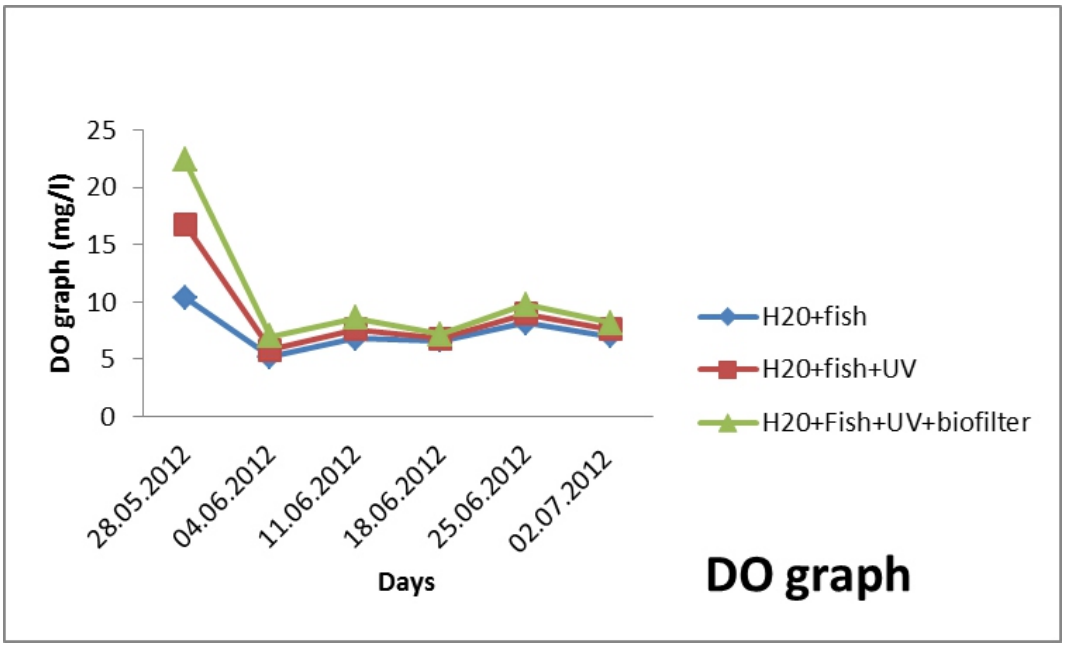


Figure 2: Dissolved Oxygen Graph

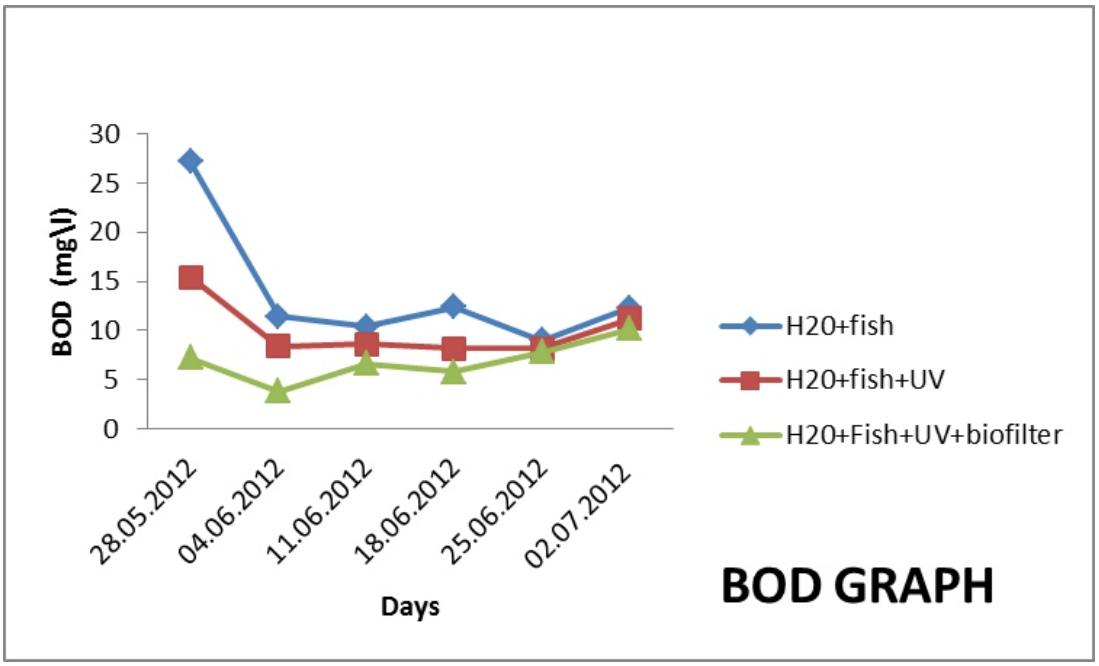


Figure 3: Biochemical Oxygen Demand Graph

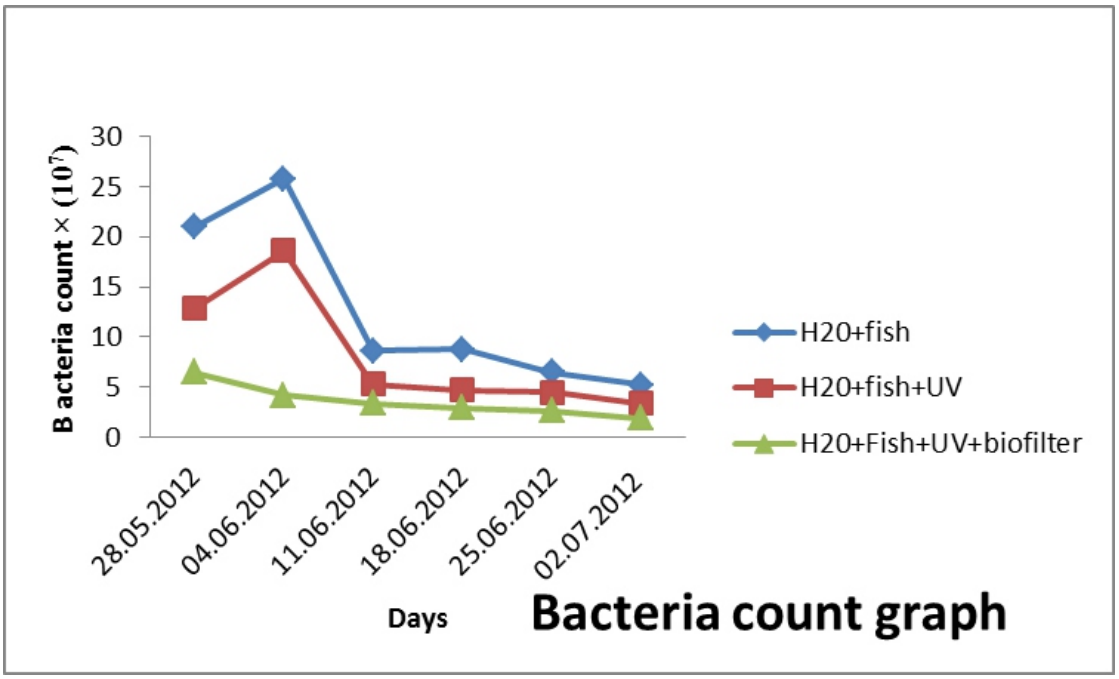


Figure 4: Bacteria Count Graph

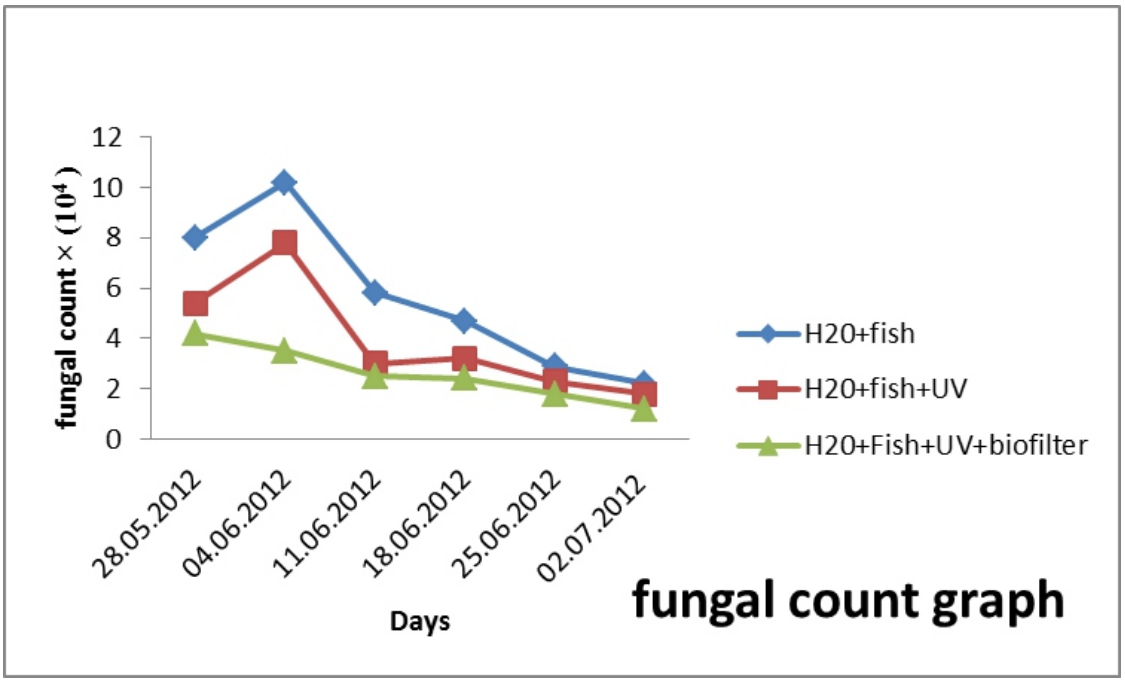


Figure 5: Fungal Count Graph

Table 3: Standard Values For Water Quality Parameters

Parameters	Unit	Target reference	reference
pH		6.5-9	Losordo et al., 1998
DO	(mg/l)	>5.0	Maser et al., 1999
BOD	(mg/l)	<20	Steicke et al., 2011
Temperature	^{0}C	21-29	Bocioc et al., 2011



Plate 1. Biofiltration Unit.



Plate 2. Sedimentation Tank

ASSESSING THE SODICITY AND SALINITY STATUS OF THE DAM OF AGRICULTURAL SERVICES AND TRAINING CENTRE PLATEAU STATE- NIGERIA

Oiganji Ezekiel *, B.C Falemara* , S. H. Kwarams*, A.A Stanley**
*Forestry Research Institute of Nigeria. Federal College of Forestry,
PMB 2019 Jos- Plateau State
*Ahmadu Bello university, department of Agricultural Engineering Zaria.
Corresponding author Email :ezeganji@gmail.com Phone : +2348061279887

ABSTRACT
Assessment of the sodicity and salinity status of the Agricultural Services and Training Centre Dam water for Irrigation purposes was carried out. Water samples taken at the Upper, Centre and lower sections of the Dam and collected between December 2012 – April 2013 at Bi-monthly interval, were analyzed at Federal Ministry of Water Resources Gombe State regional water quality laboratory in accordance with the standard of National Environmental Standard and regulation Enforcement Agency (NESREA 2011) and World Health Organization (WHO,2004). The following water parameters: Electrical Conductivity EC, Total Dissolved salts (TDS), Sodium and Sodium Adsorption Ratio (SAR) were analyzed. There was significant difference in the variation of the Total hardness in the dam water during the study period. It was revealed that the ASTC Dam contains allowable levels of TDS (13-14mg/L), the SAR (1.07-1.17mg/L , EC (20-22.33mg/L) Sodium (5.87-6.30mg/L) and TH (95-110mg/L) values were within ranges that will not cause salinity problem and so, there should be no restriction on the use of this water for irrigation purposes. Therefore, the water quality of ASTC Dam is good for Irrigation purposes.

Keywords: Water quality, Irrigation, Salinity, Sodicity, Water

1.0 INTRODUCTION

In the not-too-distant past water was uncontested, and not necessarily closely monitored or regulated by stakeholders as reported by Miller and Gardiner (2007). Growing competition and accountability of the use of water have contributed to increasing scrutiny about how water is used and how much water is available to the public for non-agricultural uses. The face of irrigated agriculture is changing with respect to water quantity and quality (Mustapha, 2008, 2010; Murtala, 2009). Water quality problems have intensified through the ages in response to the increased growth and concentration of population and industrial activities. Irrigation has been practiced throughout the world for several millennia but it is only in this century that the importance of irrigation water quality has been recognized; increasing world's irrigated land has adversely created problems of water logging, excessive salinity and Sodicity (WHO, 2004). The definition of quality of water depends on the desired use of water. Apart from natural factors influencing water quality, human activities such as domestic and agricultural practices impact negatively on dam water quality (Babiker *et al*.,2007). Water quality can only be defined in relation to some potential use for which the limiting concentration of various parameters can be identified (Rajendra *et al*., 2009). Water quality criteria include pH, Chemical Oxygen Demand, biochemical oxygen, total

(WHO,2006). Water quality guidelines are acceptable concentrations of substances that can be consumed by people and concentrations above these are considered dangerous to human life (Onuoha, 2010; WHO, 2006).Water quality is important because it is essential to all life forms on earth. We rely on water not only to sustain our lives, but also for both plants and animals in our environment. If the quality of water is altered by the presence of toxins, it is potentially harmful to life forms, instead of sustaining them. Water used for irrigation can vary greatly in quality depending upon the type and quantity of dissolved salts. The quality of water used to irrigate crops has great effect on soil fertility, seed germination, plant susceptibility to pests and diseases (Odjugo and Konyeme, 2008).

Urbanization and population increase contribute to water pollution through increased waste disposal on water bodies and poor agricultural practices (Ali, 2008, Cobourn and Segale, 2003; Mating *et al*.,2010 , Odjugo and Konyeme, 2008).

In irrigated agriculture, the hazard of salt is a constant threat. Salts are originated from dissolution or weathering of rocks and soil, including dissolution of lime, gypsum and other slowly dissolving soil minerals. These substances are carried with the water to wherever it is used. Water quality criteria for irrigation generally take into account, amongst other factors such as crop tolerance to salinity, sodium concentration and phototoxic trace elements. Sodium adversely affects soil structure and reduces the rate at which water moves into and through the soil. A better measure of the sodium hazard for irrigation is the sodium absorption ratio (SAR) which is used to express suitability of water for irrigation purposes (Islam and Shamsad, 2009).

Islam and Shamsad (2009) reported that irrigation water that has high sodium($Na^{+)}$ content can bring about a displacement of exchangeable Calcium (Ca^{2+}) from the clay minerals of the soil, followed by the replacement of the Cations by sodium. Sodium saturated soil peptizes and loses their permeability so that their fertility and suitability for cultivation decreases. The quality sustainability of different water sources depend mainly on the status of its chemical composition. The parameter of concern in quality determination of irrigation water include: Electrical conductivity (EC), Total dissolved solid (TDS), Cations and Anions ($Na^{+}mg^{++}$,Ca^{++},Cl^{-}, CO_3^{-}, HCO_3^{-}, SO_4^{-}), others include Ammonium-Nitrogen ($NH_4^{-}N$), Nitrate-Nitrogen (NO_3^{-}-N), Phosphate-Phosphorus (PO_4^{-}-p), Acidity and Basicity (PH) and Boron (B) (Mustapha,2010).

In Nigeria, the total water received from rainfall exceeds the total demands from agriculture, domestic and industrial uses (Othman *et al.*, 2010). Nigeria's water resources have been under increasing stress in recent years due to rapid demographic changes which have coincided with the establishment of human settlement that lacks proper sanitary infrastructure. In view of this, the Federal Environmental Protection Agency (FEPA) issued a specific decree to protect, restore and preserve the ecosystem of the Nigerian environment (Chiaudani and Premazzi., 1988). The decree empowered the agency to set water quality standards to protect public health and to enhance the quality of irrigation waters (Chiaudani and Premazzi., 1988). The Plateau State Government under Jonah David Jang in agreement with SEC Equipment and Communications Limited; gave birth to ASTC. SEC Equipment and Communications Limited is an Israeli company with excellent expertise in agricultural development and whose vision is to revolutionize agriculture from its initial traditional method. A Dam is now used as source of water for the Agricultural Services and Training Centre (ASTC) (Oiganji *et al*., 2012). This research work therefore attempts to assess the Sodicity and salinity status of the dam.

2.0 MATERIALS AND METHODS

2.1 Description of the Study Area

A field study between October 2012 and April 2013 to evaluate the suitability of water for irrigated agriculture was conducted at Agricultural Services and Training Center (ASTC) Dam Vom, which is located between latitude $9^{o}44^{i}$ 27.8^{ii} longitude $8^{o}44^{i}$ 18.5^{ii} with altitude of 1247m above sea level; Jos South Local Government area Kassa-Vom ; Plateau State.

2.2 Water Sampling

Samples were collected bi-monthly in the morning between 7-9am at the upper, centre and the lower section of the dam during the said period. High density PVC bottles were used for sampling. They were thoroughly cleaned by rinsing with 8N HNO_3 and deionized water followed by repeated washing with water sample as suggested by De (1989). The bottles were kept air-tight and labeled properly for identification, aeration during sampling was avoided by corking the bottle quickly. Samples collected from study area were quickly transported to the Federal Ministry of Water Resources Gombe State regional water quality laboratory. A total of thirty (30) samples were collected, 10 samples from each of the three (3) zones of the dam and their means for each section were estimated as recommended by Kirda (1974).

2.3 Chemical and Physical Analysis

The chemical analysis of water involves the chemical tests which were carried out to determine some chemical parameters and the corresponding chemical characteristics of the water. The chemical tests carried out include total solids, pH, chloride, nitrate, electrical conductivity, Sodium Adsorption Ratio, sulphate, magnesium, sodium, Magnesium, calcium (Modi, 2006); while the physical analysis of water involves the physical tests carried out to determine the physical impurities and corresponding physical characteristics of water. The physical parameters determined were Total dissolved solids (TDS) and total carbonate hardness (TH).

2.4 Water Sampling Analysis

The water samples were analyzed for physical and chemical characteristics. For irrigation purposes, bacteriological analysis is unimportant (Ayers and Westcott, 1985). Standards methods and procedures described by the National Environmental Standard and regulation Enforcement Agency (NESREA 2011) and WHO (2004) were used to analyze the parameters. The parameters analyzed, unit and method used are indicated in Table 1. The sodium absorption ratio were calculated using equation 1 which quantifies the proportion of sodium, calcium, and magnesium ion in a sample, the Sodium percentage values estimated using equation 2 as reported by Richard (1954).

$$SAR = \frac{N_a}{\sqrt{\frac{C_a + M_g}{2}}} \quad (1)$$

$$N_a = \frac{(N_a + K)100}{C_a + M_g + N_a + K} \quad (2)$$

3. RESULTS AND DISCUSSION

3.1 Total Dissolved Salts

The results from Table 2 and Fig 1 shows that the Total Dissolved salts (TDS) were within the range of 13-14mg/L which were not significant during the study period. Total Dissolve Salts measures the concentration of dissolved solutes in irrigation water

used to evaluate salinity hazards. Comparing the total dissolved salts with WHO and NESREA standard, it can be seen clearly that the ASTC Dam contains allowable level of TDS that will not cause salinity problem. So there should be no restriction on the use of this water for irrigation purposes.

3.2 Electrical Conductivity

Electrical Conductivity is an indication of total quantities of soluble salts in solution, used to determine salinity level of water. The EC values obtained were within the range 20-22 μS/cm which was also not significant during the study period as shown in table 2 and fig 2. Nevertheless these values are less than 0.7dS/m which is the permissible range (0-0.7dS/m) for WHO (2004) and 0-1000 for NESREA standard. Therefore the ASTC Dam poses no Salinity problem.

3.3 Sodium Hazards

Sodium hazard can be expressed based on the sodium adsorption ratio (SAR), the SAR mean values for the study period were in the range of 1.07 -1.17mg/L which was also not significant throughout the period of research as shown in table 2 and Fig. 3 but however were within the acceptable limit as recommended by Ayers and Westcott (1985) (0-10mg/L). The SAR values were within these ranges of 0-3 and < 0.2dS/m, this again confirms that the Dam water has low salinity but may be corrosive and tend to leach surface soils free of soluble minerals and salts especially calcium, reducing their strong stabilizing influence on soil aggregate and soil structure (Ayers and Westcot,1994).

3.4 Percentage Sodium

The percentage Sodium within the study period ranged from 41.9- 49.97mg/L as shown in table 2 and Fig 4 & 5 , according to Ayers and Westcott (1985) recommendation; if the percentage Sodium is < 20 , it is considered excellent, 20-40mg/L is Good and 40-80mg/L is fair. The values obtained in this research were within the range 40-80 mg/L which is considered fair, which may result in sodium accumulations that will cause a breakdown in the soil's physical properties.

3.5 Total Carbonate Hardness

Sulphate ion concentration were in the range 95- 110mg/L in the abstracted samples of the different sections of the dam as shown in table 2 and Fig 6, and was significantly different during the study period. During the month of October total carbonate hardness was significantly different with that of the month of February; However for the month of December it was statistically at par with the month of October and February. Nevertheless, when compared to the recommended range for NESREA (2011) and WHO (2004) standard 0-150 and 0-150; indication shows that the dam water is very soft and it may probably be related to lack of some essential nutrients like calcium, sulphate and bicarbonates; then it is necessary to add necessary supplement for the deficiency. The hardness of water prevents formation of sufficient lather with soap.

4. CONCLUSION

Water quality for Agricultural Services Training Centre was carried out by considering the physico-Chemical parameters of the samples taken at the Upper, Center and Lower sections of the Dam between October 2012 – February 2013. The results showed that the parameters considered were in compliance with NESREA and WHO standards. It can be concluded that the water quality of ASTC Dam is good for Irrigation purposes as the EC values is below 3mmhos/cm and salinity value are suitable for irrigation purposes throughout the study period. To safeguard long-term sustainability,

the dam water quality should be monitored continually since it is majorly used for drip irrigation through denitrification and nutrient control to prevent degradation. Also an on-going irrigation water quality monitoring program should be established in order to document changes over time.

REFERENCES

Ali, M.S.(2008). Land pollution. Edward's College Peshawar. Available at http://en.wikipedia.org. accessed on the 7th February; 2010.

Ayers, R.S and D.W Wescott (1985). Water Quality for Agriculture. FAO Irrigation and Drainage paper No.29 Food and Agriculture Organization of the United Nations pp1-117

Babiker, I.S., M.A.A. Mohammed, T. Hiyama.(2007). Assessing Groundwater Quality using GIS. Springer : Water Resources Management Vol.21, Issue 4, pp699-715

Chiaudani, G. and G. Premazzi (1988).Water Quality Criteria in Environmental Management Report EUR 11638 EN,Commission of the European Communities, Luxembourg.

Cobourn, J. and Segale, H. (2003). Where does Tahoe's water pollution \come from? The lake Tahoe Report. Tahoe Environmental Research Centre

De, A.K (1989). Environmental Chemistry. Wiley Eastern Limited, New Delhi, India. pp 42-43

Islam, M.S. and S.Z.K.M Shamsad (2009). Assessment of Irrigation Water Quality of Bogra District in Bangladesh. Bangladesh Journal of Agricultural Research 34 (4):597-60

Kirda,C.(1974). Assessment of Irrigation Water Quality. CIHEAM-options Mediterranean

Marting,R; Olaleye, A.O and Johanne M. (2010). Assessment of Water Quality in Mohale Dam and Associated Rivers in Lesotho. Second RUFORUM Biennial Meeting 20-24 September 2010, Entebbe, Uganda.

Miller, R.W, and D.T. Gardiner (2007) Soil in our environment . 9th edition. Prentice Hall Upper Saddle River, New Jersey 07458.ISBN 0-13-020036-0, Table 15-6, page 452

Modi, P.N (2006). Environment Engineering-1, Water Supply Engineering. 2nd Edition. Standard Book House, Delhi pp741-790.

Murtala A.A. (2009): Investigation of Physical Properties of Soil for Irrigated Agriculture. Proceeding of the 2nd National Engineering Conference, Institute of Technology Kwara State Polytechnic Ilorin, Kwara State , Nigeria.

Mustapha, M.K. (2008). Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, Using Selected Physico-Chemical Parameters. Turkish Journal of Fisheries and Aquatic Sciences 8: 309-319 (2008).

Mustapha, H.I (2010). Water Quality Assessment of River Chanchaga for Irrigation purposes,Minna, Niger State, Nigeria. Proceedings of the 31st National Conference of the Nigerian Institution of Agricultural Engineers (NIAE). Vol 31: pp304-309

Adeogun, A.O; Chukwuka, A.V and Ibor, O.R (2011). Impact of Abattoir and Saw-mill Effluents on Water Quality of Upper Ogun River. American Journal of Environmental Science,7:525-530.

Oiganji, E., O.E Nwafor and A.Ahmed (2012). Review on the Use of Drip Irrigation in Nigeria. Proceedings of the 33rd National Conference of the Nigerian Institution of Agricultural Engineers (NIAE). Vol 33: pp153-156

Odjugo, A.O.P, and Konyeme, J.O. (2008).The Impact of urban, environment and Seasonality on 6he quality of Ikpoba River in Benin City, Nigeria. Journal of Food, Agriculture and Environment 6(2):362-369.

Onuoha S.N. (2010) Basic Concept of Irrigation and Drainage Engineering, Codat publication university of Ibadan.pp18 -20.

Othman, M.K, A.I Arab, A. Ibrahim and M.S Kallah (2010). Mitigating Desertification through Irrigation: Opportunities and Challenges in Northern Nigeria. Proceeding of the 10th International Conference of Nigerian Institution of Agricultural Engineering .Pp 338 -352

Rajendra Prasad, D.S., Sadashivaiah, C, and Rangnna G.(2009). Hydrochemical Characteristics and Evaluation of Ground water Quality of Tumkur Am,anikere Lake Watershed, Karnataka, India. E-journal of chemistry, 6(1):211-218.

Richard, L.A (1954).Diagnosis and Improvement of Saline and Alkaline Soils. Agricultural Handbook 60.Washington, DC: USDA,pp.160

WHO.(2004), accessed on the 4th January 2013. www.who.int/water_sanitation-health/publication/facts2004/en/index.html.

WHO. (2006). Guidelines for drinking water quality. Volume 1.Third Edition Geneva WHO Switzerland. http://www./whoint/watersanitation health/dwq/gdwq00506_ann4. Accessed on 14th August 2010.

Table 1: Parameters, Units And Method Used For Analyzes Of Samples

PARAMETERS	UNIT	METHOD USED
Elect. Conductivity	µS/cm	Conductivity meter
TDS	mg/L	Conductivity meter
Sodium (Na^+)	mg/L	Photometer
SAR	mg/L	Calculation
Percentage Sodium	%	Calculation
Sulfate($SO4^{2-}$)	mg/L	Sulfa Ver 4
Chloride(Cl^-)	mg/L	Argentometric
TH as ($CaCO_3$)	mg/L	EDTA titrimetric

Source: NESREA 2011 Cited by Adeogun *et al*., (2011)

Table 2: Sodicity And Salinity During The Study Period

Parameters	Oct	Dec	Feb	SE±	LSD	Remark
EC	22.33^{a}	20.67^{a}	20.00^{a}	1.05	0.367	Ns
TDS	14.00^{a}	13.00^{a}	13.00^{a}	0.53	0.391	Ns
Sodium(Na^{+})	5.87^{b}	6.27^{ab}	6.30^{a}	0.10	0.071	Ns
SAR	1.07^{a}	1.14^{a}	1.17^{a}	0.03	0.139	Ns
Percentage Sodium	41.90^{a}	48.40^{a}	49.97^{a}	2.09	0.104	Ns
TH as ($CaCO_3$)	95.00^{b}	101.67^{ab}	110.00^{a}	2.55	0.035	S

Remarks: Means In The Same Row Having The Same Superscript Are Not Significantly Different ($p>0.05$)
S= Significant, Ns= Not Significant

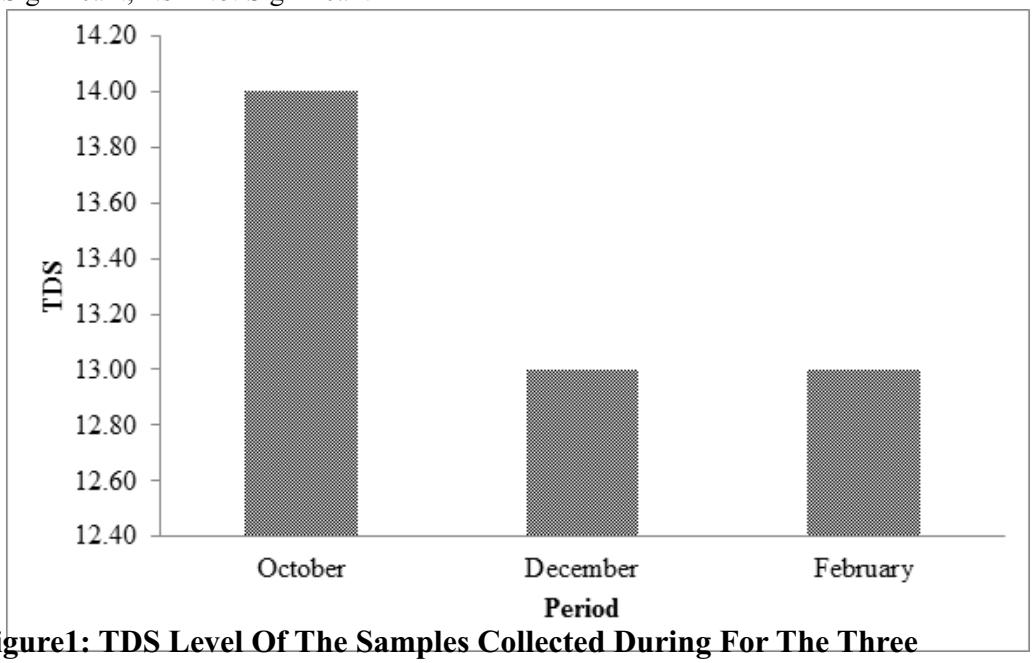


Figure1: TDS Level Of The Samples Collected During For The Three Periods Of Months

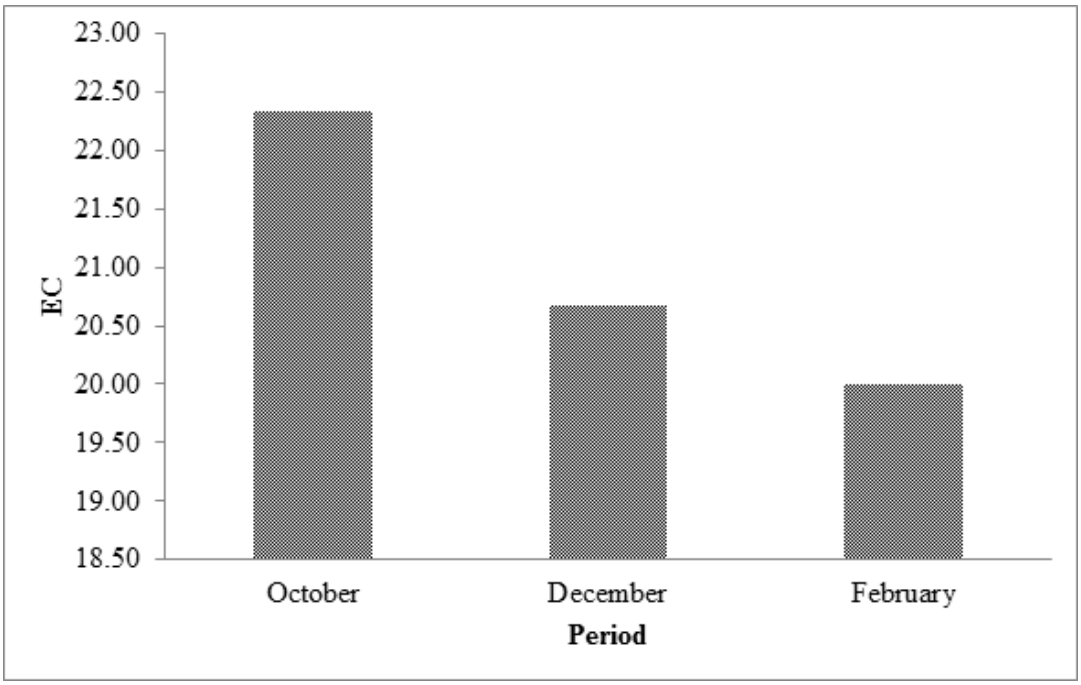


Figure 2: EC Level Of The Samples Collected During For The Three Periods Of Months

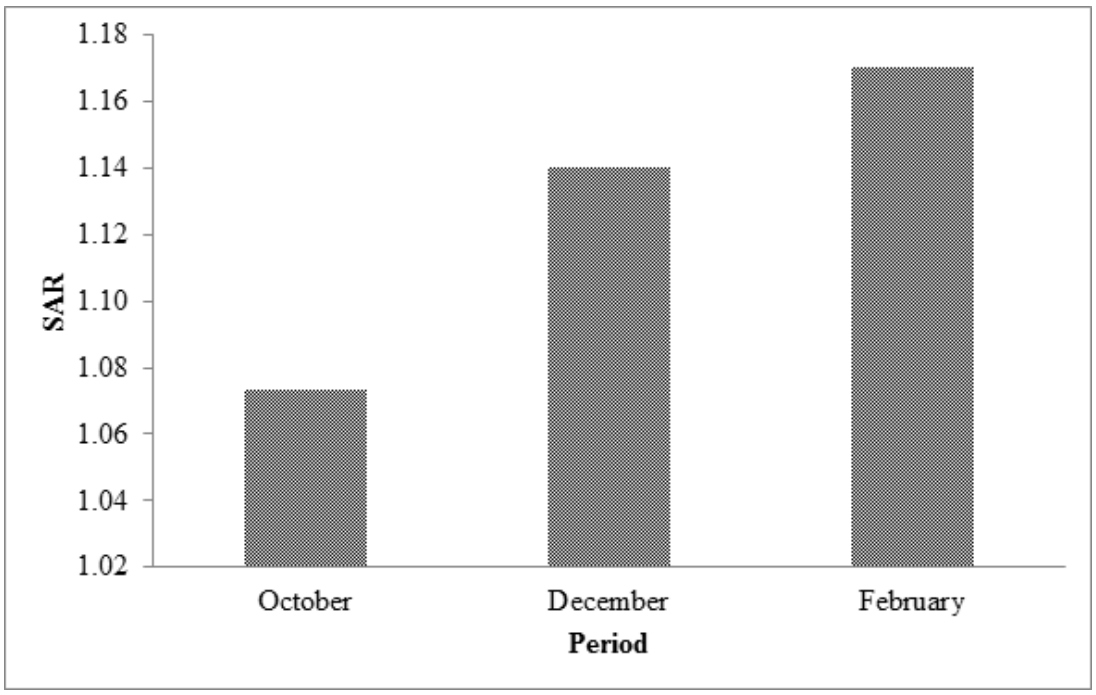


Figure 3: SAR Level Of The Samples Collected During For The Three Periods Of Months

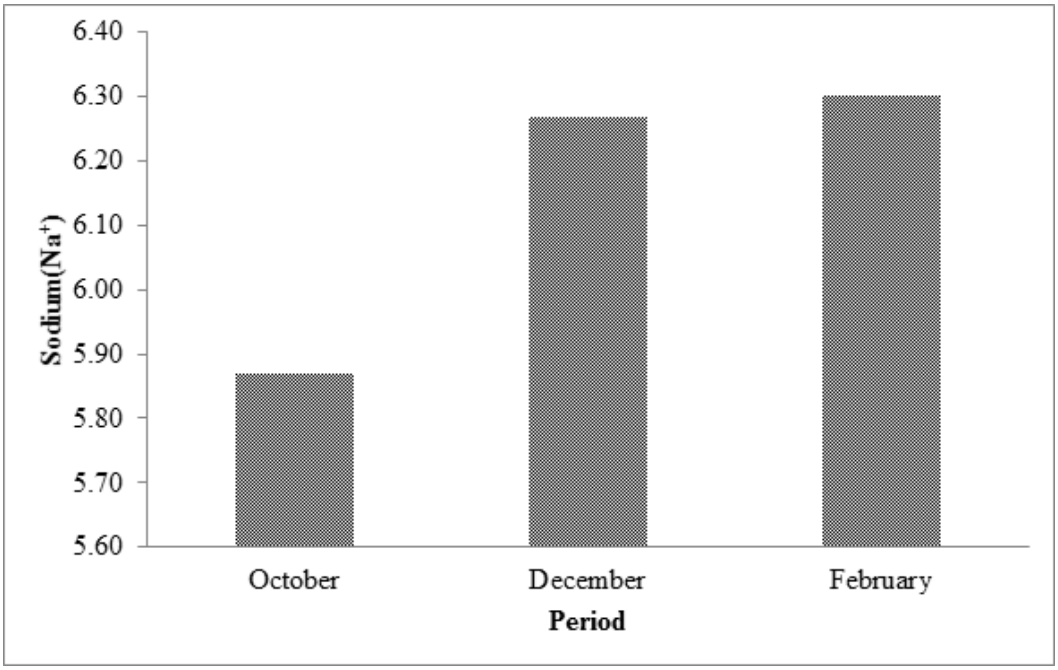


Figure 4: Sodium (Na^+) Level Of The Samples Collected During For The Three Periods Of Months

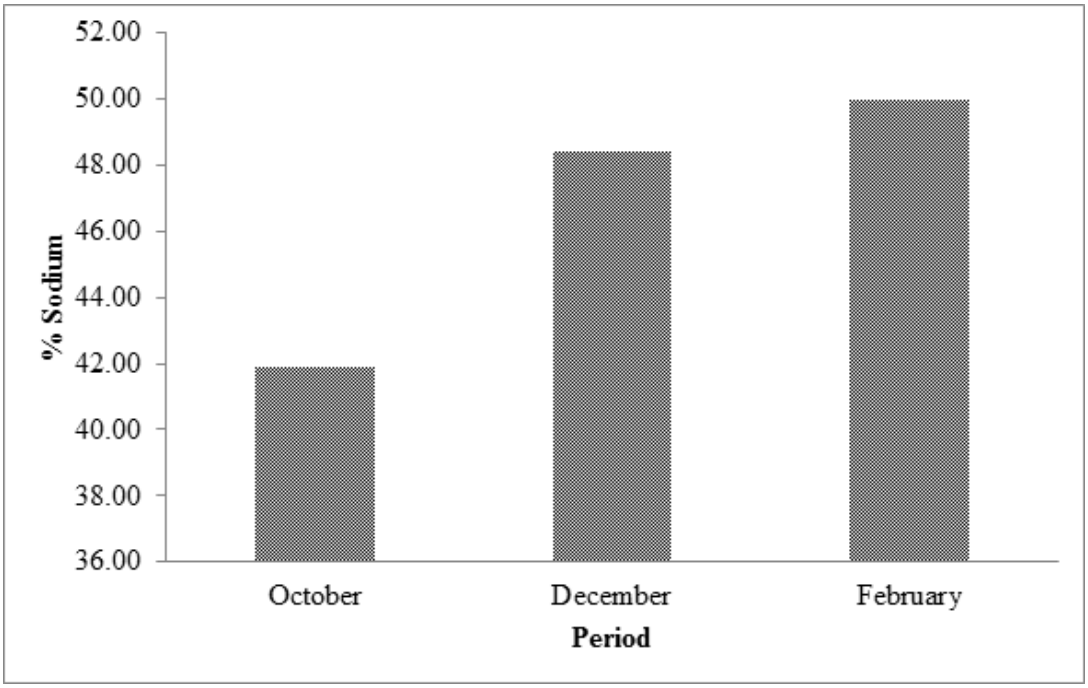


Figure 5: Percentage Sodium Level Of The Samples Collected During For The Three Periods Of Months

WATER QUALITY OF BOREHOLES IN FEDERAL POLYTECHNIC, BAUCHI.

Ahuchaogu, I. Israel[1] and Udusuyi, O. Felix[2]
[1]Department of Agricultural & Food Engineering, University of Uyo, Nigeria.
[2]Department of Civil Engineering, Federal Polytechnic, Bauchi, Nigeria.

ABSTRACT
The study covers the analysis of water samples collected from Boreholes within the polytechnic. The water sample collected was analyzed at RUWASSA (Rural Water Supply and Sanitation Agency) laboratory, Bauchi within 3hrs after collection. From the analysis of water sample available for distribution, the value of pH is 7.5, the turbidity is 7.2NTU, the mean temperature is 30.3^{0}C, free chlorine is 0.2mg/l, conductivity is 172.7µs/cm, the total solid (TDS) is 87.2mg/l. All these values including the amount of calcium 16mg/l, copper 0.025mg/l, manganese 0.01mg/l, Zinc 0.32mg/l, Iron 0.85mg/l, sulphate15mg/l, nitrate 22mg/l and nitrite 0.059mg/l, correspond to World Health Organisation (WHO) and National Agency for Food and Drug Control of Nigeria (NAFDAC) standard. While the water quality meets the bench mark of portable water (WHO & NAFDAC).

Keywords: Water Sample, Analysis, WHO, NAFDAC, Projected Population, RUWASSA.

1.0 INTRODUCTION

The Federal Polytechnic Bauchi has initial student's population of 245 and staff strength of 138 at inception, the Polytechnic can now in (2013) boast of about eleven thousands three hundred and thirty eight (11,338) students' population and an estimated staff strength of 800. As the population grows, there is an attendant growth of social amenities of which the forefront of such amenities is water supply. There was a precarious water supply within the Polytechnic community until between 1985 and 2012 when the situation began to improve with the attendant provision of water supply infrastructures to ameliorate the situation (Shinga, 2003).

One of the major problems confronting Federal Polytechnic Bauchi is the non-availability of portable water supply, a commodity which is very scarce to come by in so many communities from cities to villages for domestic use.

The common sources of water are the hand dug wells and boreholes. The well water is obtained through mannual means while that of the borehole is obtained by pumping water through network of pipes. Borehole water collected within the school form the main source of water sample for this study. Water plays a vital role in the development of any community. This is evidenced by the continual existence and development of the Federal Polytechnic Bauchi campus. However, portable water is seldom always available at the right quantity and place.

The distribution of water to consumers within the Polytechnic community is of paramount interest and concern has created the need to study the quality of water that is available in the polytechnic community using WHO and NAFDAC standards. This study examines the quality of water samples from borehole sources within the study area.

In an ideal water works projects, the water supplied for public distribution should be free from pathogenic organisms, undesirable taste and colour, palatable, of reasonable

temperature, neither corrosive nor scale forming in pipes and should be free from minerals which could produce undesirable physiological effects (Kamala, et al 1993).
The public health and socio economic development of a community can be enhanced if there is adequate accessibility to safe water supply. The availability of portable water plays a key role in the realization of health improvement measures in any community and it is an acceptable fact that water supply contributes to the reduction of the infancy mortality and mobility rate and increase the children's life expectancy. For some diseases, water provides the only transmission route, so that improved supplies are the only way to reduce disease incidence. Before the supply of piped water in 1963 and 1965, Fidti and Igbo-Ora in Nigeria (combined population 30,000) recorded incidences of Guinea worm of 20% among school children in one town and 60% among the total population in the other. No further cases were reported two years after completion of the water supplies, even though the disease was endemic in the surrounding areas (Yusuf, 1999).
Official statistics indicate that access to improved water sources rose from 49% in 1990 to 57% in 2000. While access in urban areas increased from 78% in 1990 to 81% in 2000, it declined to 72% in 2002. In the rural areas, where the majority live, only 33% had access in 1990, 39% in 2000 and 49% in 2002, suggesting slow growth. This implies that to achieve the MDG target Nigeria must reduce the proportion of rural populations without access to an improved water source from 67% in 1990 to 33.5% in 2015 and the urban proportion from 22% to 11% (Water Aid, 2006).

Water- related diseases result in over five million deaths annually, of whom most are children. Over 1.1 billion people lack access to safe water and 2.6 billion live without proper sanitation (Mark, 2007).

Governments and non- governmental organization (NGOs) alike have been making massive world-wide efforts over the past 25 years to find lasting solution yet the problem remains. The recent statistics prepared by the (WHO) highlights the alarming global water supply situation and the need for some radical alternative solution. An adequate provision of water to urban and rural areas by Nigerian government with emphasis on sanitary conditions can greatly reduce the incidence of water borne diseases. As a region's economy develops and its population grows, water supply systems typically also grow from serving one jurisdiction to several.

This study focuses on determining the suitability of water samples collected from existing boreholes within the study area which the population has depended on for consumption. In so doing, the physical chemical and bacteriological properties use in measuring the portability of water for consumption by WHO would be employed. The international standard for drinking water WHO (1993) in its definition for water fit for human consumption stated that water intended for human consumption must be free from organism and concentrations of chemical substances that may be hazardous to health. Furthermore, the WHO stipulates stringent conditions for standards of raw water sources for drinking purposes. Other bodies such as the American water works Association (AWWA), Environmental Protection Agency (EPA), Standard Organization of Nigeria (SON), and the United States public Health Services (U.S.P.H.S), all stipulates standards to be met for either the influent or effluent water produced or both.

2.0 MATERIALS AND METHODS

The Federal Polytechnic Bauchi is located in Bauchi, the state capital of Bauchi state. The school is 14 kilometers to the south-western part of Bauchi town along Bauchi-Dass road which is about 9km away from wunti gate and is on latitude $030^{0}\ 31'\ 30''$ and longitude $090^{o}\ 00'\ 00''$. It has an area of about 748 hectares.

2.1 Analysis of Water Sample

2.1.1 Water sampling

The reliability of laboratory analysis and test depend upon the method of sampling. The sample of water was taken from three boreholes in Federal Polytechnic, Bauchi. The samples were properly labeled with each sample data attached. The data includes: date and time of collection, sources of the sample and the temperature of the water collected at the time of sampling.

The water sample was collected from existing boreholes in the study in a container made of polythene glass. The sample bottles were carefully washed three times. The sample of the water collected reached the place of analysis at RUWASSA laboratory within 3hrs after collection.

The method of analysis of the borehole water samples for physical, chemical and bacteriological analysis were carried out in the Laboratory for the following properties: colour, Appearance, Taste/odour, pH scale, Total dissolve solids, Free chlorine, Conductivity, and Turbidity.

2.1.2 Determination of colour

About 0.249g of potassium chloroplatinate (K_2PtCl_6) and 0.200g of crystalized cobalt chloride ($CoCl_26H_2O$) were dissolved in a small amount of distilled water. 20ml of concentrated hydrochloric acid was added and diluted with 200ml of distilled water. Nessler tubes of 1, 2, 3, to 10ml was placed and diluted to the mark. Another 100ml Nessler tubes were flled to the mark with the water sample to be tested. The color was compared with the standards prepared above, by looking vertically down through the tubes on a white surface.

Calculation:

$$\text{Colour of water} = \frac{Ml\ of\ standard\ platinium\ solution \times 500\ on(Haze\ Unit)}{Ml\ of\ sample}$$

2.1.3 Determination of appearance using clean glass

The appearance of the water sample was carried out by using clean glass. The sample was observed as clear, sparkling, and cloudy. The result obtained is shown in table 1.

2.1.4 Determination of taste/odour using glass bottle with stopper

The water samples were put into a clean glass bottles half-full and glass stoppers were used to close the bottles and were vigorously shaken. The stoppers were removed to sniff the odor, and any distinctive odors were noted. The result is shown in table 1.

2.1.5 Determination of pH value

The pH meter was warmed for 20 minutes. The electrode was removed from inside the distilled water and rinsed with fresh distilled water. It was then wiped with soft tissue. The meter was calibrated using the buffer solutions at ambient temperatture. The pH knob was switched off and the glass electrode was removed from the second buffer and rinsed throughly with distilled water and then wiped with soft tissue. The clean and dried glass electrode was inserted into the water sample and the pH knob switched on and the pH value was directly read from the scale. See result in table 1.

2.1.6 Determination of turbidity using Dr/2000 model spectrometer

A Dr/2000 model 1990 spectrophotometer was used. The stored program number

for turbidity was entered by pressing number 750 read/enter. 25ml of distilled water was poured into a sample cell (blank) and placed into the cell holder, and the zero number of the machine pressed. Then, 25ml of the samples each was poured into another sample cell and immediately placed into the cell holder. The read/enter was pressed after closing the light shield. The turbidity values were then read. The result obtained is shown in table 1.

2.1.7 Determination of free chlorine using screen

10ml of borehole water sample was diluted with DPD content, the mixture was placed into a calorimeter, and then the result in mg/L chlorine was then displayed on the screen. The result obtained is shown in table 1.

2.1.8 Determination of conductivity using electrical conductivity meter

A sample of borehole water was collected into a clean beaker. The electrical conductivity meter was inserted into the beaker containing the sample of the water. The reading was measured and recorded. The result obtained is shown in table 1.

2.1.9 Determination of temperature

The temperature measurement was done at the time the sample was collected by using the ordinary thermometer (liquid in glass thermometer). The thermometer was completely immersed in the water sample; the value of the temperature obtained is shown in table 1.

2.1.10 Determination of bacteriological analysis

The water samples for bacterial test were collected in a sterilized bottle. 1ml of the sample was withdrawn and dispersed in tube labeled 10^{-1} which contains 9ml of peptone water. Another 9ml was withdrawn into the second tube labelled 10^{-2}. The same continued to tube labelled 10^{-3} and 10^{-4} respectively. A 0.1ml of the samplewas dispersed into a sterile petri dish in duplicate using another sterile pipette, another 0.1m was dispersed in each of the tube 10^{-2}, 10^{-3}, 10^{-4} in duplicate. The molten nutrient agar was cooled around 45^{0}C and was poured into the petri dish and gently rotated to have equal spreading of the samples. This was allowed to solidify before incubating at 37^{0}C for 24 hours and the visible colonies were counted in a calorie counter. The result obtained is shown in table 1.

2.1.11 Determination of total bacteria count of the water samples

Three samples each from all the water sources under investigation were cultured, and colonies counted. Pour plate method was used as described by Bissnette (1977). The water samples were diluted serially according to standard method APHA, (1983).Dilutions of the at 1.100 were made, then serially diluted to three folds (10-3). With distilled water as described by Dukka (1978). I ml at the 3rd diluents of each sample was introduced into sterile plates. Nutrient agar was poured and swirled gently for proper mixing. The plate were allowed to solidify and incubated at 370C for 24 hours. Colonies were then counted.

2.1.12 Determination of total dissolved solids (TDS) using Hach model 44600-00

The total dissolved solids (TDS) and conductivities were determined using HACH model 44600-00. About 80ml each of the three samples from all the water sources were poured into 120ml beaker. The probe of the meter was inserted into the sample and allowed for 2 minutes. The conductivity button was pressed and the result displayed on the screen in microsiemens/cm. For the same samples, the total dissolved solids (TDS) button was pressed and the result displayed in mg/L. The result obtained is shown in table 1.

2.1.13 Determination of suspended solids using photometer method

Water samples from the boreholes were shaken for 2 minutes and each were poured into a 500ml beaker. The stored program number for suspended solids was entered by pressing 630 read/enter botton. The wavelength dial was rotated to 810 µm. By pressing read/enter, the values of the suspended solids were determined. The result obtained is shown in table 1.

2.1.14 Determination of iron

The photometer was calibrated with the water sample to be tested. The test was carried out by adding Iron tablets (alkaline thioglycolate) to a 10ml sample of the water sample. The content was allowed to stand for 1minute to allow full colour development. The color produced was directly proportional to the Iron concentration was measured using the WAGTECH photometer at 570nm wavelength. The percentage transmitters obtained was converted to mg/l Fe with the aid of Iron calibration chart.

2.1.15 Determination of sulphate

Exactly 200ml of the sample was measured into a 400ml beaker. 10ml of a 1% solution of Hydroxylamine hydrochloride and 20ml of Benzidine hydrochloride were added and stirred vigorously and the precipitate was allowed to settle. The solution was filtered through paper. The beaker and paper were washed throughly with small amount of distilled water. The filter paper was pierced in the funnel and the precipitate washed. About 3 drops of phenolpthaline was added and titrated with 0.05M sodium hydroxide (NaoH) until the first permanent pink colour was obtained. A blank determination was run under identical c$MI\ of\ 0.05M\ NaoH\ used\ x\ 9.6\ =\ ppm\ (SO_4^{2}\ =)$ ı^3 of NaoH used was recorded. The value of the sulphate obtained in ppm was converted to mg/l.

Calculation:

2.1.16 Determination of calcium and magnesium

50ml of distilled water was placed into 250ml of Erlenmeyer flask and 25ml of concentration ammonia solution was added. Also, 10 drops of calcium and magnesium solution and 3 drops of criochrome black T was added. The solutions were shaken to obtain wine red colour. The solution was titrated against standard EDTA solution to obtain blue end point. About 50ml of water sample was added to the Erlenmeyer flask and shaken. 2ml of 1.5M KCN was added to mask Zn, Cu, Co, etc. 2ml , 2% hydroxyl amine hydrochloride were added to mask the Mn, and 1ml , 30% triethanol amine was added to mask, Fe, Al etc. The solution obtained was titrated against standard EDTA with gentle shaking to avoid splashing until the blue end point is obtained. The volume of the EDTA used which is for both calcium and magnesium used is recorded as A. 50ml of distilled water was placed into another Erlenmeyer flask and 25% KOH was added. 10 drops of Ca and Mg solution and few grains of 1% calcein were indicator were added and shaken to obtain light standard EDTA to obtain fluorescent yellow end point. 50ml of water sample was measured into the flask and shaken to revive the initial light colour. 2ml of 1.5M KCN was added to mask Zn, Cu, Co etc. 2ml hydroxyl amine hydrochloride was added to mask Fe,Al etc. The solution was titrated against the standard EDTA with gentle shaking to avoid splashing, to obtain fluorescent yellow end point. The volume obtained was recorded as B. The values of calcium and magnesium were obtained from the formula below

$$\therefore\ Volume\ for\ Mg\ alone = A - B$$

Calculation:

$$Ca\ (mg/l) = \frac{40080 \times M \times B}{ml\,sample}$$

$$Mg\ (mg/l) = \frac{24320 \times M \times (A-B)}{ml\,sample}$$

Where A= volume (ml) of EDTA for Ca and Mg titration.
B= volume (ml) of EDTA for Ca titration.
M= molar concentration of EDTA.

3.0 RESULTS AND DISCUSSION

From table 1, the colour of the water sample was 10.5 which is within the acceptable value. The colour unit obtained indicates that the water is safe for consumption when compare with the world health organization (WHO) standard. The pH scale shows that the water sample falls within the acceptable range; hence the water is fit for human consumption. The turbidity of the water sample is about 7.2 NTU. It can be deduced here that the turbidity is within the acceptable limit. The temperature of the region of sample collected reflects also the temperature of the water samples. The temperature is within the acceptable limit of the World Health Organization. The appearance of the water is clear. The total dissolved solid is 87.2mg/l, this indicates that the boreholes were properly developed after construction to achieve better water quality. Free chlorine of the water sample was about 0.2mg/l. The electrical conductivity of the sample water was about 172.7υs/cm which is within the limit of the World Health Organization (WHO).

From table 1 also, the bacteriological analysis of filtered water shows a complete removal of bacterial load (Total Coli, Faecal Coli form and E. coil) obtained is 0.0cfu/mil. The result shows that the water sample is safe for drinking compared with the World Health Organization (WHO).

The findings from the work carried out in the course of the data collections and the subsequent water sample analysis shows that the results contained in Table 1 meet international standards for drinking water. Results of the water sample available for distribution are as follows, the value of pH is 7.5, the turbidity is 7.2NTU, the mean temperature is 30.3^0C ,free Chlorine is 0.2mg/L, Conductivity is 172.7μs/cm, the total dissolved solid (TDS) is 87.2mg/L. All these values including the amount of calcium16mg/L, copper 0.025mg/L , manganese 0.01mg/L, zinc 0.32mg/L, iron 0.85mg/L, sulphate 15mg/L, nitrate 22mg/L and nitrite 0.059mg/L , correspond to the World Health Organisation (WHO) and National Agency for Food and Drug Agency of Nigeria (NAFDAC) standards.

4.0 CONCLUSION

Having determined from the analyzed water samples collected from the studied boreholes meet the standard for consumption, it become imperative to recommend that the borehole water is safe for drinking, and the number of boreholes be increased to meet the ever increasing need of the Polytechnic's population. The service of technicians should be employed in case of unsuspected breakdown to maintain the boreholes.

REFERENCES

Anon (1993). World Health Organisation Guidelines for Drinking-water Quailty Standard. Volume 1, 2nd Edition , WHO Geneva.

Babbit, H. E Doland, J.J. and Cleasby, J.C.(1962). Water Supply Engineering. 6th Edition Mc Graw Hill Book Co. New York, N.Y.

Escrit, L.B(1978). Water Supply and Building Sanitation volume 1. Public Health Engineering Practice, Fourth edition, MacDonald and Evans Ltd

Fapojuwo, O.A. (1982). Water Resource Bulletin Vol. 1 No 5
Kamala, A.(1993). Environmental Engineering. Water Supply, Sanitary Engineering and pollution. Tata .Mc Graw Hill Publishing Company Ltd. New Delhi

Larry, W. M (2001). Water Resources Engineering First Edition. John Wiley and Sons, New York, N.Y. Pp343-347, 409-468.

Mark, J. H (2007). Water and Waste water technology Fifth edition .Prentice –Hall of India Private Limited New Delhi – 110 001. Pp 98-99,149 and 208.

Mustapha, S. and Yusuf, M.I (1999). A textbook of Hydrology and Water Resources. First Edition, Craft Technics Publishers. Pp317

Odo, F.O (1995). Experimental Procedures for Food and Water Analysis. First Edition. Amana Printing press Kaduna Nigeria. Pp 89-119.

Olabode, T.O and Rimfat N.Z (2001). Strategies For Improved Access To Water supply in Rural Areas. Paper presented at the 2nd National Engineering Conference, Federal Polytechnic Bauchi.

Schulz, C.R. (1992). Surface Water Treatment for communities and Developing Countries.A Wiley Inter-Science publication

Shinga, I.S (2003). The Journey so Far. First Edition.Amana Printing press Kaduna Nigeria.

Twort, A.C, Law, F.M, and Ratnayaka, D.D(1994). Water Supply. Fourth Edition.John Wiley and Sons (UNEP). Pp 457 – 476.

UNECE Technical Information Report.(http://www.unece.org/env/water/test/text protocol.htm)

UNICEF, (1975). Rural Water Supply. Fourth Edition. John Wiley and Sons.

Water Aid (2006). National water sector assessment, Nigeria. (www.wateraid.org).

Wikipidia encyclopedia (2003). http://en.wikipedia.org/

World Bank technical report series No18,1981

World Health Organization Dec. 5 , 2003 http://www.who.org

Table 1: Result of Water Analysis Samples

Parameter	**Measured value**	**WHO/NSDWQ*MPL**
Physical		
Turbidity(NTU)	7.2	5
pH	7.5	6.5 – 8.5
Temperature(^{0}C)	30.3	_
Colour	10.5	15
Total dissolved solid(mg/l)	87.2	500
Taste / odor	0	Unobjectionable
Appearance	Clear	Unobjectionable
Free chlorine	-	0.1
Conductivity(υs/cm)	172.7	1000
Chemical		
Barium (Ba^{2+}) mg/L	12	0.05
Chloride (Cl) mg/L	14.5	250
Chromium (Cr^{6+}) mg/L	0.02	0.05
Copper (Cu^{+2}) mg/L	0.025	1.0
Cyanide (CN-)mg/L	0	0.01
Calcium(Ca) mg/L	16	75
Fluoride (F-) mg/L	0.02	1.5
Total Hardness (as CaCO3) mg/L	50	150
Iron (Fe+2) mg/L	0.85	0.3
Lead (Pd) mg/L	0	0.01
Total Alkalinity ($Caco_3$) mg/L	21	100
Magnesium (Mg+2) mg/L	5.8	0.20
Manganese (Mn+2) mg/L	0.01	0.05
Nitrate (NO3) mg/L	22	50
Nitrite (NO2) mg/L	0.059	0.02
Sulphate (SO4) mg/L	15	100



Plate 1: Members Of The Polytechnic Community Queuing For Water

WATER RESOURCES MANAGEMENT IN SMALLHOLDER FARMS: CASE STUDY OF MINISTRY OF AGRICULTURE AND NATURAL RESOURCES, SOKOTO STATE, NIGERIA.

Ewemoje Temitayo Abayomi[1] and Abimbola Olufemi Peter[2]
[1]Department of Agricultural and Environmental Engineering, University of Ibadan, Ibadan ta.ewemoje@mail.ui.edu.ng tayo_ewemoje@yahoo.co.uk

[2]Department of Agricultural Services, Ministry of Agriculture and Natural Resources, Usman Farouk Secretariat, Sokoto State, Nigeria femi_abim@yahoo.com

ABSTRACT
Livelihood security in Nigeria strongly depends on rainfall distribution and land management practices among smallholder farmers. Over 70% of the food producing sector is done by smallholder farmers based on rain fed agriculture. The major challenge for peasant farmers is to improve the productivity of arable land, income and available water resources. Groundwater irrigation is a resource that could mitigate drought effects, such as surface water scarcity and crop failure in semi-arid regions. The opportunities of increasing the efficiency of groundwater use in smallholder agriculture under the Ministry of Agriculture and Natural Resources in Sokoto State, especially during dry seasons and drought periods were highlighted in this study. Some field experiences of water conservation for crop production focusing on the crop water management and farmer management of irrigation systems using a low-technology practice for crop production were presented. Very few farmers use mulching to check evaporation of moisture and promote aeration of the soil. However, majority of the smallholder farmers in Sokoto use mulching in nurseries to reduce radiation, thereby reducing the adverse effects of high temperature and organic materials used for mulching decay over time thereby enriching nutrient status of the soil. Spate irrigation was practiced to retain soil moisture when rainfall is inadequate to support crop growth and this has enabled a significant increase in cultivated area, fruit and vegetable yields. The study concluded by providing valuable insights into how to successfully introduce greater sustainability by smallholder farmers through the use of partial root drying (PRD) techniques.

Keywords: Smallholder Agriculture, Crop-water Management, Irrigation Efficiency, Low-Technology Crop Production

1.0 INTRODUCTION
Climate change and the environmental impacts of our resource use are becoming increasingly important factors in our day to day activities. One key area which needs attention is the future water supply and use, especially when economic realities are taken into account. Widespread changes are needed in how we use this resource - water in the future, taking steps to increase efficiency and reduce the amount we use. This is because the available water resources are under pressure due to increasing demands and it is high time when this water resource, which we have always thought to be available in abundance and free gift of nature, may become a scarce commodity (Madhaorao, 2006). However, the level of changes needed require large shifts in farming practices and irrigation techniques. Smallholder farmers will have to adopt more economical, sustainable and environmentally friendly techniques if they want to increase their income

and save the environment.

Agriculture is Nigeria's greatest untapped potential. It is believed that agriculture, a sector neglected by successive governments, holds the greatest potential for foreign exchange earnings. Approximately 66% of the country's total landmass of 92.377 million hectares is arable and suitable for the cultivation and production of a vast variety of crops. Agriculture is also Nigeria's biggest employer of labour with over 70% of the population engaged in the sector. Poor subsistence farmers, who live in small farming communities, make up a large percentage of the farming population in Nigeria. In sub-Saharan Africa, the majority of the population make their living from rainfed agriculture, and to a large extent depend on small-holder, subsistence agriculture for their livelihood security (e.g., Kenya, 85%; Botswana, 76%; Malawi, 90%; and Zimbabwe, 70–80%, of the population). An estimated 38% of the population in sub-Saharan Africa, (roughly 260 million people) lives in drought prone drylands (UNDP/UNSO, 1997).

According to FAO (2011) and Turner et al. (2011), the world will increasingly experience water scarcity for agriculture as a result of climate change, a phenomenon that will affect the livelihoods of rural communities and the food security of urban dwellers. Without appropriate and effective water management, poor farmers will be unable to turn agriculture from a nourishment activity into an income-generating enterprise.

There is a connection between poverty alleviation and water management. The availability of water for irrigation in rural communities helps boost food production. It increases the potential for producing more food consistently in drought-prone and food-insecure areas (FAO, 2003; COMPETE Network, 2009). Small-scale groundwater irrigation offers significant potential to lessen the effects of drought and erratic rainfall on agricultural production in semi-arid, sub-Saharan Africa. This is because groundwater supplies are less prone to drought than surface water since groundwater levels are less correlated with rainfall. The potential of groundwater resources in sub-Saharan Africa is significant, going by past evaluations (Allaire, 2011).

1.1 Agriculture in Sokoto State

Sokoto state (13°05'N 05°15'E) is one of the drought prone areas of Nigeria. It is in the dry Sahel, surrounded by isolated hills and sandy savannah. With an annual average temperature of 28.3°C (82.9°F), Sokoto is, on the whole, a very hot area and in fact, one of the world's hottest cities (Roder, 2008). The rainy season is from June to October with showers which rarely last long and are a far cry from the usual torrential rain known in wet tropical regions. The region's lifeline for growing crops is the floodplains of the Sokoto-Rima river system, which are covered with rich alluvial soil. For the rest, the general dryness of the region allows for few crops, millet perhaps being the most abundant, complemented by rice, corn, other cereals and beans. Apart from tomatoes, few vegetables grow in the region in the dry season (Anonymous, 2011; Adams, 1986).

One of the challenges farmers in Sokoto state are facing in attaining food security and alleviating poverty is high dependence on rain fed agriculture. Incomes of farmers are very much weakened by periodic droughts. The major problem associated with the rainfall-dependent agriculture is the high degree of variability of the rainfall pattern. To overcome the problem, farmers need to optimize the use of all potential water resources to feed the growing population.

A key problem to expansion of groundwater irrigation in the state is economic water scarcity. Despite the fact that physical water resources are available, there is presently lack of economic resources and motivations to develop this resource. As a result, emphasis has been placed by the government particularly on the development and expansion of irrigated land through World Bank-assisted Fadama projects which focus on the use of groundwater irrigation during dry seasons. In the past, these Agricultural

Development Projects (ADPs) drilled tubewells, which were made available to farmers at less than cost, and also sold small gasoline-powered pumps. Traditionally, many families had cultivated small areas in Fadamas during the dry season using water drawn manually from shallow wells or streams. The advent of pumps and tubewells allowed the extraction of increased amounts of water at modest cost, and also increased the area of land irrigated (The World Bank Group, 2011).

The Sokoto-Rima River Basin Development Authority has a mandate to transform the people within the catchment area to become highly productive communities, through efficient and effective supply of water for multi-purpose use for the development and alleviation of poverty. The mandate is also to increase more food production, water supply, control of drought, flood and erosion, to ensure better living and jobs for the people in the catchment area (Federal Ministry of Water Resources, 2011).

There is an increasing awareness that major irrigation systems in smallholder farms in Sokoto are not sustainable. Farm lands are increasingly flooded, soil structure destroyed and topsoil lost through soil erosion during flood irrigation. The effects on production are dramatic, with a tendency of constant decrease in crop yields for staple food crops. Irrigation, therefore, which used to be farmer's watering the land, is becoming highly technical, calling for the gathering of vast amounts of information about overall water resources, the quality of the soil, and the condition of the water table underneath it. This is a task that lies beyond the means of smallholder farming. A major drive of research today is to develop techniques to conserve land that is already under irrigation (Anonymous, 2008).

1.2 Hydro-climatic Impacts on Risk Management

Dry lands are characterized by a low annual rainfall concentrated to one or two short rainy seasons. Rainfall in Sokoto shows a marked variation, with annual mean precipitation varying from 350mm (Kamalo in the extreme north) to 670mm (Sokoto Airport). Rainfall is concentrated in a short wet season, which extends from mid-May to mid-September whilst dry season, lasts more than 7 months (Adelana et al., 2006). Rainfall is highly erratic, and most rain falls as intensive, often convective storms, with very high rainfall intensity and extreme spatial and temporal rainfall variability. The outcome is a very high risk for annual droughts and intra-seasonal dry spells. An agricultural drought occurs when the cumulative plant available soil water is significantly lower than cumulative crop water requirements, i.e., there is absolute water scarcity. A dry spell occurs as short periods of water stress, often only a couple of weeks long, during crop growth. Such short periods of water stress can have a severe effect on crop yields if they occur during water sensitive development stages like flowering (Rockstrom and de Rouw, 1997). Use of fertilizer in agriculture in sub-Saharan African is the lowest in the world, with an average of some 11kg of fertilizer applied per harvested hectare. Developing countries apply an average of 62kg ha^{-1} (FAO, 1995). Farmers avoid investing in inputs due to high risks of crop failure as a result of droughts and dry spells (Brouwer and Bouma, 1997).

2.0 METHODOLOGY

Development of water conservation practices for irrigated agriculture in Sokoto is an important feature of soil and water conservation. Smallholder farmers in this region use different conservation methods to minimize water loss in order to boost agricultural productivity and these methods are discussed briefly.

2.1 Mulching – A Field Experience

Mulching, spreading of materials on the ground to protect the roots of plants from extreme temperature and moisture changes (Plate 1). Mulching reduces the soil temperature by some degrees in the upper centimetres of the topsoil and provides better moisture conservation by reducing the intensity of radiation, wind velocity, and evaporation. In Sokoto State, in-situ water conservation systems are not so common. From a development point of view, the argument for the promotion of water conservation systems - generally referred to as soil and water conservation measures - has been to control soil erosion. Very few farmers use mulching to check evaporation of moisture and promote aeration of the soil. As shown in Plate 1, smallholder farmers at the Ministry of Agriculture orchard in Sokoto use mulching in nurseries to reduce radiation and evaporation from seed beds. Organic materials used for mulching, in addition to protecting the plants, decay in time and enrich the soil.

2.2 Conservation Tillage

A major cause to human-induced land degradation in smallholder farms are the intensive soil preparation, which together with the removal or burning of crop residues, leaves the soil exposed to climatic hazards such as wind, rain and sun (Benites et al., 1999). Conventional tillage using ox- or tractor-drawn ploughs has over the years been perceived as the indicator of agricultural modernization in Nigeria. However, it is becoming more evident, that ploughing techniques developed in semi-arid regions with short heavy rains, high wind and water erosion problems, can have serious undesirable effects on the long-term productivity of farmlands.

In addition, conventional tillage practices require high labour and energy inputs, and are often associated with poor timing of farming operations. These factors strongly affect poor smallholder farmers in Sokoto, who usually depend on ox-traction for ploughing operations. Conservation tillage refers to planting crops in soils which have received little or no mechanical tillage (either by ploughing or turning over with hoe), and which only a small hole or narrow trench is opened to plant and cover the seed. Plant residues are left on the surface throughout the year (Quinones, 2011).

2.3 Spate Irrigation – A Field Experience

Increasing agricultural productivity with groundwater irrigation, and lessening reliance on surface water sources, can reduce the impacts of predicted declines in rainfall. In most parts of Sokoto state (e.g., Sokoto North, Sokoto South, Kware, Bodinga, Wammako), farmers have developed spate irrigation techniques for fruit and vegetable production. Farmers cultivate tomatoes, peppers, carrots, onions on sediment rich flatlands. Groundwater from boreholes sunk on farms is pumped into cultivation basins using shallow channels and soil bunds created from 25–50cm high earth (Plates 2, 3 and 4). It is a basin-to-basin system. Large volume of water passes from basin to basin by breaking basin bunds after a bunded basin is filled with water to predetermined depth. Spate irrigation is practiced to retain much moisture in the soil when rainfall is very low to support the growth of crops. It has enabled a significant growth in both cultivated area and in fruit and vegetable yields.

2.4 Partial Root-Zone Drying – A Field Experience

Rural farmers in Sokoto State produce vegetables for the fresh vegetable market on small scale irrigated lands. This is mostly because the cost of irrigation water, especially during dry season, is a major expense associated with vegetable production. Recent improvement of on-farm irrigation systems and the introduction of low-cost, water-saving irrigation technologies such as Partial root zone drying (PRD) have been identified as key and attainable components for reducing agriculture's water demand.

Partial root zone drying uses biochemical responses of plants to water stress to achieve a balance between vegetative and reproductive development. By doing so, it achieves a secondary goal of significant improvement in production per unit of irrigation water applied. Even though the irrigation amount was halved, there was no significant reduction in yield due to PRD treatment.

Research into the physiological changes that occur during water stress has led to improved understanding of plant response to stress in terms of chemical signals passing from roots to leaves. A plant's first line of defense when faced with water shortage is to close its stomata to conserve moisture. One of the principal compounds that elicit this response is abscisic acid (ABA) which stimulates the closure of stomata (water stress brings about an increase in ABA synthesis). Also, ABA inhibits shoot growth but will not have as much effect on roots or may even promote roots growth. As soil water availability falls following the cessation of irrigation, ABA acid is synthesized in the drying roots and transported to the leaves in the transpiration stream. Stomata respond by reducing aperture, thereby restricting water loss. Improvement in water use efficiency results from partial stomata closure. However, an inevitable consequence is reduced photosynthesis, as carbon dioxide and water vapour share the stomata pathway through the leaf surface (McCarthy et al., 1999; Leib et al., 2004)

3.0 RESULTS AND DISCUSSION

3.1 Millennium Development Goals PET Project: Vegetable Propagation From Partial Root-Zone Drying Technique in Sokoto

A demonstration project which involved two experiments, using flood irrigation and PRD, was carried out on a smallholder farm in Sokoto in order to determine the irrigation practice with higher water-use efficiency and yield. The project goal tested the feasibility of using partial root zone drying (PRD) to reduce the amount of water used in vegetable production and, thus, increase grower net income. The Millennium Development Goals Advocacy (MDGs/MAC) project was funded by the Department of Agricultural Services, Ministry of Agriculture, Sokoto State. Smallholder farmers were allowed to plant Amaranthus on a small plot using flooding, which was their irrigation technique during dry season. PRD was used on the second plot.

For the flooded plot, seeds were broadcasted and irrigated every day until crop maturity (Plate 6). After the third week, all plants experienced wilting even though the calculated crop water requirement was applied. This was largely due to the high evapotranspiration. For the PRD plot, three treatments were compared: half of the root system watered and half droughted by delivering 50% less water per irrigation than the well-watered control (50% PRD); both halves of the root system watered delivering 50% less water per irrigation than the control (50% NI); and both halves well-watered (100% NI). The wetted and dried sides of the root system of 50% PRD were alternated on a 7-day cycle. The effects of the differences in water-use on growth parameters, such as plant height, girth, number of leaves and leaf area were examined for the control and the other two treatments (Plate 7). Wet weights and their ratios were also compared.

Drying about half of the root system caused marked declines in all growth parameters in 50% NI but only slight declines in 50% PRD. Since the main effect of water stress on Amaranthus is yield reduction, achieving better yields require an adequate water supply from planting until ripening. Average edible wet weights (yields) of the 50% PRD plants and 50% NI plants were 81% and 25% of control respectively. The higher yield in 50% PRD, to a limited extent, appears to be linked to high stomatal sensitivity to drought signaling.

The demonstration project helped to improve the understanding of how

smallholder farmers viewed water conservation and environmental sustainability. The results provided valuable insights into how to successfully introduce greater sustainability into our societies.

4.0 CONCLUSION

Small-scale groundwater irrigation using PRD technique offers significant potential to mitigate the effects of drought and erratic rainfall on agricultural production in Sokoto state and other semi-arid regions. It also offers significant potential to increase the income of smallholder farmers while ensuring environmental sustainability. Groundwater supplies are less susceptible to drought than surface water since groundwater levels are less correlated with rainfall. Past assessments suggest that the potential of groundwater resources in sub-Saharan Africa is significant. A major difficulty to the development of groundwater irrigation in Sokoto state is economic water scarcity. While there is availability of physical water resources, there is presently lack of economic resources and incentives to develop the resources. Strategies for encouraging groundwater irrigation in a sustainable manner include management of irrigation systems, concurrent groundwater monitoring and development, and subsidies for pumps and well construction. Water harvesting techniques for crop production also has a large potential in Sokoto state and this potential is, to a large extent, untapped.

When it comes to water resources management, national development strategies have to a large extent focused on large scale irrigation schemes and projects. There is a great need and opportunity to shift attention to small-scale groundwater irrigation using PRD technique and rainwater harvesting systems. The challenge is to find ways of securing innovative water harvesting systems in the present rural communities by moulding them within the site-specific bio-physical and socio-economic contexts.

ACKNOWLEDGEMENTS

Authors are grateful to Alhaji Aminu Umar Kasarawa, Director of Agricultural Services Department and Mr. Aminu Bala Rumgumi, Zonal Horticultural Officer in the Ministry of Agriculture

and Natural Resources in Sokoto State for their assistance. Special thanks to Hajiya Iliya Rakiya, Schedule Officer of the Millennium Development Goals Advocacy Club (MDGs/MAC); Mrs. A. D. Manga of National Bureau of Statistics, Sokoto state in obtaining statistical data. Mr Martins Kiorgwu of NMA for meteorological data

REFERENCES

Adams W. M. (1986): Traditional Agriculture and Water Use in the Sokoto Valley, Nigeria. The Geographical Journal. Vol. 152, No. 1, pp 30 - 43.

Adelana S. M., Olasehinde P. I. and Vrbka P. (2006): A Quantitative Estimation of Groundwater Recharge in Part of the Sokoto Basin, Nigeria. Journal of Environmental Hydrology. Volume 14, paper 5. http://www.hydroweb.com/jeh/jeh2006/adelana.pdf. Accessed 28 August, 2011

Allaire M. (2011): Drought Mitigation in Semi-Arid Africa: The Potential of Small-Scale Groundwater Irrigation. Resources for the Future. International Water Management Institute. http://www.sustainus.org/docs/citsci/winners/2009/Maura%20Allaire.pdf. Accessed 21 June 2011

Anonymous (2008): Irrigation. Microsoft Encarta 2009. Redmond, WA: Microsoft Corp.

Anonymous (2011): Sokoto State. http://en.wikipedia.org/wiki/Sokoto_State. Accessed 12 August, 2011

Benites J., Chuma E., Fowler R., Kienzle J., Molapong K., Manu J., Nyagumbo I., Steiner K., and van Veenhuizen, R. (1999): Conservation Tillage for Sustainable Agriculture. Proceedings from an International Workshop, Harare, 22–27 June; Part 1 Workshop Report. Deutsche Gesellschaft, GTZ, Eschborn, Germany. p 59

Brouwer, J and, Bouma, J., (1997): Soil and Crop Growth Variability in the Sahel: Highlights of Research (1990-95) at ICRISAT Sahelian Center, Information Bulletin No 49. ICRISAT, Patancheru, Andra Pradesh, India

COMPETE Network (2009): Improved agricultural practices in farming systems of semi-arid and arid Africa in view of future possibilities for bioenergy production.

COMPETE (INCO-CT-2006-032448) Second Periodic Activity Report – Annex 2-2-1

FAO (1995): World Agriculture: Towards 2010. An FAO Study. Ed. N. Alexandratos, FAO, Rome, Italy. p481.

FAO (2003): Working Towards Unlocking the Water potential of Agriculture, Rome, Italy.

FAO (2011): Water Reports: Climate Change, Water, and Food Security.

Federal Ministry of Water Resources (2011): Sokoto Rima River Basin Development: Service Charter. http://www.servenigeria.com/charters/water-sokoto-rima.doc Accessed 15 August, 2011

Leib B. G., Caspari H. W., Andrews P. K., Redulla C. A., Jabro J. D., and Strausz D. (2004): Deficit Irrigation and Partial Rootzone Drying Compared in Fuji Apples: Fruit Yield, Fruit Quality and Soil Moisture Trends. ASAE/CSAE Meeting Paper No. 042284. St. Joseph, Mich.: ASAE.

Madhaorao B. D. (2006): Rain Water Harvesting and Ground Water Recharge. National Seminar on Rainwater Harvesting and Water Management 11-12 Nov. 2006,

Nagpur McCarthy M. G., Loveys B. R., Dry P. R. and Stoll M. (1999): Regulated Deficit Irrigation and Partial Rootzone Drying as Irrigation Management Techniques for Grapevines. Australian Journal of Grape and Wine Research http://www.fao.org/docrep/004/Y3655E/y3655e11.htm. Accessed 31 December, 2008

Quinones M. (2011): Conservation Tillage Gaining Ground in Africa. 3332 Newsletter Issue 17 http://www.saa-tokyo.org/english/newsletter/pdf/issue17.pdf. Accessed 28 August, 2011

Rockstrom J. (2000): Water Resources Management in Smallholder Farms in Eastern and Southern Africa: An Overview. Phys. Chem. Earth (B), Vol 25(3), 275 – 283

Rockstrom, J., and de Rouw A., (1997): Water, Nutrients, and Slope Position in On-farm Pearl Millet Cultivation in the Sahel. Plant and Soil, 195: 311 - 327.

Roder, W. (2008): Sokoto. Microsoft Encarta 2009 (DVD). Redmond, WA: Microsoft Corp.

The World Bank Group (2011): Nigeria - Kano and Sokoto Agricultural Development Projects - Independent Evaluation Group Publications. http://lnweb90.worldbank.org/oed/oeddoclib.nsf/DocUNIDViewForJavaSearch/996144d276b46fd4852567f5005d12bd? Accessed 15 August, 2011

Turner N. C., Li F., Xiong Y., and Siddique K. H. M. (2011): Climate Change and Agricultural Ecosystem Management in Dry Areas. Crop and Pasture Science, 62, i–ii http://www.un.org/apps/news/story.asp?NewsID=20581&Cr=unep&Cr1=water Accessed 15 August, 2011



Plate 1: Pre-mulching (Left) and Post-Mulching (Right) Of Nursery Seedlings



Plate 2: Basins and Channels Prepared for Irrigation



Plate 3: Gasoline Pump In Shallow Groundwater Tube-Well For Irrigation



Plate 4: Spate Irrigation Channels



Plate 6: Spate Irrigation Experiment 0 Week (Left) and 3 Weeks (Right) After Planting



Plate 7: PRD Experiment 0-Week (Left) and 5-Week (Right) After Planting

SOIL AND WATER ENGINEERING FOR ENVIRONMENTAL SUSTAINABILITY
CASE STUDY OF SUMBU GULLY EROSION CONTROL PROJECT

Engr Matthew Boniface Kamai.
College of Agriculture, P.M.B 1025 Jalingo. Taraba state. Nigeria.
awoshiri@gmail.com
0706+7497543

ABSTRACT
The rate at which some elements of the environment is being degraded is by far higher when compare to the rate at which they are formed. And the environments most have the quality and ability to be able to provide the essential needs of the fast growing population of human being. Therefore, something most be done in order to manage or conserve the environment. Soil and water engineering is a branch of Agricultural engineering which among other tasks deals with conservation of water and limiting of erosion This paper assess the effectiveness of some gully erosion control measures used in controlling gully erosion at the "Sumbu gully erosion control project". At the project site, tress was planted and concrete structures mostly the Gabion structures and rock mattresses were also constructed A survey was carried out to asses the effectiveness of these gully erosion control measures used at the project site. The record of measurements of the depths from bottom to the top for twelve gullies which was taken before the project and five years after was gotten from the office of the technical officer in charge of the project. Varied degrees of success have been achieved with the remedial measures so far adopted. In most areas, gullies have apparently stabilized, in some few areas, the gullies have continued but at a reduced rate, No sign of formation of new gullies was noticed on site. T- test was ran using the depths of the twelve gullies measured before the project and five years after, to determine the difference between, before the project and five years after completion, and the results showed that there was significant difference between the two periods. It could be concluded that the measures adopted to control the gully erosion were very effective despite the fact that there was disturbances at site by farmers and grazers after completion of the project. So, proper supervisions have to be carried out on project site of this type to avoid destructions from people who are completely ignorant of the work.

Keywords: Soil, Water, Engineering, Environment, Sustainability.

1.0 INTRODUCTION
Land degradation is as old as man, because his activities to cultivate the soil started the exposition of the soil material to unfavorable climatic effects that lead to its weathering. Plaster (1992) observed that, over the past 40 years, a stream of technological improvement, including fertilizer and improved crops varieties, has masked the effect of erosion on productivity. Interrill erosion leads to soil impoverishment as nutrients are washed away leading to loss of livelihood from the farm lands that end up into waste lands especially under heavy population and mismanagement. To support this fact, UNEP (1986) noted that 1.5 billion ha of land are cultivated in the world and that additional 2

billions ha of lands that were once biologically productive have gone out of production. It is feared that some 5 to 7 millions ha of cultivated land now is completely lost every year through soil erosion (UNEP, 1986)

The World Bank (1990) recognized three main environmental problems facing Nigeria: soil degradation and loss, water contamination and deforestation. In addition, six other problem areas were specified: gully erosion, fishery loss, coastal erosion, wildlife and biodiversity losses, air pollution and the spread of the water hyacinth. Gully erosion contributes to each of the three main problems and causes damage with an annual cost to the nation estimated at $100 million in 1990. In Nigeria, FGN (1997) recorded an estimate of over 90% of the land mass under severe interrill, rill and gully, with the severest gully erosion occurring on 80% of Nigeria's total land area.

OBJECTIVES

The main objective of this study is to asses the effectiveness of the gully erosion control measures used in controlling gully erosion in the sumbu gully erosion control project. Other objectives are to;

(1). Emphases on the need to control erosion.

(2). Provide some recommendations on how best gully erosion can be control.

2.0 PROJECT AREA

2.1 Sumbu the Project Site

This project is a gully erosion control project. The site covering about five thousand hectares of very fertile land is badly affected by gully erosion. The soil conservation project was done in 1979, when the State was not carved out from former Gongola State. The Gongola State Government then, in conjunction with the Federal School of soil conservation Kuru carried out the project to control gully erosion in the area. The soil is so fertile that many crops such as Yam, Beans, Groundnut, Corn, Bambara nut, etc, can grow and yield highly on the soil which is mainly Sandy. The area is a valley and also produces different species of grasses which also attract the Fulani headmen's to take their animals to rear them in this area. The area is also blessed with many and different species of tress that bears wild fruits and this also attract so many people from far and near to harvest the fruits for consumption, for example there are so many stands of Locus bean trees (Dorowa) which produces fruit which are eatable and the seed used for preparing local spices for soup (dawadawa).

The name Sumbu is after the late head of the village called Jauro Sumbu. The settlers in this area are predominantly the Mumuye tribes who migrated from yorro local government area to .settle on this land for the cultivation of Tuber crops mostly yam

This project site is located just about 3km away from the Jalingo city gate on the road to Yola (Adamawa State) by the .right. When the project work was completed the then Gongola State Ministry of Agriculture constructed an office and a store on site and posted some of its staff to take care of the site. Some of the duties of these staff are;

1 To raise nursery of different types of trees to be planted on site.

2. To control any further erosion that may occur on site

3. Maintenance of the gully erosion control structures put in place and

4. To report to the ministry the progress on site.

2.2. Erosion Control Measures Done On Site.

Generally actions have been based on techniques capable of reducing the erosive capacity of the flood water, which are those measures that either reduces the velocity of the flowing water or those capable of increasing the resistance of the soil relative to the erosive capacity of the flood waters.

A total number of two thousand eight hundred (2800) stands of different species of economic trees were planted on the affected area with the hope that when the trees grows, it make the area a forest so that the rain water falling can be intercepted by the vegetation, and also, the binding effect of the roots of these vegetation on the soil can increase the resistance of the soil to detachment which consequently reduces erosion. The runoff velocity of the flowing water can also be retarded by the vegetation thereby reducing erosion. Drop structures were put in place to allow runoff to drop vertically to a lower level, where the energy is dissipated before flowing down the water course. The structures are mostly of Gabion and rock mattresses.

2.3. Activities on Site.

The period from the late 1980s, the ministry of agriculture members of staff that were posted to this site decline from reporting on site, in fact since 1992 when the Taraba State was created till date no body is taking care of the place. The office and the store that was constructed no longer exist. And as a result of the absence of the officiating personnel, some activities which aid erosion is now going on, on site., Some of these activities are;

1. People come from the town to excavate the top soil in this area to be use for construction work, even some of the stones or rock materials that were used for construction of .erosion control .structures were excavated,
2. Most of the trees that were planted on site were felt and dried to be used as fire wood and the, seedlings are also uprooted and taken way to be planted somewhere
3. Because of the fertile nature of the soil in this area, there is influx of farmers to this site and they engaged in farming practices which does not in anyway conserve the soil. And the Fulani Heads men also patronized the area with their animals in search of feed.
4. Some of the gullies have developed to streams which contain water during the raining season, and in the dry season the villagers around, dig into the stream so that they can access water.

3.0 ASSESSMENT OF THE EFFECTIVENESS OF CONTROL MEASURES ADOPTED AND DISCUSSION

3.1 Measurement of Depths of Some Gullies.

For purpose of comparism, so as to deduce weather there was improvement in terms of healing of these gullies, measurements of some twelve gullies using meter tape was done before the project by the staff of Ministry of Agriculture Gongola State. Five years after, same gullies were measured again, this information was received and it's shown on table I below

Table 1 Measurement Of Depths Of Gullies Before The Project And Five Years After Completion

S/N	Depths before project (m)	Depths five years after project (m)
1	10.7	11.5
2	8.8	2.4
3	10	1.5
4	5.6	2.0
5	10.2	3.6
6	12.3	15.5
7	17	3.2
8	17.8	4.4
9	30	12.5
10	2.7	1.2
11	5.3	1.3
12	3.7	3.9

3.2 Success and Failures.

Despite all the negligence and other problems which occur in this project site; varied degrees of success have been achieved with the remedial measures so far adopted. In most of the areas, gullying has apparently stabilized after some years of the construction of the remedial measures, in some the gullying has continued but at a much reduced rate, while at other few, gullying has continued unabated.

3.2.1 Areas with apparent success.

In this areas gullies are still shallow (that is less than 10m deep) and have not cut into the cohesion less and very permeable white sands. The ground water table is also far beyond the gully bottom as no springs or seepages are seen on the gully walls. Apparently the effect of groundwater on the gully advancement is minimal. No recent gully activities have been observed and vegetation has started thriving on the gully slope.

3.2.2. Areas with partial success.

In these areas, gully activities have been significantly reduced. The erosion activities are confined to surface removal of grains and small chunks of soil at the upslope side of the .hydraulic regulation structures and at the banks of the main gully trunks. Intense gully sliding appears to have subsided as indicated by the absence of large volumes of recent debris at the gully floors in those areas. These partially stabilized gullies have cut into the cohesion less and very permeable sands but the groundwater levels rises above the gully bottom only during the raining season (April to October). The areas are classed as partially successful because they appear to work well only during periods of non – saturation of the sandy horizon. For example, some sports that were assumed relatively safe during my inspection visit toward the end of the 2012 raining

season were beginning to show signs of yielding. As the surface water appears to be well controlled, groundwater apparently has some effect on the gully propagation.

3.2.3 Most dangerous sports.

In these areas, the gullies have cut deep into the cohesion less sand and the sand horizon remains perpetually saturated, the control measures appears to have totally failed to stop the development and advancement of the gullies. Sliding and slumping have continued despite the control measures. Some of the structural framework of the remedial measures such as concrete structures of interceptor channels can be seen lying at the bottom of the new gullies in the failed mass of earth materials. Tree planting has not help, as surviving trees and shrubs are constantly uprooted, carried down and buried in large masses of earth materials. In these areas, gully walls are indented with springs and seepage faces.

3.2.4 Comparism of depths of gullies before the project and five years later

The data's in table 1 was analyzed using Excel in order to determine weather or not there was a significant difference between when the project was not done and five years after completion of the project. The results is as shown on table 2

Table 2 t- Test Paired Two Samples for Means

	Before	*After*
Mean	11.175	5.25
Variance	57.72386	24.62818182
Observations	12	12
Pearson Correlation	0.544894	
Hypothesized Mean Difference	0	
Df	11	
t Stat	3.195241	
P(T<=t) one-tail	0.004263	
t Critical one-tail	1.795885	
P(T<=t) two-tail	0.008527	
t Critical two-tail	2.200985	

The null hypothesis is that there is no significant difference between before establishment of the project and five years after. And it could be seen from the t-test that the t- stat (3.195241) at 0.05% confidence interval and degree of freedom 11 is greater than t-cretical (2.200985), so we reject the null hypothesis and conclude that there was significant difference between before the project was done and five years after.

3.3. Discussion

The control measures so far adopted in the gullied areas have been concentrated on regulation of surface water (Their volume and velocity), and planting of trees to strengthen the soil. These measures appear to have been successful in shallow (less than 10m deep) gullies cut mainly into red clayey earth, they have failed in deep gullies cut into very permeable and cohesion less sand where the gully walls are indented with springs and seepages at various horizon. This implies that the remedial measures takes care of only the surface runoff, and fail to accommodate the disastrous effect of groundwater. Field inspection of the failed or failing structures reveals that most of them fail after undercutting and piping in the foundation. Piping results from uncontrolled

seepage of groundwater along with seepage forces. Uncontrolled seepage patterns lead to saturation, internal erosion, excessive uplift and seepage forces to the extent that soil particles migrate to an escape exit and cause piping and erosional failure.
Also affecting surface failure of the structures is the negligence on part of the Government to put proper supervision on this project. Apart from the people removing part of these concrete work for their personal uses, animals continuously tramples on these structures thereby weakening their strength and consequently they failed.
As stated earlier tree planting as a stabilizing measure has been effective only on minor gullies that is, those that have not reached considerable depths (less than 5m). The reason appears to be explained by the fact that the disturbance in deeper gullies originates several meters below the zone influence of tree roots. In the deep gullies whose slopes are constantly undermined by flood and internal erosion, the trees close to the gully edge usually flows as soon as the slope is undermined. Also the vegetation species (Neem, Eucalyptus, Cashew, Malyna, Mango and other types of trees) used so far on the gully floors have failed to thrive on saturated and sometimes running sand that characterize the floors of the deep gullies

3.3.1 Some practices to control erosion by water.
Soil conservation is the preservation of soil from deterioration and loss by using it within its capabilities, and applying the conservation practice needed for its protection and improvement. Certain lands are suited to cultivation, while others are not. The natural limitations on the use of land constitute the basis for all soil conservations
Soils have physical and chemical characteristics which get modified under the influence of water and vegetation. These characteristics are determined through soil surveys which give information on the nature of the parent materials, colour, texture and structure of the soil, depth of the soil, slope and situation of the land- upland or valley bottom – permeability, degree of wetness, salt concentration, and other related aspects. Each of the above characteristics, working singly or in combination, affect the management of land to varying degrees. The parent material indicates the potential fertility, status of the soil, texture and structure reveal as to how the water would move in the soil, and the type of clay and depth of soil .would reveal as to how much water would be held in the soil profile. Land features such as slope, erodibility as well as wetness would indicate the limitations of the land which have to be overcome to raise and maintain the productivity of the land.
Soil conservation planning should generally be done on a watershed basis. The watershed is the total land area above a given point on a waterway that contributes runoff water to the flow at that point. Soil conservation works should start at the head of such topographical units and precede in the same way the water flows: downstream. One of the first principles in a watershed development programme is to manage the land so as to conserve as much of the rainfall as possible to infiltrate into the soil

3.3.2 Steps in controlling gully erosion
The first step in controlling gully erosion is fencing of the gully head to protect it from grazing cattle and/or wild animals. Second, diversion ditches or waterways should be installed to divert the surface runoff away from the gully head. The waterways should be properly designed and laid out. The runoff should be properly disposed to avoid erosion. The land use and soil management in the watershed area feeding into the gully should be changed to soil-enhancing practices, e.g., planting cover crops and trees. Stabilizing the eroding faces and bed of gully is an important reclamative step. Establishing vegetation at the gully bed to provide more biomass is an important factor in decreasing the sediment-carrying capacity of the gully runoff. Engineering structures for gully erosion control are good. They are however expensive to install and maintain. There are a wide range of

engineering structures, e.g., diversion channels, gabions, check dams, rino blankets, and drop structures.

4.0. CONCLUSION

The following conclusions are drawn from the study;

(1). The success of any gully control measures without any doubt depends on the stages of gully development, the local geological setting (Stratigraphy and groundwater conditions), the characteristics and hydrogeotecnical properties of the eroded soils and their response to varying meteorological and hydrological conditions. Gullies cut into young and recent riverine alluvial deposits can be controlled by proper regulation of flood waters in conjunction with the use of vegetation. The use of only these measures may not be effective in controlling gullies cut deeply into non – cohesive sands.

(2). The rate of expansion and the mode of bank failure in gullies depend on the influence of not only surface flows but also groundwater conditions Gullies that are not seriously affected by groundwater advanced slowly by superficial removal of soil grain and small chunks of earth masses, where sliding and slumping involving large soil masses characterize gullies seriously affected by groundwater. Effective control of the second category of gullies involves not only controlling surface waters but also controlling groundwater effects.

(3). Gullies cut into very permeable and non – cohesive sands are more difficult to control than those cut into slightly cohesive soils. This is because high seepage forces in very permeable sands leads to internal erosion of the soils thus undermining structures that are constructed to control surface runoff. Channel structures that are terminated into gullies rather than at the local base levels of rivers also suffer undermining

(4). Design and constructions of gully erosion control structures should be based not on the general factors adduced to be responsible for gully problems but on the site specific factors (such as geology and hydrology) of the gullying area.

Controlling gully erosion can be an elusive process. The rate of success in such schemes depends on the planning, design, and techniques employed. The ultimate success is governed by the proper diagnosis of the problem, steps taken to eliminate the causes, and the drastic changes in land use to stabilize the ecosystem. The benefit/cost ratio of gully control must be carefully assessed. Some gully control measures are extremely expensive and resource-poor farmers cannot afford to invest. Furthermore, subsistence farmers, pre-occupied with food production for hand-to-mouth consumption, are not concerned with the stewardship appeal for preserving the resources for future generations. This means that gully preventive or control measures must produce short-term benefits in terms of increased yield, more land available for cultivation, and reliable crop yields through improved soil-water use. Above all, expensive measures of gully control and/or restoration have not been widely successful. Inventory of land, vegetation, hydrology and drainage pattern, climate, and land use is the first major step towards understanding the present status and potential risks of soil erosion. It is also important to assess the capability and suitability of major landscape units and to evaluate various options and priorities them with due considerations to socio-economic factors.

RECOMMENDATIONS

The following recommendations will help in reducing soil erosion to the minimum.

1) A comprehensive topographical survey of the affected area shall be done to determine locations and paths of traditional flood channels and this shall provide

the basis for management of all the floodwater..

2) No part of a designated natural floodwater channel shall be blocked or tampered with in ways that shall divert or impede the normal patterns of water flow in this channel.
3) Large pits shall be placed at appropriate intervals along designated floodwater channels to hold runoff with the objective of ensuring that floods do not reach erosion gully sites directly from an uphill distance of more than 200 meters
4) Trees, shrubs and grass shall be used to cover exposed topsoil and residential compounds to minimize surface erosion as well as to encourage optimal seepage of rainwater into the ground before a major runoff develops. Clear-cutting of trees and covering vegetation in erosion-prone localities is to be prohibited.
5) Maintenance culture is very important, gully erosion control measures is very expensive, therefore there is no sense in wasting huge amount of resources on projects of this kind then later allowed to be wasted.

REFERENCES

Federal Government of Nigeria (F.G.N) (1997). The Fifth Session of the United Nation Commission on sustainable Development. Federal Government of Nigeria Agenda 21

Plaster E.J 1992, Soil Science and Management H.Edward Telley (ED) Delman Publishers Inc. New York 415.

United Nation Environmental Programme (UNEP) 1986, Farming systems principles for improved food production and the control of Soil degradation in The Arid, Semi-Arid and Humid Tropics. Experts Meeting, June 20 – 30 1983 ICR, SAT Hyderabad

World Bank 1990 towards the Development of an Environmental Action Plan For Nigeria. World Bank,

INFILTRATION CAPACITY OF SOILS IN FEDERAL COLLEGE OF EDUCATION (TECHNICAL) OMOKU, RIVERS STATE

***Ahiakwo, A. A and Nnah, M.B Department of Agricultural Education Federal** College of Education (Technical), Omoku
* Correspondence author: a.ahiakwo@yahoo.com, 08038778669

ABSTRACT
This research is carried out to investigate the infiltration capacity of soils in Federal College of Education (Technical) Omoku in River State. This is necessary especially when considering an irrigation method to recommend or apply to a given soil. Besides giving insight on the contribution of soil disturbance and vegetal cover to the rate of infiltration, it suggested possible approach to reduce soil degradation. Single ring infiltrometer of diameter 30cm with a height of 20cm above the ground was used by the researchers to measure infiltration rates on bare and cultivated farm, sparsely vegetated and forested surfaces and on land cleared for civil works. Five locations on the school premises were selected and the test replicated three times in each location. Because soil type has a great bearing on infiltration rate, soil samples were collected from the sampling points for analysis using a soil auger at a depth range of 0-12cm. The results revealed that the school farm has a high mean infiltration rate of 288.6cm/hr, with highest infiltration recorded at the forest zone, where as the soil behind science block recorded a lowest infiltration value of 32.76cm/hr. The physical characteristics of the soil samples obtained from the test locations reveal a mean proportion of 79, 14 and 9 per cent for sand, silt and clay respectively in four of the five test locations including the school farm, and proportions of 58.60, 8.07 and 33.33 percent for sand, silt and clay respectively at the back of science block. This shows that the soil at the Federal college of Education (Technical) Omoku is dominated by sandy soil, where as the soil behind the science block has higher percentage of clay content. In view of the high infiltration rate of the soils analyzed, the installation of sprinkler system of irrigation will be beneficial. The researchers therefore recommend this system for the school farm in growing crops in and out of season.

Keywords: Infiltration, Soils, Disturbed, Vegetal Cover and Irrigation

1.0 INTRODUCTION
Infiltration is the process when rain or irrigation water which is supplied to a field seeps into a soil. The design, operation, management and hydraulic evaluation of on-farm irrigation application methods depend on the water infiltration properties of the soil (Abdelwahab, 2000) The infiltrate rate of a soil is the velocity at which water can seep into the soil. It is commonly measured by the depth (in mm) of the water layer that the soil can absorb in an hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the surface of the soil, will take one hour to infiltrate into the soil (Geolearning 2007)

Infiltration is important because it is an indicator of the soil's ability to allow water movement into and through the soil profile. Soil temporarily stores water, making it available for root uptake, plant growth and habitat for soil organisms.(NRCS 2011) It is governed by two forces: gravity and capillary action. While smaller pores offer greater resistance to gravity, very small pores pull water through capillary action in addition to and even against the force of gravity (Michael 2010; Agnihotri ,Yadav, (2002))

soil, soil texture and structure, humus content, soil surface roughness, the moisture content of the soil, rainfall intensity, temperature, vegetation types and cover, hydraulic characteristics, and permeability (Amin, 2005; Geolearning 2007; Michael,2010). Water in excess of infiltration capacity of the soil will flow overland as surface run-off once the minor undulations in the surface have been filled. Runoff occurs most frequently on degraded soils depending on topography and rainfall intensity. This phenomenon is common in tropical landscapes of the world, dominated by unwholesome land use practices. Runoff resulting from low infiltration capacity of soil accelerate erosion process and contributes to the flooding of regional lowlands and streams. The occurrence of surface runoff and other problem associated with excess infiltration above the threshold value of soil is traceable to high intensity rainfall.(Kign 2006)

Wood and Finger (2007) are of the opinion that variation in the rate of infiltration across the soils in Australia is due to high rainfall, landuse type, the vegetation cover, temperature, and geology. Vegetation such as trees and grasses increase infiltration compared to barren land because the leaves help in shielding the soil from severe rainfall impact. It retards surface flow, thereby giving water more time to infiltrate and promotes the activities of burrowing animals and insects.

In Nigeria, the rainforest which covers two percent of the total area is being depleted at an annual rate of 35 per cent from various man induced activities like deforestation, timber logging, fuelwood extraction, urbanization, oil exploration and all forms of landuse practices. Disturbance created by these human activities, impact on soil structure negatively and reduces its ability to provide the necessary ecological function at full capacity to support life forms.

Amusan and Anderson (2005), have noted that as the alteration intensifies, the texture, organic matter content, permeability, water holding capacity and infiltration capacities of the soils decline. A high infiltration rate is generally desirable for plant growth and the environment. In some cases, soils that have unrestricted water movement through their profile can contribute to environmental concerns, if misapplied nutrients and chemicals reach groundwater and surface water resources via subsurface flow.

Conservation practices that lead to poor infiltration include:

- Incorporating, burning, or harvesting crop residues leaving soil bare and susceptible to erosion,
- Tillage methods and soil disturbance activities that disrupt surface connected pores and-prevent
  accumulation of soil organic matter, and
- Equipment and livestock traffic, especially on wet soils that cause compaction and reduced porosity.

Several conservation practices, Saika and Zonn(2003) help maintain or improve water infiltration into soil by increasing vegetative cover, managing crop residues, and increasing soil organic matter. Generally, these practices minimize soil disturbance and compaction, protect soil from erosion, and encourage the development of good soil structure and continuous pore space.(Lowery, Hickey, Arshad, and Lal. 1996, Soil Quality For Environmental Health,2011)

This study seeks to determine the infiltration capacity of different soils and some soil physical properties which influences infiltration rates of soils in Federal College of Education (Technical) Omoku in River State, Nigeria.

2.0 MATERIAL AND METHODS

In carrying out this study, infiltration capabilities of soils, five sites where selected from Federal College of Education (Technical) Omoku premises both at the temporary and permanent sites. The sites selected where:

1. Soil at FCE(T) farm site
2. Soil at the Back of science block
3. Soil besides mathematics block building
4. Soil at the back of business lecture theatre
5. Soil beside FCE(T) library

These areas were categorized into disturbed and undisturbed soil. The disturbed soil was further divided into soil disturbed by

1. farming activities
2. bulldozer clearing for civil work

In each of the sites under study, the single ring infiltrometer was used. The infiltrometer was carefully driven into the soil to avoid disturbing the soil structure, and the volume of water was introduced. The stop watch was started to record the time it took the volume of water to infiltrate into the soil. The experiment was replicated three times in each of the selected sites. Also soil samples were taken from each of the sites for analysis. The samples were dried in an oven, crushed to finer particles and sieved using a 2cm sieve and then stored in fresh clean polythene bags in the refrigerator at 20C between 7-14 days so as to maintain the stability of samples without significant alteration in the biological properties.

The result of the infiltration capabilities of the soils in the area under study and the soil analysis are presented in the tables

3.0 RESULTS AND DISCUSSION

Table 1 shows variations in the infiltration rates of soil in the school farm, as a result of differences in surface conditions. Here the forested and undisturbed surface recorded highest infiltration rate of 375cm/hr, followed by sparsely vegetated surface, 205.8. Whereas bare and disturbed surface resulting from cultivation recorded a relatively lower infiltration rate of 140cm/hr.

Table 2 present the mean infiltration rates of soils in the five locations in the area of study. From the result, the FCE(T) farm site recorded the highest average infiltration rate of 228.6cm/hr, followed by the soil behind business lecture theatre 177.83cm/hr, where as the soil at the back of science block recorded the lowest infiltration rate average of 32.76cm/hr. This was followed by the soil behind mathematics block building 94.8cm/hr. In between the highest and the lowest is soil behind the library with an average infiltration rate of 136.67cm/hr. The physical characteristics of the soil samples obtained from the various test site shown in table 3, reveal that the soil in the area of study contains a high proportion of sand which is within the range of 56.8 - 82 percent. This is closely followed by silt, which ranged from 8.07 – 16 percent, and clay 8 – 33.33 percent. The mean values for sand, silt and clay in four of the five test location were 79, 14 and 9.

In table 2 it is observed that the soil behind science block also recorded the lowest infiltration rate of 32.76cm/hr. It can be seen from this result that the infiltration rate of the soil behind science block is remarkably lower than that obtained from the bare surface at the farm. Comparing the result of the soil analysis of the two locations shows a proportion of sand, silt and clay combination of 80, 12.5 and 9 percent respectively from the school

farm and a proportion of sand, silt and clay combination of 58.60, 8.07 and 33.30 percent from the soil behind the science block. From this comparison it is observed that the soil at the school farm is more of sand, whereas that at the science block contains high percentage of clay. The high clay content of this location was observed to be as a result of removal of top soil at this point by bulldozer. This obviously explains the reason for the relatively low infiltration rate at this point.
Another location that recorded low infiltration rate is the soil behind science administration block. Referring to table 2 the infiltration rate is at 94cm/hr. It was also observed that this area was freshly cleared by bulldozer, but the top soil was not removed

The results in Tables reveal that the study of infiltration rate is very important in an environment that is sensitive to changes in the protective cover of vegetation. They also show that infiltration rates is higher in forested and grass covered soils. The removal of the vegetation cover reduces infiltration rate as shown in table 1 and 2
The research shows that destruction of the vegetal cover promotes surface scaling by direct raindrop impact on soil surface, which inhibits rapid percolation of water. It is clear from the results obtained, that exposure of the soils to direct raindrop destroys the soils structure.

The study also revealed that soil structure is the most vulnerable physical property of the soil when vegetation cover is destroyed. Structurally unstable soils are readily slaked and tend to form a semi-permeable surface crust which leads to concentration of runoff on slopes. However, vegetated surface is believed to encourage high infiltration and thus reduces overland flow which in turn conserves the soil.

4.0 CONCLUSION

The soils in the Federal College of Education (Technical) is predominantly sandy, and generally has a high infiltration capacity as shown from the result. The variation in the infiltration rate noticed was dependent on the level of soil disturbance and surface condition of the soil. Among the three situations observed: bare and cultivated surface, bare surface resulting from bulldozer clearing land surface of vegetation and removal of top soil, the later has a greater effect in reducing the infiltration capability of the soil. On the other hand, sparsely vegetated and forested surface was observed to have an increase effect on infiltration capability of soil in the area of study.

Since the soil in the school farm is predominantly sandy and has high infiltration capacity, the sprinkler system of irrigation is highly recommended. Also, since soil must be disturbed during farming activities which expectedly will affect infiltration rate, soil conservation methods that will reduce the direct impact of raindrop on the soil surface, should be encouraged as it will boost the infiltration capability of the soil

REFERENCES

Abdel Wahab, D. M. (2000). Evaluation, Prediction and Optimization of Long Furrow Irrigation under Kenana Conditions. P.h.D. Dissertation. Water Management and Irrigation Inistitute, University of Gezira,Wad Medani, Sudan.

Agnihotri, R. & Yadav, R. (2002). Evaluation of Infiltration Capacity of Fluvent Soils Susceptible to Gully. Journal of Hydrological science, 37, 399-606.
Amin, M. (2005). Spatial Variability of Infiltration in Watershed. Journal of Hydrology, 45, 101-122.

Amusan, B., Ball, E. & Anderson, G. (2005). Changes in Characteristics of a Degraded

Soil under Fallow in South Western Nigeria. Journal of Agricultural Engineering, 4, 12-17.
Antigha, N. & Amalu, U. (1999). Physical Properties and Moisture Retention Characteristics of some Coastal Plain Soils in Calabar South-east Nigeria. Global Journal of Pure and Applied Science, (6) 2-10.

Ayoade, J. O. (2004). Introduction to Climatology for the Tropic. Ibadan, Spectrum Book.

Kigne, J. W. (2006). Salinization in Irrigated Agriculture in Pakistan: Mistaken Predictions. Water Policy, 8, 325-338. Lucyllan Kou Irrigation Systems, China. Irrigation and Drainage, 56, 523-539.

Lowery B., Hickey W.J., Arshad M.A., and Lal R.. 1996 in Soil Quality for Environmental Health (2011)

Michael H.(2010). Abiotic Factor. Encyclopedia of Earth. National Council for Science and the Environment, Washington DC

NRCS (2011) National Soil Survey Center, ARS National Laboratory for Agriculture and the Environment Illinois @http//soils.usda.gov/contact/nssc/

Saiko, T. A. and Zonn, I. S. (2003). Landuse and Management Impacts on Structure and Infiltration Characteristics of Chio-Soil. Science, 169, 167-177.

Wood, M. and Finger, L. (2006). Influenced of irrigation method on water use and production period partners in Northern Victoria-Australian Journal of Experimental Agriculture, 46, 1604-1614.

Table 1: Infiltration Rate (Average) of Soils at FCE(T) Farm Site

Test location on farm site	Surface condition	Infiltration rate (Average) cm/hr
Site 1	bare and disturbed by Crop cultivation	140
Site 2		205.8
Site 3	Forested area	375
Average		228.6

Table 2: Average Infiltration Rate Of Soils In The Area Under Study

S/No	Test Locations	Infiltration Rate (Average)cm/hr
1	School Farm	228.60
2	Behind Science Lecture block	32.76
3	Behind Science Admin. block	94.80
4	Behind business Lecture Theatre	177.83
5.	Behind FCE(T) Library	136.67

Table 3: Physical Characteristics Of Soil Samples From Sites Under Study

S/No	Sample points	Sand (%)	Silt (%)	Clay (%)
1	School Farm	80	12.5	9
2	Behind Science Lecture block	58.60	8.07	33.33
3	Behind Science Admin. block	78	15	8
4	Behind business Lecture Theatre	76	13	10
5.	Behind FCE(T) Library	82	16	9

DETERMINATION OF COMPACTED SOIL PROPERTIES USING A BELOW FLOOR LEVEL SOIL BIN

[1]Olutayo, L.A and [2]Agbetoye, L.A.S
[1]Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic Owo, Ondo State
[2]Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State
E-mail: lewisdigital78@yahoo.com, lasagbetoye@yahoo.com

ABSTRACT
A below floor level outdoor soil bin facility for evaluation of full scale tillage and other soil engaging machines was developed and tested; the soil bin has a total length of 25m, width of 15m and depth of 1.2m, its base and top slab thickness is 120mm. The soil bin walls are supported by reinforced concrete columns with a steel railing of size 150mm x 150mm x 10mm on which mounted implement could transverse up and down. Properties of soil at various location within the soil bin determined are, the penetrometer load, penetrometer depth, soil PH and the moisture content. The soil PH varies from 5.08 to 6.24 and the moisture content varies from 9.4 to 10.9 % dry basis. The mean penetrometer load varies from 2758 to 4527 kpa while the depth varies from 29 to 23 cm.

Keywords: Soil Bin, Compaction, Tillage, Soil Properties.

1.0 INTRODUCTION

The application of soil mechanics is a very important aspect for tillage and the design of tillage tools for optimum crop production. In many developing countries most especially Nigeria, agricultural implements and machinery are obtained via importation which usually do not last before breaking down or damage beyond repair due to the use of inappropriate tools or implement for tillage operation on a particular soil. Agbetoye (2003) observed that the machine were not designed base on the local soil and climatic conditions and thus result in frequent damage, ineffectiveness, general under-utilization of their capacities, difficulty in spare parts procurement and high cost of maintenance. It has been deduced from research findings that for successful mechanization of agriculture in Nigeria, innovative development of indigenous machinery and equipment for performing the various field operations ranging from primary tillage to harvesting, post-harvest handling, processing and storage must be performed (Ijioma, 2000; Odighoh, 1997; Onwualu, 2001; Ademosun, 1997; Achukwu, 1987; Agbetoye, 2003). This will prevent frequent damage and ensure low cost of procuring machinery (due to local sourcing of materials) as well as allow for easy training of operators via extension services.

Therefore, the concept of tillage optimization become necessary as the knowledge of draught and energy requirement of tillage implement on a particular soil are essential for proper design of the implement, appropriate matching of the implement with their power sources and the selection of the optimum operation conditions.

Soil bin investigations of the tillage tools are essential for the development and improvement in performance of tillage implement. According to Kepner et al (1978), soil bin system enables test to be performed under controlled or specific soil condition. Description by Abdulrahman and Abdalla (1997) and Rahman et al (2005) explains soil bin as a stationary structure constructed for experimental purposes use to determine several parameters of the soil for analyzing the effects of compaction, loading, leaching,

depletion and so on during soil preparation.
Hence, to determine the several parameters of the soil that are required for optimum crop production, a below floor soil bin facility for the evaluation of full scale tillage and other soil engaging implement was developed and tested to determine the properties of compacted soil.

2.0 MATERIALS AND METHODS

2.1 Experimental Site

The site was a portion of the research area of the Science and Technology Education Post – Basic (STEP – B) project of the Federal Ministry of Science and Technology awarded to the Federal University of Technology Akure Nigeria (75'N 50 15E)

2.2 Design Concept and Considerations

The plan of the researchers was to develop a multi bin system similar to what is obtained at the National Soil Dynamics laboratory at Alabama, USA. The soil bin which was constructed more or less by manual method had a total length of 25m, width of 1.5m and depth of 1.2m, the bin has both base and top slabs of thickness 120mm. it walls were adequately supported by reinforced concrete columns and steel panel of 8mm thickness in order to improve the finish from its outlook. The soil bin was equipped with steel railing of size 150mm x 150mm x 10mm on which mounted implement could traverse up and down the soil bin. For the compaction test, a compaction roller was coupled to the tractor and moved or traversed up and down on the soil bin, and for each pass on the soil bin, a penetrometer readings was taken in ninety-five (95) different location within the soil bin.

2.3 Particles Size Analysis Using Hydrometer

Soil samples were collected from five locations on the Soil Bin. Each 5m apart from each other. Soil from each spot (10cm diameter x 20cm depth). The collected soil samples were air dried. 50g of the dried soil was soaked with 100ml of calgon and allowed to soak for 25minutes. It was later transferred to a dispersing cup. The suspension was stirred and mixed for about 3minutes with a mechanical stirrer, the suspension was then transferred quantitatively to a sedimentation cylinder and filled to the mark with distilled water while the Hydrometer was in the suspension. The plunger was inserted and moved up and down to mix the content thoroughly. The Hydrometer was covered into the suspension and the reading was taken and recorded after 40 seconds. The Hydrometer was then removed and the temperature taken with a thermometer. The suspension was then remixed and reading was taken after 40 seconds until a steady reading was obtained. Finally, after 2 hours of the final mixing of the suspension, hydrometer reading was taken again along with the temperature. The percentage of sand, silt and clay size were then determined using equations 1and 2 as expressed by Ibitoye (2006).

$$\%\ of\ silt++\ clay\ = \frac{R_{40s} - R_a}{W} + R_c\ x\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

$$\%\ of\ silt++\ clay\ = \frac{R_{2n} - R_b}{W} + R_b\ x\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 2$$

Where R_a = 40 sec. (Blank Hydrometer reading), R_b = 2hrs. (Blank Hydrometer reading), R_c = 40 sec. Correction factor (Temp. x 0.36), R_d = 2hrs. Correction factor (Temp x 0.36), % sand + silt + clay = 100, % silt = (silt + clay –clay), % sand = 100 – (silt + clay)

2.4 Determination of Soil Moisture Content

Soil samples were collected randomly from 5 locations in the soil bin. The soil collected were kept in air tight polythene bags and taken to the laboratory for analysis. Each sample was weighed and oven dried at a temperature of 105°c for 24 hours in an air circulated oven. The samples were reweighed and the mass was noted. The volumetric water content, Q of the soil sample was determine using equation 3 as expressed by Ibitoye (2006)

$$Q = \frac{V_w}{V_t} \ x \ 100 \quad \text{...} \quad (3)$$

Where Vw = volume of water. V_t = total volume (soil volume + water + void space),

$V_t = Vs + V = Vs + Vw + Vc$ .... (4)

While Gravimetric water content, U was determine with equation 5

$$U = \frac{M_w}{M_s} \ X \ 100 \quad \text{..} \quad (5)$$

Where Mw = mass of water, Ms = mass of soil

2.5 Determination of Soil PH Using Electronic PH Meter

The acidity and alkalinity of the soil was determined using an electronic PH meter with a glass electrode. It was determined when 10g of air dried soil was placed into 50ml beaker and 30ml of distilled water was added to the soil, the moisture was allowed to soak for about 30 minutes and the electrode of the PH meter was then inserted into partly settled suspension and the PH reading was taken and recorded.

RESULTS AND DISCUSSION

The result of the soil moisture content and particle size distribution is as shown in Table 1. From the result, all the samples seems to be very much the same both in textural classification and moisture content. Table 2 shows the penetrometry soil resistance load (kpa) and penetrometer depth at different passes of the compaction roller in (cm) at various location within the soil bin.

The load (force) increase in each of the location and the depth of the penetrometer decrease, as the number(s) of the compaction roller increases as shown in Table 2, this is as a result of the nature of the soil used in the soil bin, that is (sandy, clay, loamy) soils

CONCLUSION

A below-floor level soil bin was developed and tested, properties of the soils at various location within the soil bin were investigated and analyzed. The soil PH varies from 5.08 to 6.24 and the moisture content varies from 9.4 to 10.9 % dry basis. The mean penetrometer load varies from 2758 to 4527 kpa while the depth varies from 29 to 23 cm. The decrease in depths of the penetrometer as the numbers of the compaction roller increases was as a result of the increased in load (force) in each of the location and the clay content present in the soil.

REFERENCES

Absulrahman, A.A and M.E Abdulla (1997). Development of soil bin test facility for soil –tillage tool interaction studies Res, Built No.72 Agric. Res. Centre, King Saud University Pp 5-26.

Achukwu, W.O (1987)Prospects of indigenous manufacture of Agricultural Equipment

and needed spare parts in Nigeria. Proceeding of the conference of the Nigeria Institution of Agricultural Engineering. 11:57-61

Ademosun, O.C. (1997), Indigenous Technology for local Agro-base Industries, Inaugural Lecture series II T FUTA. Pp 55.

Agbetoye L.A.S (2003), Engineering Challenges in Developing Indigenous Machinery for Cassava production and processing, proceeding of the annual conference of the Nigeria Society of Engineers (Lagule 2003), cultural Centre, Ibadan, Oyo State, 8th – 12th Dec. 2003 Pp 80-86.

Ibitoye, A.A. (2006) Laboratory Manual on Basic Soil Analysis Foladay, Akure Nigeria.
Ijioma, C.I (2000) Agricultural Mechanization as a tool for Agricultural Development. Proceedings of the Conference of the Nigerian Institution of Agricultural Engineers. 22 Pp 16-18.

Kepner, R.A., Bainer, R. and Berger, E.L. 1978. Principles of Farm Machinery. 3rd edition. AVI Pub. Co. Westport.
Odighoh, E.U (1997). Confronting the challenges of Agricultural Mechanization in NigeriaProceedings of the Conference of the Nigerian Institution of Agricultural Engineers.9; Pp 7-17.

Onwualu A.P (2001) Agricultural Engineering Practice in Nigeria; NIAE Book of Achievements. NIAE pp 80-83.

Rahman, S.Y., Chen and D.A. Lobb (2005), Soil movement resulting from sweep type manure injection tools, Bio system Engineering 91; Pp 379-392.

Table 1: Soil pH, Moisture Content and Particle Size Distribution of the Soil Bin

Soil sample	Soil pH	Moisture Content (%)	Particle size			Textural class		
1	5.65	10.4	54.8	20.0	25.20	Sandy	Clay	Loam
2	5.51	9.6	60.8	16.0	32.2	Sandy	Clay	Loam
3	5.08	10.9	46.8	17.2	36.0	Sandy	Clay	Loam
4	5.45	10.3	52.8	8.0	39.2	Sandy	Clay	Loam
5	6.24	9.4	64.8	10.0	25.2	Sandy	Clay	Loam

Table 2: The Penetrometry Soil Resistance Load (kpa) And Penetrometer Depth At Different Passes Of The Compaction Roller In (cm) At Various Location Within The Soil Bin

	Load/depth kpa/cm location 1	Load/depth kpa/cm location 2	Load/depth kpa/cm location 3	Load/depth kpa/cm location 4	Load/depth kpa/cm location 5
Control	2158 / 50	1165 / 52	975 / 55	1021 / 55	2218 / 50
1 passes	4027 / 22	2358 / 45	2140 / 28	3250 / 26	4090 / 20
2 passes	4027 / 22	3333 / 24	2140 / 28	3250 / 26	4090 / 20
3 passes	4999 / 14	4308 / 17	3115 / 19	4225 / 15	5065 / 12
4 passes	5974 / 7	5283 / 8	4090 / 10	5200 / 8	6040 / 6
5 passes	6949 / 2	6258 / 4	5065 / 5	6175 / 3	7015 / 2

DESIGN OF TERRACE STRUCTURE FOR SOIL CONSERVATION ON DISSECTED GULLIED STEEP UPLAND OF USE SUB CATCHMENT

Obot Ekpo Essien
Department of Agricultural and Food Engineering,
University of Uyo, P.M.B 1017, Uyo, Nigeria.
email: obotessien@uniuyo.edu.ng
Phone: +2348023232195.

ABSTRACT
Bench terrace slopping inward also called drainage terrace was found most suitable permanent structure for soil conservation against gullied upland of use. Sub catchment with dissected land form with steeped slopes of ($20 – 35^0$), productive soil depth of 50 – 65cm and very low infiltration capacity in very high tropical rainfall area with-daily rainfall of 180 – 200mm in rainy season or annual rainfall of 2988 – 3000mm. Terrace width of 15m and vertical inter-distance of 4m was designed for a terrace capacity of 0.017 m^3/s for $15m^2$ drainage area per ha. The safe flow velocity of 0.11m3 was the asonable to abate further gully ravages while the spacious terrace width provided for the mechanined cultivation of crops on the steep slopes with clay of gravely clay texture. Percentage loss of agricultural land was minimum and institutional community participation was effective for construction, maintenance and sustained agricultural development of high price vegetables.

Key words: Soil Conservation, Steep Slope Furrigenized Landfarm, Drainage Terrace, Terrace Design, Soft Cross Velocity.

1.0 INTRODUCTION
Terraces are a kind permanent gully control structure which aimed to convert surface soil from erosive runoff over stop slopes (Suresh, 2006; Michael and Ojha, 2006). Design features are made to reduce soil erosion by shortening slope length, reduce the velocity of the runoff and or improving soil infiltration. These are different types of terraces having specific design features to meet these functions.

Terrace design aims primarily to intercept runoff at upslope and channel it through lateral or cross-slope along the width of the field to protected outlets at the edge of the field width. Therefore, the design functions of this structure as stated above, but designs incorporating agricultural purpose include channel cross section being modified to become more nearly compatible with modern mechanization (Suresh, 2006). Such a broad-based terrace occupying a width of about 15m is enough to be cultivated even by mechanization if bank slopes do not exceed 14% (Suresh, 2008). For steeper slopes, bench terrace are suited for cultivation. The risers can be protected by vegetative cover or by concrete fencing.

The primary function is to protect the soil, reduce erosion by preventing erosive velocity and protect the silted spring at the valley from further siltation by deposition of eroded sediments from upland debris from the upslope stone quarries, and also check gullying and enable restoration by gully plug. Thus the purpose of the design is soil conservation on steep dissected slope of use swamp by bench contour design and side

of adequate carrying capacity.

To design bench contour that can reduce upland erosive velocity down slope and present downslope erosion and to design side drainage channels of adequate carrying capacity to evacuate collected runoff from the terrace to protected outlet.

2.0 METHODOLOGY

2.1 Study Area Physical Characteristics

The slopes of the catchment are divided into three grades – the flatter upland, the steep or average grade slope and the steeper areas. The flatter area is found along the edge of the catchment where the slope averages 16%. This includes the area around where houses have been constructed. The areas are immediately below the dwellings, the slopes are steeper, varying between 20 and 33%.

The upland soils characteristics are dependent on the steepness of the slope of their position. In areas where the slope is gentle, the soils are well drained, deep, yellow red to yellow red to yellowish brown with sandy clay loam and change to clay at the depths [AKADEP, 1995]. The topsoil is sandy loam or loamy sand. The soil has high erodibility when undisturbed but under the pulverization and soil clod breaking by gravel quarrying equipment, its erodibility is high. The soil texture and erodibility class on the affected catchment are shown in Table 1.

In the areas with steeper grades, soils at the edges of steeper slopes became shallower, containing rounded quartz gravel or regular fragment of ferruginized sandstone at depth less than 50cm brown sandy clay overlying brown yellow gravelly clay (AKADEP, 1995). An impenetrable stony layer exists at depths ranging from 20 to 65cm (AKADEP, 1995).

Wet aggregate stability of the soil shows moderate stability hence indicating that significant erosion risk exists in there. (Hence this gives greater imperative of designing protective structure for the steep grade. The soil pH varies from a pH of 4.5 – 6.5 or from very strongly to medium acidic soils.

2.1.1 Application of terrace to use swamp soil conservation: Bench terrace

1. The type of terrace application is the bench terrace slopping inward, also called drainage terrace, which is adopted in areas of heavy rainfall and less permeable soil, so as to drain off large portion of rain water as runoff (FAO, 1979; Suresh, 2006; Michael and Ojha, 2006). The study area, is humid tropical rainforest area of Nigeria with very high rainfall of about 2192mm per year (AKADEP, 1995). This is more than what irrigated terrace can handle, which is for permeable soils (Suresh, 2006). The soil structure is shallow (20-65cm), ferrogenized clay or gravelly clay forms with very low infiltration capacity and rate (AKADEP, 1995), subject to water logging and is highly susceptible to gullying. The slope is very steep, 20 – 35%, more than ordinary level or broad based terrace can handle/where slope is kept as mild as 10% for uniform water impounding over them. Therefore the bench terrace slopping inward is the most applicable structure for this upland subcatchment, as it has provisions for growing crops such as upland rice and okro or tree crops as well as drain the runoff from their inner side by constructing a drainage channel, so that erosion loss in retarded.

2.1.2 Agricultural application

The slope is steep (20-35%), soil is rough, eroded, gullied, as shallow (20 – 65 cm). these are land suited for permanent recitation (Michael and Ojha, 2006)

2.2 Design Procedure

2.2.1 General Consideration

In the design of bench terrace, both the ground slope and the length of slope are changed to reduce erosive flow down the length. (Note that reducing only the length without the slope constitutes contour bund).

The change of original slope means that the original contour elevation will be reduced by cutting a depth in the soil hence a vertical drop is the vertical interval (VI) or riser between any two of such consecutive shelves or benches. While the short downslope length is the bench or horizontal distance (HD) between any two consecutive steps or VI. Thus, the terrace is constituted by a series of alternating consecutive steps (risers and benches) of appropriate dimension down the modified ground slope.

The width of the bench or horizontal distance can be made wide enough for cultivation even by tractors, power tillers or walking tractors (Suresh, 2006). However, it must not be too wide so as to become instable on steep slope, ensure no flooding, ensure correct infiltration and that no large amount of runoff gathers to wreck erosion havoc on it. Also, the riser must be sizeable since the deeper it is the more voluminous the spoil or burden of cut soil to be moved, which may require heavy duty equipment, which is not desirable here both for cost and protection of the cut soil from erosion and for productivity. In this case, the depth of soil in the gravelly clay or loamy clay soil is not deep (20 – 65cm). Hence, mechanical grading and exaction should be reduced. Therefore, the terrace will be constructed within wider bench width except that the slope will be reduced as required of terrace.

2.2.2 Design steps

The design of the bench terrace can take three design steps, namely (Suresh, 2006):

1. The hydrologic design
2. The hydraulic design
3. The structural design

2.3 Hydrologic Design

The hydrologic design of bench terrace involves the following variables: field slope to protected outlet under heavy rainfall. Channeling of runoff water across average annual rainfall, soil types, soil depth and average slope of the land. The soil type is generally clay or clay or clay loam. The most important terrace design adapted to the hydrologic and erosion control needs are:

(1) terrace spacing (vertical interval (VI) and horizontal distance (HD) or bund width),
(2) length of terrace in lateral or cross-slope direction, and
(3) slope of the riser (VI) and location of outlets, (Suresh, 2006).

2.4 Design Parameters

1. Slope: The natural ground slope of the catchment varies from 20 to 35% which is steep; hence bench terrace is suitable. Practical limits of steep slope is about 20% for convenience of machine construction and maintenance for terraces and 25 to 30% when hand made (Suresh, 2008). The provision of terrace or 350 for hand made terraces (Suresh, 2006) gradient, especially in high rainfall areas is most

essential to dispose the excess water very quickly. The most important design parameters are the (1) terrace risers (VI), (2) bench (HD) and (3) slope of risers. For bench terrace slopes of 7% to 30% is recommended.

2. Rainfall: The permeability of the gravelly clay soil is not generally good to permit adequate infiltration, hence the use of the terrace is for runoff diversion and safe discharge at non-erosive velocity (and not for conservation – storage of runoff).

The hydrologic design involves the estimation of design runoff rate and flood volume, and the factors associated with these parameters are rainfall amount and intensity. (Rainfall characteristic) and its distribution pattern (Suresh, 2006).

The rainfall characteristics (intensity and return period) are shown in Table 2 for intensity of not more than 2-hours rainfall.

Rainfall return period shows that:

Wet-year rainfall	=	4-in-5 years
Dry-year rainfall	=	1-in-5 years

Also the hydrologic design of permanent gully control structures requires the computation of runoff rate for 25 to 30 years return period which assumes that the heaviest rain is a 1-in-25 to 30 years period (Suresh, 2006).

However, in the study catchment, the highest rainfall amount was in 1994, regarded as the second highest rainfall in history (AKADEP, 1995), and its return period was 1 in 2½ years, while the mean rainfall was 1½ years rainfall. Hence the 10 years return period was safest. Table 2 shows the rainfall intensities of 1 – 20 year return period.

3. Terrace spacing (vertical interval (VI) and horizontal distance (HD) or bund width)

4. Side slope of riser

5. Length of terrace in lateral or cross-slope direction

6. Also the cultivable width can be more nearly compatible with modern mechanization practice. For ease of cultivation and practical construction" the width of terrace increases the amount earth burden to be moved, making narrow terraces cheaper than wider terraces for the mechanization on terrace by walking tractor, the 2 – 5m bench width is feasible while for wheel tractor cultivation, a minimum width of 3 to 4m is desirable (Suresh, 2008).

7. Location of outlets, (Suresh, 2006)

8. Terrace area per hectare

9. Discharge

2.5 Design

Fig 1 shows typical bench sloping inward with component design parameters.

2.5.1 Side slope of risers

For clayey soil, as in the study area, side slope is 1:1 vertical to horizontal (Michael and Ojha, 2006).

2.5.2 Length of bench terrace

From Fig. 1, for side slope of 1:1, the horizontal distance (HD) or bed width is:

$$HD = (W + D) \quad (1)$$

or

$$HD = \frac{100D}{S} \quad (2)$$

where HD = bench terrace horizontal distance, m
D = Vertical distance between two consecutive terraces (or VI)
S = ground slope

Hence,

$$W = D(100/S - 1) \quad (3)$$

Or

$$D = \frac{WS}{100 - S} \quad (4)$$

2.5.3 Width of bench terrace

Also, width of bench terrace sloping inwards is (Suresh, 2006):

$$W = \frac{100D}{(S + s)} \quad (5)$$

Assumption;
For 20% bench slope or ground slope (Michael and Ojha, 2006):

i. Preferred vertical drop (selection from best practice (FAO, 1979; Raju, 1956)) = 2m and 2.5m. Trials were computed for D = 3m and 4.5m (Suresh, 2006).
ii. Slope of riser is 0.2% and bund ridge is 30cm (FAO, 1979; Lakshimipathy and Narayanaswany, 1956)

Thus, the computed width of bench terrace with inward slope are below given:

D	W
2m	10.10m
2.5m	12.63m
3.0m	15.15m
4.5m	22.72m

2.5.4 Length of bench terrace with inward sloping

$$L = \frac{10{,}000}{W} \quad (6)$$

Computed length for selected width are given below

D	W	L
2 m	10.10m	999.0m
2.5m		792m
3.6m		333m
4.5m		222m

2.6 Alternative terrace design

For a check on the computed terrace design above Singh equation could also be used for comparative purpose.

2.6.1 Vertical interval (VI)

Considering soil erodibility limitation, Singh's formula (Singh, 1999) becomes appropriate for use as:

$$VI = \frac{S}{a} + b \quad (7)$$

or empirically,

$$VI = \frac{S}{10} + 2 \quad (8)$$

Where VI is vertical interval between two consecutive terraces, M and S is percentage slope terraces a and b are constant with 'a' varying from 1.5 for low rainfall to 4.0 for high rainfall areas; and 'b' varying from 1 to 3, depending on soil erodibility.
Using Singh's formula, (Singh,1991; EUROCONSULT, 1989) HD is given as,

HD = (200/s) + 10 (9)

Where S is still slope between two terraces.
Given S varying between 20 and 35%, then the values of HD and VI are given in Table 1.

2.6.2 Length of bench terrace:

Using Singh's fomula (Singh, 1999), the terrace length per ha (L) is given as

L = 10,000/HD

For HD = 15m, L = 666m per ha.
The maximum bench terrace length is 600m (Michael and Ojha (2006, Euroconsult, 1989). Table shows variation of discharge with length and terrace microcatchment a drainage surface area. For velocity to be controllable within the ability of local farmers the 100m length is recommended.

From computed values in Table 2, the average bench width of 15m make it feasible for mechanized tillage by tractor up to 3 strips of tractor width can be cultivated. Also manually aided or power-tillers can be used on cleared lands. On the other hand, the terrace bench width is ample enough for fuel wood plantation, which is of enormous needs for economic rice processing in the area, or for cultivation of mixed cropping of fluted pumpkins and cassava. It can also be used for orchard of fruit trees, which can be built on very steep slopes of 25 to 300. This width is good enough and will require protected edge.

2.7 Runoff Rate, Q_r

From theoretical consideration and assuming a steady state condition, the runoff rate Q_r is given as (Suresh, 2006):

$$Q = (I - i) L. \sin \varnothing \quad (10)$$

Where I is rainfall intensity, I = soil infiltration rate, L is slope length and ? is slope angle. This equation is good enough for drainage terrace as runoff storage for water conservation structure. However, this bench terrace is to divert or drain runoff at non erosive velocity. Hence, drainage flow from a flow surface is considered using rational equation as (Euroconsult, 1989):

$$Q_r = CiA\,1360 \quad (11)$$

where Q_r is terrace drainage capacity m^3/s
i = is velocity of flow (m/s) or rainfall intensity mm/hr
A is terrace catchment area (length of terrace (L) x width), in ha.

i = rainfall intensity for 10 years rainfall intensity, mm/hr
A= area of the terrace microcatchment
Note that for the whole terrace area, total area = No of terrace of same length x width of terrace, ha; C = runoff coefficient, dimensionless

i. The area is partly cultivated and some parts area under natural cover fruit trees, a compromise value of C = 50% is applied on a steep slope.
ii. Let L = 100m, Terrace width HD = 15m.
iii. Q_r = 0.5 x 83 x 0.15/360 or 0.017m^3S

2.8 Hydraulic design

This considers terrace width as a water way or channel through which required surface drainage must be discharge in a non-erosive manner. The dimensions a must have sufficient capacity to cope with peak runoff rates with a 10 years return period.

2.8.1 The flowrate

The computed flowrate is given in Table 3.
Using the best section or economic section of hydraulic channel for terrace conservation rate (Schwab et al, 1993; Suresh, 2006) and assuming *V* channel section, drain slopes of 1:2 (from a range of 0.5% - 1.5 terrace conservation (Suresh, 2006) area of v-channel (a) = zd^2 where Z = side slope (Suresh, 2006).

$R = d/2,$

$$V = \frac{d^{2/3}.}{2}{}^{31/2}.K$$

Where k = manning – stricker coefficient $K = {}^{1}/n$
From continuity $Q_r = Q_d$ (12)
or

$$v_r a_r = v_a a_d$$

Where *Q, a* and *v* stand for terrace discharge area and velocity and a and d subscripts indicate and drain channel respectively. Therefore using above result of Q_r = $0.017 m^3/s$ for the terrace,

$$v_r a_r = Q_r = 0.017 m^3/s \quad (14)$$

$$a_r = 15m \times 100m \Rightarrow v_r = \frac{0.017}{15} \times 100 = 00.00113 \times 10^{-2}$$

2.8.2 Discharge drain:

For the drain, from the continuity (Eq 12), $V_d = V_r = 0.11 m/s$
The drain shape = v =shape or up-ended triangular cross section

$Q_r = 0.017 m^3/s$
Then
$Q_d = v_d a_d = 0.017 m/s$

$$\Rightarrow a_d = \frac{Q}{v_d}$$

But v_a by manning equation is $V_d = R^{1/2} . S^{1/2} k$

For the economic or best section of triangular channel $R = zd$ (15)

Given Data: z = side slope = $\frac{1}{2}$ hence or R = $\frac{d}{2}$
s = bed slope = 0.002
K = Manning - Stricker coefficient = $\frac{1}{n} = 30$
Where n is roughness coefficient for grass =
Hence, $v_d = \left(\frac{d}{2}\right)^{2/3} . (0.002)^{\frac{1}{2}} . 30$
$v_d \cong 0.28 m$

2.8.3 Freeboard

A freeboard of 0.02m was applied to supplement the depth of v-drain. Total depth of v-drain become 0.30m.
Drain specification of velocity (flowrate) = 0.11m/s
Drain discharge = 0.017m^3/s

3.0 CONCLUSION

Bench terrace with inward sloping was designed for Use upland landform. This was compared with alternative design.

REFERENCES

AKADEP (1995). Northern Akwa Ibom Swamp study, Stage 2 Report, Akwa Ibom Agricultural Development Project, Ministry of Agriculture and Natural Resources, Uyo, Nigeria.

Euroconsult. (1989). Agricultural compendium for Rural Development in the Tropics and sub tropics. Elsevier, The Netherlands. pp454 – 459.

FAO. (1979). Watershed Development. Soil Bulletin 44. FAD, Rome.

Lakshimipathy, B. M. and Narayanaswany, S(1956). Bench Terancing in the Nilgiris. Journal of soil and water in India 4/4.
Michael, M. A and Ojha, T.P. (20060. Principles of Agricultural Engineering, vol. II. Jain brothers, New Delhi 110005. pp 670 – 853.

Raju, C. P. (1956). Bunding in deep black soils of Andhra State. Journal of soil and water conservation of india, 4(4).
Suresh, R. (2006). Soil and water conservation Engineering. Standard Publishers Distributors. Delhi 110 006. pp 404 – 522.

Table 1: Terrace Slope, Vertical Interval And Bench Width Design For Use Catchment

Slope, %	VI, m	HD, m
20	2	20
35	5.5	15
Average	-	15

Table 2: Storm Duration, And Return Period Use Catchment (Study Area)

Return Period T (yrs) Duration t (hrs)	2	5	10	20
0.50	45	52	59	66
0.75	50	58	65	73
1.00	53	62	70	78
1.25	56	66	74	83
1.50	59	69	77	87
1.75	61	71	80	90
2.00	63	74	83	93
2.25	65	76	85	96
2.50	67	78	88	98
2.75	69	80	90	101
3.00	70	82	92	103
3.25	72	83	94	105
3.50	73	85	95	107
3.75	74	86	97	109
4.00	75	88	99	111
4.25	77	89	100	112
4.50	78	90	102	114
4.75	79	92	103	116
5.00	80	93	104	117
5.25	81	94	106	118
5.50	82	95	107	120
4.75	83	96	108	121
6.00	83	97	109	122

Table 3. Economic Length Of Bench Terrace On Steep Slopes (20-30^{0}c)

Terrace length (m)	Area (ha)	Terrace discharge m^3/s	Channel flow rate m/s
100	0.15	0.017	0.11
150	0.225	0.026	
200	0.300	0.035	
250	0.375	0.043	
300	0.45	0.052	

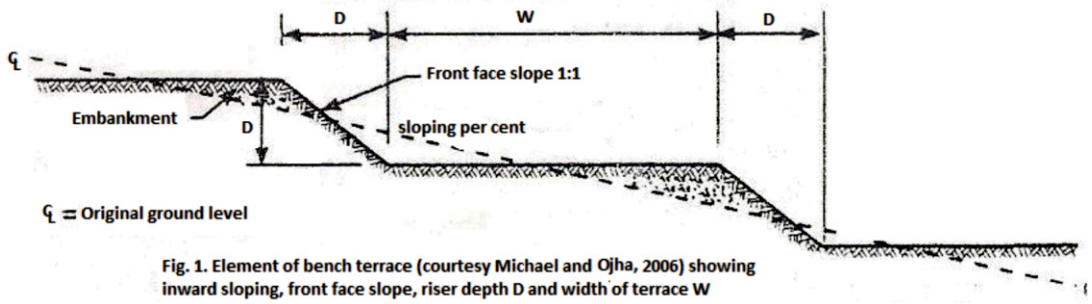


Fig. 1. Element of bench terrace (courtesy Michael and Ojha, 2006) showing inward sloping, front face slope, riser depth D and width of terrace W

FEASIBILITY OF RAINWATER HARVESTING SYSTEMS FOR POULTRY PRODUCTION AND WATER CONSERVATION IN NORTHERN AKWA IBOM STATE, NIGERIA.

Ikpe J. Udom[1] and Christopher B. Afangideh[2]
[1]Department of Agricultural Engineering,
Akwa Ibom State University, Ikot Akpaden, Nigeria
[2]Department of Mechanical Engineering
Akwa Ibom State University, Ikot Akpaden, Nigeria.
E-mail:ikpeudom@yahoo.com.
+2348027845880

ABSTRACT

Water supply in Akwa Ibom State is inadequate both in quantity and quality and only 2 percent of the state has access to portable water. This study investigates the feasibility of Rainwater Harvesting Systems (RWHS) for small and medium scale layer chicken production in Northern Akwa Ibom State. Data on rainwater use and production practices as well as housing characteristics and water use patterns under these production scales were collected using direct measurement and structured questionnaire. Average roof catchment areas commensurate with 500 and 1000 layers stock sizes at the rate of 3birds/m^2 floor area were 203.5m^2 and 396m^2 respectively, including roof overhang of 1m in both length and width of the poultry house. Ten years monthly rainfall data obtained from two sources close to the study area were combined with roof catchment characteristics to obtain the total monthly rainwater that can be harvested from the roof catchment. In line with accepted standards, 50 litres of water per day was assigned to each 100 layer chicken and 182 litres per day was assigned for attendant's sanitation and cooking. The sum of these requirements was used to predict the monthly demand of rainwater in the study area. The mass curve principle was used to predict the cumulative supply which was compared with the cumulative demand over a 12-month period to obtain the required storage for the above stated production scales. The dimensionless graph principle was then used to scale down the annual supply to give the volume of storage required. Finally, the results obtained showed that for small scale layer production, annual rainwater demand was 36, 46 and 48% of annual rainwater supply for small scale layer production in Ibiono, Obot Akara/Ikot Ekpene and Ikono/Ini Local Government Areas (LGA's) respectively while for the medium scale layer production, annual rainwater demand was only 29, 36 and 38% of annual rainwater supply for Ibiono, Obot Akara/Ikot Ekpene and Ikono/Ini LGA's respectively. Only 57, 84 and 96% of the cumulative rainwater supply was required for uninterrupted rainwater supply at constant rate in Ibiono, Obot Akara/Ikot Ekpene and Ikono/Ini LGA's respectively for the small scale layer production. Similarly, for full utilization of rainwater potential, only 42, 58 and 62% of the cumulative rainwater supply was required for uninterrupted rainwater supply at constant rate in medium scale layer production in Ibiono, Obot Akara/Ikot Ekpene and Ikono/Ini LGA's respectively. It is therefore concluded that RWHS is feasible and the quantity of rainfall is adequate for small and medium scale layer production in Northern Akwa Ibom State.

Keywords: Rainwater Harvesting, Water Conservation, Poultry Production, Mass Curve, Northern Akwa Ibom State.

1.0 INTRODUCTION

The poultry production sub-sector is the most commercialized of all the sub-sectors of the Nigerian agriculture (Adene and Oguntade, 2006). Poultry constitutes 53.7 percent of the livestock population in Nigeria. The rainforest zone contributes 33.3 percent of this livestock population and, Akwa Ibom State which produces 4.5 percent of the zone's contribution is ranked as the ninth in poultry production in Nigeria (Ibanga, 2010). The type of poultry that are commonly reared in Nigeria are chickens, ducks, guinea fowls, turkeys, pigeons and more recently ostriches. Those that are of commercial or economic importance given the trade in poultry, however, are chickens ,guinea fowls and turkeys, among which the chickens predominate. Commercial production of chicken provides employment for over 10 percent Nigerians (Okpeke and Tibi, 2011).

The ban on importation of frozen chicken in Nigeria has made commercial production of chicken lucrative as competition between imported and locally produced chicken has been removed. Presently, less than 50 percent of chicken requirement in Nigeria is being met (Momoh, 2012). The domestic supply shortfall is estimated at 25,000 metric tons per annum (Aghadigigbi, 2013). Additionally, the poultry sector presently supplies only 5gm/caput/day which is only 14 percent of the FAO recommended 35gm/caput/day protein intake (Ojo, 2003). It is evident therefore that there is a large market for chicken production in Nigeria.

One of the challenges (Yegani, 2012) in the daily routine requirements for successful

Chicken production is the provision of adequate quality and quantity of water. This, in addition to feed and drugs, has limited the capacity of the poultry sub-sector of the economy in meeting the shortfall in supply, achieving food security and alleviating poultry.

Poultry production involves the use of enormous quantities of water. Water is not only a resource in poultry production, it is a life source. Water is involved in every aspect of poultry metabolism. Eggs are 66 percent water and to produce one dozen eggs, hens require 4.73 litres of water (Sheik, 2012). Water consumption has been found to be proportional to feed consumption and chicken consume approximately1.6 to 2.0 times as much water as feed on weight basis (Ojo, 2003). Egg production can be affected by such factors as feed and water intake. Proper watering is the next factor after feeding that should be considered in egg production and is most likely the most important element in maximizing egg production

Water supply in Akwa Ibom state is inadequate both in quality and quantity as only 2 percent of the state has access to portable water (Ukpong, 2010). Pressures on water resources are increasing daily as a result of human activity which includes urbanization, population growth, increased living standards, pollution and growing competition for water. These are aggravated by climate change and variations in natural conditions. In Nigeria, as much as 44 percent of the population is without access to improved water sources (UNDP, 2012). This deficit in water supply does not include poultry and stock water supplies.

In Northern Akwa Ibom State, (Ibiono, Ini, Ikono, Obot Akara, and Northern part of Ikot Ekpene) the aquifer if formed by the impervious clays and shale of the Ameke and Imo shale formations (AKS, 1989). This geological condition makes it difficult for groundwater extraction and where such extraction is possible, there is the other problem of mineral-based water pollution (Akpabio, 2010). The groundwater in this area is acidic and corrosive as seen from the low PH and high free CO_2 concentration which various between 40 and 200 mg/L (Akapbio, 2010). In actual fact, the northern part of the state is placed at a disadvantaged position with respect to portable water accessibility. Consequently, there is a very deep gap between water needs and supplies across the zone. As a result, there is high dependence on all forms of natural sources of supplies which the most important is rainfall. Average rainfall on the northern part of the state is

2000mm.Rainfall is inexpensive and has the advantage of allowing local communities to develop and maintain the required system themselves. The suitability of rainwater harvesting in an area can only be established if, according to skinner (1992), other sources of water are not ideal or convenient to exploit, there is availability of suitable rainfall pattern and, the people are already practising some degree of rainwater harvesting.

Rainfall is highly variable in space and time and farmers can experience unexpected and persistent drought that may last long. Developing rainwater harvesting systems is an environmentally sustainable water source that reduces the energy expenditure by bringing the source of water closer to the users and conserving water resource that would otherwise have been wasted.

However, the vulnerability of such systems to drought raises the importance of developing ideal storage requirements that are economically feasible. The traditional response to reduce variability of rainfall is by storing during the wet season for release during drier periods.

Developing ideal storage requirement depends on such factors as rainfall amount and variability, catchment surface area, type of roofing materials, collection efficiency and water use rates.

There are various methods of sizing rainwater storage reservoir. When the distribution of rainfall data is uneven, a more intensive approach to gauge the storage requirement of a rainwater harvesting unit is the mass curve analysis (Olben and Baetz, 2005). This method considers the supply side and makes use of mean monthly rainfall totals and mean monthly consumption rates. A graph of cumulative harvested water and cumulative demand are drawn and from this, the storage requirement that satisfies the consumption rate of the intended use of rainwater can be calculated. This method is suitable for finding the size of tank that is needed to sustain a water consumption rate that is equal to the maximum harvestable water for a specific roof area and rainfall pattern. It takes into consideration the accumulated inflow and outflow from the tank and the capacity of the tank is calculated as the greatest excess of water over and above consumption. This method can be carried out graphically or by the use of tables (World Bank, 1986).

In order to ascertain the potential for development of rainwater for an area, reliable rainfall records for period of at least ten years are required (Grould and Nissen-Perterson, 1999 as in Oti and Skinner, 2012).

Etuk et al (2011) studied the application of rainwater for poultry production in south eastern Nigeria and discovered that no farmer used rainwater alone as a source of water for poultry production. This was due to the unreliability and variability of rainfall in space and time.

In Akwa Ibom State, data on application of rainwater in poultry production is very scanty and virtually non-existent for northern Akwa Ibom State. Although the average rainfall of 2000mm for this zone of the state is considered adequate for chicken production, the greatest percentage of rainfall is wasted since the concept of storage in this area is restricted to earthen ponds, drums and jelly cans which do not guarantee quality of stored water and also, the quantity of water that can be stored with these devices cannot provide reliable quantity of water for portable poultry production.

This paper considers the feasibility of using rainwater as the only source of water for layer chicken production in northern Akwa Ibom State. Feasibility can be investigated if enough rainwater can be collected and stored. Historical rainfall data is used to determine whether enough rainwater can be collected and the tank's size needed to store the rainwater (Institute for Rural Water, 1982). The significance of this paper is that it will be beneficial to egg producers. This is because overestimation of storage requirement can result in an oversized and needlessly expensive storage system. Similarly, an undersized storage system restricts farmer's storage, thereby making dependence on

rainwater unreliable and impossible for farmers to change their production structure according to market needs in order to improve their income.

Water resources planners and providers will also benefit from this study. Apart from the middle part of the state, groundwater is not a safer option in the north because of mineral based pollution, and south because of saline intrusion and petroleum based pollution. In actual fact, the north and southern part of the state are placed at disadvantaged position with respect to portable water accessibility (Akpabio and Ekanem, 2009). Therefore this study on the feasibility of rainwater harvesting will provide information on alternative source of water supply that could be exploited for the benefit of the people of northern Akwa Ibom State.

2.0 MATERIALS AND METHODS

Northern Akwa Ibom State which comprises five local government areas, represent 27 percent of the total area and 21.4 percent of the total population of the state. The area is located between latitudes $5^0.00$ and $5^0 31^{'}$N and longitudes 7^0 30' and 8^0 $15^{'}$ E (fig 1).

The area is covered by the Ameke sandstone of the Imo shale formations. This geological condition makes it difficult for groundwater extraction and where such extraction is possible there is the other problem of mineral-based water pollution. Climatically, the area has a tropical rainy climate. Annual rainfall average of 2000mm is recorded on the northern fringe. The area is characterized by two seasons- the wet rainy season and the dry season. The rainy season which starts from March and lasts until mid November lasts for about nine months in this area. About 80-90 percent of the total amount of rainfall is received during the period of the rainy season. The period is marked by the "little dry season" and occurring for about 2-4 weeks in August is sometimes referred to as August break. This gives rise to two rainfall maxima –June/July for the first maxima and September for the second maxima.

Water supply in the area is inadequate both in quality and quantity. People therefore often resort to water from private boreholes, streams, rainfall and local wells. Water from these sources is often known to have serious health problem (Ukpong, 2010).
The research method for this study entailed use of questionnaires in gathering information, field visits and collection of recorded rainfall data of the study area, to verify the local RWHS and utilization practices. The population for the study consisted of all registered poultry farmers numbering 3082. Twenty four farmers were selected at random from each of the participating LGA's through balloting. A total of 60 poultry houses covering the five participating LGA's were visited between November 2012 and March 2013 for interviews and direct measurement of characteristics of poultry houses. The length and width of poultry houses, floor area, roof area, number of birds, roofing materials, type of roof and roof pitch were the parameters considered in the onsite measurement as presented in table 1.

The catchment area is where runoff is generated before it is conveyed for storage. The total amount of rain water that is available depends on the size of the catchment area. The catchment area is obtained by multiplying the roof area by the pitch (slope factor).

$$A = a_r f_s \ldots \quad \ldots\ldots \quad \ldots\ldots (1).$$

Where,

A= catchment area;
a_r= roof area
f_s= slope factor (pitch)

Actual monthly and annual rainfall data for one decade (2002-2011) for the study area were collected from the meteorological laboratory, University of Uyo and Michael Okpara University of Agriculture, Umudike respectively. The rainfall records were combined to estimate the cumulative rainwater supply by using equation (2)

$$S_r = \sum^{k}(AP_2Z)\text{----------} \quad (2)$$

Where,

S_r= Cumulative rainwater supply

A= Catchment area (m^3)

P= Rainfall over given time period (mm)

Z= Runoff coefficient

The cumulative demand for rainwater was estimated by summing the daily per capita basic requirements for layer chickens and attendants

$$D_c = \sum (DN) \text{ ----------} \quad (3)$$

Where,

D_c= Cumulative demand (m^3/day)

D = Daily per capita demand (litres/capita day)

N= number of days in the given month

The per capita basic water requirement (BWR) was estimated at 182 litres per day for each poultry attendant where there is running water in the kitchen, bathroom and laundry. The BWR for the layer chicken was estimated at 35 litres per 100 birds per day (Nustafa and Yusuf, 2000,WHO, 2003). The product of BWR and the number of attendant and chicken gave the amount of water that is required daily as shown in table 2.

Estimation of the storage requirement entailed sizing of the tank required to store enough water to satisfy the appropriate demand as required by the member of chickens and attendants. The maximum difference between the cumulative supply and the cumulative demand of rainwater at any given month was the basis for applying the mass curve analysis to estimate the storage requirement for the RWH system.

Equation (2) and (3) were combined to give equation (4) (Olsen and Baetz, 2005) which was used for the mass curve analysis.

$$S_k = \int_{i=1}^{k}(APZ\text{-}D_iN_i) \text{ ----------} \quad (4)$$

Where,

S_k= storage requirement after month k (litres)

$$S = MAX(S_k). \quad \text{.....} \quad (5)$$

Where,

S= Maximum storage requirement (litres)

Equation 4 was performed twelve times with values incrementing by one accordingly. When the difference between supply and demand reached a maximum, the resulting volume became the required storage capacity of the rainwater harvesting system (eq. 5).

The mass curve and dimensionless graph principles (Oti and Skinner, 2012) make up the core rainwater simulation methods used in this study. The mass curve and dimensionless graph entails using the principle of mass curve to predict the cumulative supply which is compared against cumulative demand over a 12-months period to obtain the maximum storage required graphically or by using tables. A further plot of scaled- down demand levels (as percentage of supply) gives a graph from which the dimensionless constant can be obtained. This quality makes the graph especially valuable for field analysis where different roof sizes and types and demand levels are inherent. However, the limitation of the tool is that the resulting graph can only be used in a particular locality because of the uniqueness of rainfall pattern used to generate it. The calculations comprising the simulations that give rise to the dimensionless graph are based on the conventional rainwater supply equations considered for the condition of rainfall in the state as stated in equation (4) above.

The basis of the dimensionless graph is the assumption that demand must always

be less than supply. As such average annual supply values need to be scaled-down based on percentages to obtain corresponding demand figures

$D_c = S_r p$----------6

Where,p= percentage for scaling-down average monthly supply.

The cumulative values of average annual supply and average annual demand are then compared to estimate the final storage as given in equation (7) below.

$V_{max} = S_k p$

Where,

V_{max} = scale-down volume of tank

V_{max} is computed in table 4 for the study area. The data could be plotted in a graph and used as reference for reading off different demand levels.

3.0 RESULTS AND DISCUSSIONS

The result of the data collected from farmers and field measurements are presented in tables 1-3.

The characteristics of poultry houses are presented in table 1. Poultry distribution according to their numbers show that majority of the farmers in the study area (65.3%) operate at the small scale level. The medium scale farmers were 28.3% while the large scale farmers constituted only 1.7% of the layer producers in the study area. The dominant position occupied by small scale producers does not augur well for the need to alleviate the huge shortfall in the contribution of poultry to the current protein supply deficit. A high value is placed upon rain-fed crop production rather than livestock in the study area and this is a constraint to poultry layer production as this affects the willingness to put much time, expense and effort into livestock production. Access to adequate water during the dry period of the year is also a major factor that limits the scale of layer production in the area. Most farmers produce boilers so that their production schedules can be timed within the rainy season when there is adequate water. Feed and drugs, which are also important inputs for successful layer production, are not seasonal in supply.

Table 2 and 3 present data on sizing of the storage to determine the feasibility of using RWHS for the production of 500 and 1000 poultry layers in the study area. The annual monthly average rainfalls of the study area are taken from the University of Uyo and Federal University of Agriculture, Umudike meteorological stations.

In the table, the monthly average rainfalls are given in column number (2). The monthly supply which results from multiplying the monthly rainfall with the runoff coefficient, the catchment area and the pitch are given in column number (3). The catchment areas used for 500 and 1000 layers at 0.35m^2 per layer and roof overhang of 1 metre were 203.5 and 396m2 respectively. The runoff coefficient and the roof pitch used were 0.85 and 1.1 respectively. The monthly supply based on the summation of 182 litres/day for attendant's sanitation and 50 litres/100 chickens per day are given in column number (4). The variation of the consumption during the different months of the year is accounted for by considering the different days in the month. The difference between the monthly supply and the monthly demand gives the amount of water that can be stored. (Helou and Shaheen, 2012)

From table 2 (a) and 3 (a), the storage required to satisfy the annual consumption of the layers and attendants is the difference between the maximum value of the total storage and the minimum value. This gives a storage volume of about 278 and 596m^3 for 500 and 1000 layers respectively. These amounts would optimally satisfy the annual average consumption of about 158 and 268m^3 for 500 and 1000 respectively.

This means that a farmer may take all its water needs from rainfall using RWHS that has the catchment areas used in this study.

By comparing values in table 2(a) and 3(a) above, it is discovered that the annual demands are only 36 and 29 percent of annual rainfall supply from the roof catchments for

500 and 1000 layers respectively. Similarly, the annual demands are only 57 and 42 percents of total storage for 500 and 1000 layers respectively. This will affect the volume of storage tank. Thus a corresponding volume of tank can be calculated for any level of demand estimated in the field, any level of production and any LGA in the study area as illustrated in figure 2 for Ibiono/Itu LGA for 500 layers.

Table 4 presents the minimum storage as percentage of annual supply. By considering the demands as percentages of supply in column number 6, the study shows that less than half the annual supply was needed to meet rainwater demand for the small and medium scales of layer production in the study area. Storage that could last a minimum of the 3 months critical dry periods in the study area is what is needed to be able to use rainwater all year round. If other sources of water are used to meet non-portable purposes, with some level of discipline in water use pattern, the adjusted size of the tank for rainwater storage can be reduced to a much more affordable size. Although for such sizes, water is likely to overflow during the rainy season, temporary storage of the overflowing water will reduce the need to carry water from other sources in the rainy season and therefore conserve the rainwater for other uses.

4.0 CONCLUSIONS AND RECOMMENDATIONS

In this paper, the feasibility of rainwater harvesting systems (RWHS) for layer production in Northern Akwa Ibom State was investigated. The practices of using RWHS were studied using field data which were collected through the use of questionnaires, direct measurements and meteorological data obtained from university of Uyo and Federal University of Agriculture, Umudike.

Mass curve analysis was used to determine the storage required to meet the rainwater needs of 500 and 1000 poultry layers under an intensive production system. The dimensionless graph principle was used to scale-down the volume of storage and can be applied for any level of demand estimated in the field and any scale of layer production. Since rainwater supply far outweighed the demand for water in the considered scales of production, rainwater harvesting is proved to be feasible and therefore, recommended for layer production in the study area.

Due to exorbitant initial cost incurred if the RWHS is built in the conventional manner, using prefabricated cisterns made of either precast concrete, segmented steel units or fibre glass and standard engineering designs, will contribute to lowering the initial cost.

It is recommended that government should development rainwater resource in the study area. Apart from the fact that rainfall provides large volume of water that is naturally available in the area, the poor groundwater quality in the area presents rainwater resource development as an economical and sustainable alternative for water conservation and all-year-round source of potable water supply in northern Akwa Ibom state.

Table 1 Characteristics Of Poultry Houses

item	Frequency	Percentage	Operation scale
A :Number of chicken			
< 500	79	65.8	Small scale
500-1000	34	28.3	Medium
1000-3000	3	2.5	
3000-5000	2	1.7	Large scale
>5000	2	1.7	
	120	100	

B: Floor area (m^2)	72	percentage	Roof type	Roof materials	Roof pitch	Roof coefficient	Catchment
100<2000	42	60		Corrugated galvanized steel sheet			18.7
200-400	2	358		1.1		0.85	374
400-1000	2	1.7		1.1		0.85	935
1000.1800	2	1.7		1.1		0.85	1683
>1800	1	18		1.1		0.85	1870
	120						

Table 2 (a) Sizing of Storage Tank Using Mass Curve Analysis for Ibiono/Ikono LGA's

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	20.2	3.84	13.39	9.59	-9.59
February	21.7	4.13	12.53	8.40	-17.99
March	174.5	33.20	13.39	19.81	1.82
April	188.6	35.77	12.96	22.81	24.63
May	260.6	49.59	13.39	36.2	60.83
June	261.6	49.66	12.96	36.70	97.53
July	320.0	60.89	13.39	47.50	145.03
August	302.0	57.46	13.39	44.07	189.10
September	324.1	61.66	12.96	48.7	237.8
October	280.3	53.33	13.39	39.94	277.74
November	121.6	23.14	12.96	10.18	287.92
December	18.3	3.48	13.39	-9.91	278.01
Total	2293.5	436.15m^3	158.09 m^3		287.9

(b) Sizing Of Storage Tank Using Mass Curve Analysis For Obot Akara/ Ikot Ekpene LGA's

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	15.3	2.91	13.39	-10.48	-10.48
February	19.1	3.63	12.53	-8.9	-19.38
March	139.5	26.54	13.39	13.15	-5.38
April	151.1	28.75	12.96	15.79	9.91
May	208.5	39.67	13.39	26.28	36.19
June	209.3	39.77	12.96	26.81	63.00
July	239.5	45.47	13.39	32.08	96.44
August	241.5	45.95	13.39	32.56	128.52
September	259.3	49.33	12.96	36.37	164.89
October	224.1	42.64	13.39	29.25	194.14
November	97.0	18.46	12.96	5.5	199.64
December	21.7	4.13	13.39	-9.26	189.5
	1825.9	347.25	158.09		198.38

(c) Sizing Of Storage Tank Using Mass Curve Analysis For Ini LGA.

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	41.1	2.68	13.39	-10.71	-10.71
February	18.2	3.46	12.53	-9.07	-19.78
March	136.2	25.88	13.39	12.49	-7.29
April	148.5	28.26	12.96	15.30	8.01
May	202.9	38.60	13.39	25.21	33.22
June	190.7	36.28	12.96	23.32	56.54
July	230.2	43.80	13.39	30.41	86.95
August	239.8	45.64	13.39	32.25	119.20
September	253.9	48.31	12.96	35.35	154.55
October	159.7	30.39	13.39	17.0	171.55
November	98.3	16.99	12.96	4.03	175.58
December	20.6	3.92	13.39	-9.47	166.11
	1754.1	324.21	158.09		

Table 3: (a) Sizing Of Storage Tank Using Mass Curve Analysis For Ibiono/ikono Lga's.

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	20.2	7.48	21.14	-13.66	-13.66
February	21.7	8.03	17.78	-9.75	-23.41
March	174.5	64.61	21.14	43.47	20.06
April	188.6	69.83	20.46	49.37	69.43
May	260.6	96.49	21.14	75.35	144.78
June	261.6	96.86	20.46	76.40	221.18
July	320.0	118.48	21.14	97.34	318.52
August	302.0	111.82	21.14	90.68	409.20
September	324.1	119.96	20.46	99.82	502.02
October	280.3	103.78	21.14	82.64	584.66
November	121.6	45.02	20.46	24.56	609.22
December	18.3	6.60	21.14	14.48	594.74
	2293.5	8849.02	247.60		609.22

(b) Sizing Of Storage Tank Using Mass Curve Analysis Obot Akara/ Ikot Ekpene LGA's

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	15.3	5.66	21.14	-15.48	-15.48
February	19.1	7.07	17.78	-10.71	-26.19
March	139.5	51.65	21.14	30.51	4.32
April	157.1	55.94	20.14	35.80	40.12
May	208.5	77.20	21.14	56.06	96.18
June	209.3	77.50	2014	57.04	153.22
July	239.5	88.49	21.14	67.35	220.57
August	241.5	89.23	21.14	68.09	288.66
September	259.3	96.01	20.14	75.55	364.21.
October	224.1	82.93	21.14	61.79	426.00
November	97.0	35.92	20.14	15.46	441.46
December	21.7	7.78	21.14	-13.36	428.1
		675.38	247.60		441.46

(c) Sizing Of Storage Tank Using Mass Curve Analysis For Ini LGA's

Months	Monthly Rainfall (mm)	Monthly Supply (m^3)	Monthly Demand (m^3)	Amount Stored(m^3)	Total Storage(m^3)
January	14.1	5.22	21.14	-15.92	-15.92
February	18.2	6.74	17.78	-11.04	-26.96
March	136.2	50.43	21.14	29.29	2.33
April	148.5	54.98	20.46	34.52	36.85
May	202.9	75.13	21.14	53.99	90.84
June	190.7	70.61	20.46	50.15	140.99
July	230.2	85.23	21.14	64.09	205.08
August	239.8	88.79	21.14	67.65	272.73
September	253.9	93.68	20.46	73.22	345.95
October	209.7	77.64	21.14	56.50	402.45
November	89.3	33.06	20.46	12.6	415.05
December	20.6	7.63	21.14	-13.51	405.54
		649.14	247.60		399.13

Table 4: Adjusted Tank Sizes

LGA	Nos. of Layers	(2) Roof catchment m^2	(3) Mean annual rainfall (mm)	(4) Annual demand (m^3)	(5) Annual supply mm	(6) Demand as % of supply	(7) Total Storage (m^3)	(8) % storage of supply	(9) Adjusted Volume of tank(m^3)
Ibiono/Itu	500	205.5		158	436	36	278	64	175
	1000	396	2294	248	849	29	595	70	416
Obot Akara	500	203.5		158	347	46	187	54	101
	1000	396	1826	248	675	37	426	63	268
Ini/Ikono	500	203.5		158	324	49	168	52	84
	1000	396	1754	248	649	38	399	61	243

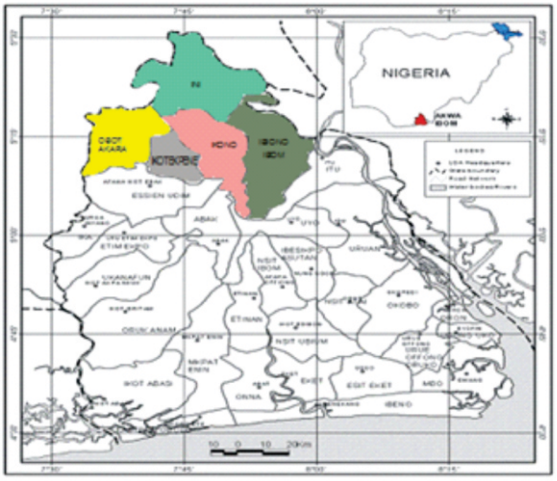


Fig. 1: Map of the study area

500 layers: Ibiono/ Itu LGA
Roof = Catchment = 203.5m2
Mean annual rainfall = 2294mm
Annual demand = 158m3
Annual supply = 2294x203.5x0.85x1.1
100
= 436m3
Demand as % of supply= 158x100
436
= 36%
Total storage = 278m3
% storage of supply = 278x100
436
=63%
Therefore volume of tank = 63%x278
=177m3

Fig. 2 Adjusted tank volume

INFILTRATION RATE DETERMINATION USING PRESSURE HEAD DIFFERENTIAL APPROACH IN DRY SEASON

Othman M. K[1], N.A Sale[2] and Jonah J[3]
[1,2]National Agricultural Extension and Research Liaison Services
[3]Department of Agricultural Engineering Ahmadu Bello University, Zaria
E-mail MKothman@yahoo.co.uk

ABSTRACT
An experiment was conducted to determine the soil infiltration rates using pressure head differential approach during the dry season of 2011/2012. The experiment was done by taking infiltration measurements from 20 different points on the field. The work consisted of assembling of a glass tank and an infiltrometer in which readings were taken from the glass tank directly for 10 different points after installation of the infiltrometer. The analyzed data were compared with that obtained from the conventional method of using double ring infiltrometer at 1.0m away from where each pressure head differential approach readings were taken along the column for the remaining 10 points. Soil physical properties such as bulk density and moisture contents of the individual plot were measured. Statistically the data was used to compare the soil infiltration rates for dry and raining season conditions. The result shows no significance difference between the two methods in dry and raining season when the data were subjected to t-test at 5% level. This established that, the pressure head difference approach could be used during dry and wet season condition as an alternative to the use of double ring infiltrometer.

Keywords: Infiltration Rate, Pressure Head Differential Approach (PHDA), Conventional Method (CM), Dry Season

1.0 INTRODUCTION
Infiltration is the process by which water moves into the soil through its surface. It is measured in inches per hour or millimeter per hour. The rate decreases as the soil approach saturation. If the rainfall intensity exceeds the infiltration rate, runoff usually occurs unless there is some physical barrier. The rate of infiltration is affected by soil characteristics including ease of entry, storage capacity, and transmission rate through the soil. The soil texture and structure, vegetation types and cover, water content of the soil, soil temperature, and rainfall intensity all influence infiltration rate and capacity.

In Northern Nigeria, agriculture is the main source of income to the teeming population but crop production is greatly affected by insufficient amount of rainfall and water available for agricultural purposes. Therefore, to meet the demand of water for food production, irrigation projects were put in place in many northern states. To design an efficient irrigation system the important variable that needs to be put into consideration is the soil infiltration.

There are many methods of measuring infiltration rate but the most adopted method is the use of cylinder infiltrometer because it allows a direct measurement within a specific location. However, the method is characterized with some problems such as; difficulty to maintain a constant head while infiltration is still taking place and turbulence caused by the water added to maintain constant head.

Various research works have been done to determine the rate at which water infiltrate into the soil especially using conventional method but in this study the rate at which water infiltrates into the soil was determine using less popular method; Pressure

head differential approach. The method is a simple technique of infiltration rate measurement, with locally available materials.

2.0 MATERIALS AND METHODS

2.1 Description of the Experimental Site

The experiments were conducted at the experimental plot of the Department of Agricultural Engineering, Ahmadu Bello University Samaru, Zaria. The plot is located within the latitude 11°11^{1}N, longitude 7°38^{1}E, and altitude 686 m above the sea level. The mean annual rainfall is 1120 mm which starts in May and ends in October with a peak value in the month of August.

2.2 Description of the Soil Physical Properties of the Experimental Site

The Samaru soils were formed from sedentary soils derived of basement complex formation and there is a high proportion of fine soil at or near the surface (Higgins, *1963).* There is an increase in the clay content as the profile goes down deeper, and water available for plants use also decreases and is strongly held, making extraction of the available water by plants increasingly difficult with depth (Igbadun, 1992). Soil physical properties were determined by taking samples at 0 - 15 cm and 15 - 30 cm. the samples were subjected to soil textural analysis using the textural triangle after laboratory analysis.

2.3 Field Layout and Experimental Set Up

The area of the experimental site for the study was 12 X 6 m^{2}**.** A total of 20 measurements of infiltration rate were made at sampling locations. The 20 measurements were taken as follows; 10 measurements using the cylinder infiltrometer and 10 measurements using the pressure head differential approach. The experiment was repeated five times (5). The infiltration rate was taken at 3 m distance intervals along the rows, and at each time measurements were taken, 2 sets of readings were taken; one for the cylinder infiltrometer and the other for pressure head differential approach at a distance of 1.0 m along the column. The double ring cylinder infiltrometer used for the experiment had dimensions as; outer ring diameter of 400 mm, a height of 250 mm, the inner ring diameter of 300 mm and a height of 250 mm. The buffer zone which is the distance between the inner and outer rings spacing, was 50 mm. The pressure head differential approach tools included: rectangular tank of dimension 50.40 cm length, 29.00 cm width and 50.00 cm height, cylinder, tape and tube

2.4 Infiltration Rate Measurements

Infiltration rates were measured in two different ways, the standard method of using double ring infiltrometer and the pressure head difference method. When using the pressure head differential method readings were taken from 7:00 am to 10:00 am, before the sun reaches its peak at noon in order to prevent cavitations in the flow tubes, arising from water vapour being produced as a result of high temperatures. All infiltrometer measurements were made at points which were free of any visible holes that could affect the rates of Infiltration being measured.

2.5 Measurements Using Cylinder Infiltrometer

The double ring infiltrometer was driven into the soil to an approximate depth of 100mm. the infiltrometer was then pounded with water simultaneously as quickly as possible to an approximate depth of *150* mm. The water level readings were taken in the inner ring with the aid of a red tape fixed at the inside of the wall of the inner cylinder. The

readings were taken at 1 - minute's intervals for the first 3 minutes, *5* - minute's intervals for the next 10-minutes intervals for the next 20 minutes, 15 - minute's intervals for the next 30 minutes, 30 -minute's intervals for the next 1 hour 1- hour interval respectively. The total elapsed time of 183 minutes was used for the measurements. Each time interval Water was added to top both compartment, to keep the head at the same levels throughout the period of measurements.

2.6 Measurement Using Pressure Head Differential Approach

During the use of pressure head differential approach, a rectangular tank of dimension 50.40 cm length, 29.00 cm width and 50.00 cm height was incorporated. The infiltrometer was driven into the soil to an approximate depth of 100 mm; the tank was placed close to the infiltrometer in such a way that the base of the tank on the ground was on the same level as the 150 mm mark of the ring. Water was then poured into the tank to a level, such that the water level in the tank and the 0.0 mm mark of the ring were approximately equal. The actual depth of water in the tank was taken from the tape glued to the tank internally; the tape was used for the calibration of the tank. Two long tubes connected together through a rubber hose were used to transfer water from the tank to the inner cylinder when the experiment started. A tripod stand clamp was used to have the tube in the tank, stand vertically, without touching the base, while the other tube was placed in the inner ring. When the experiment was started, water was pounded in the buffer zone and the inner ring simultaneously as in the case of the conventional approach, and immediately after, the tube in the inner ring was sucked slightly such that water could flow from the tank to the inner ring through the tubes. Each infiltration run was then carried out for a total of 183 minutes (3.05hrs), as in the case of the conventional method, with the same time intervals being used. In order to determine the actual depth of the water infiltrated using this approach a conversion factor was determined as follows;
Volume of tank = volume of cylinder, therefore,
$L \times W \times H = \pi r^2 h$..... eq. 3.1
Where:
L = Length of tank (cm)
W = Width of the tank (cm)
H = Depth of water in tank (cm)
R = Radius of the inner ring (cm)
h = Depth of water in the inner ring (cm)
considering a depth of 1mm in the tank, we have
$50.40 \times 29.00 \times 50.00 = \pi 15^2 \times h$
h =2.07cm
Therefore, for every 1cm drop in the tank, 2.07 cm of water was infiltrated into the soil.

3.0 RESULT AND DISCUSSION

The soil physical properties of the two plots A and B are presented in Table 4.1. The textural classification grouped the soil as sandy loam for both plots while the bulk densities ranged from 1.794 to 1.918 g/cm^3 and moisture content ranged from 1.246 to 2.334 units. Table 4.2a and 4.2b present the readings of mean average of infiltration rate (mm/hr) for Pressure Head Differential Approach (PHDA) and the conventional method (CM), respectively. The highest infiltration rate of 600 mm/hr was obtained using conventional method while the low infiltration rate of 8.98 mm/hr was found using PHDA. When the readings were plotted, the graphs of infiltration rate against time for both pressure head difference approach and the conventional method as shown fig. 4.1a, 4.1b, 4.2a and 4.2b were observed to follow common pattern of infiltration graphs; At the

initial stage the infiltration rate was high and then gradually drop down as the time increased to reach a steady state. This explains the phenomena that the infiltration decreases as the soil became saturated. Using the two methods, the conventional approach was found to have the highest infiltration rate at initial time. The rate of infiltration and cumulative depth using the conventional method were higher than those obtained using pressure head approach but there is no significant difference between the two as indicated by the t-test. This means that the CM might over estimates the rate of infiltration rate due to water ponding in the inner cylinder.

Table 4.3 presents pool values of cumulative depth and infiltration rate using pressure head differential approach (PHDA) and conventional method (CM). The result indicated that as the depth increases infiltration rate decreases for both methods this may be due to the soil type and soil hydraulic conductivity.

4.0 CONCLUSION

The experiment was carried out at experimental field where the soil moisture content and bulk densities of the soil were taken before performing the infiltration experiment. The PHDA method unlike the conventional method, reduce error when taking reading and also eliminate the fatigue involved when adding water into the inner ring to maintain the head.

The result of the t-test carried out to check the level of significance between the infiltration rate measurement using PHDA and CM, the tp-calculated was found to be 1.903, when compared with t-value from the table at *5%* level of significance and 11 degree of freedom the tp value is 2.201, this means that infiltration rate measurement using pressure head differential approach (PHDA) and Conventional method (CM) were insignificant which indicate that there is no differences between the two methods. However, the PHDA is found to be simple technique of measuring infiltration rate, with locally available materials can also be used for infiltration rate measurement.

REFERENCES

Bertrand, A.R and Parr J.F. (1960): Development of a Portable Sprinkler Infiltration. Trans. Seventh International Cong. Soil science Pg. 433 - 437.

Chow. V.T, David R.M and Larry, W.M. (1988): Applied Hydrology Chapter 4, Pg. 108-109

Douglas, J. F., Hasiorek, J.M and Swaffield, J.A. (1995): Fluid Mechanics Third Edition. Educational Low — Priced Books Scheme Funded by the British Government.

Gray, D.M. (1970). Handbook on Principle of Hydrology: with special Emphasis Data, Ottawa. Pg. 324- 327

Haise, H. F, Donnan, W. W, Phelan, J. T, L. F. and Shockley, D. G. (1956). The use of Cylinder Infiltrometers to determine the intake Characteristics of Irrigated Soils ARS Infiltration Government Printing Office, Washington D.C.

Hogan,C. Michael 2010. Abiotic factor. Encyclopedia of Earth. eds Emily Monosson and C. Cleveland. National Council for Science and the Environment

Horton, Robert E. (1933): The Role of Infiltration in the Hydrological Cycle Trans Amer.

Geophy Union. 14; pp.446 — 460.

Huberty, M.R and Philsbury, A.F (1941): Factor Influencing Infiltration Rates into some California soils. Trans. Ax. Geophy Union Part III pg. 686—694

Ibrahim, A.Y. (1991): Evapotranspiration Estimate on Irrigated wheat in Sarnaru B. Eng. Igbadun H.E. (1992): Estimation of Evapotranspiration Using Soil Moisture Content Data. Project Report, Submitted to the Dept. of Agric. Of Agic. Eng. A.B.U. Zaria. Nigeria.

Israelson, O.W. and Hansen V.E. (1962): Irrigation Principles and Practices 3rd Edition.

John Wiley and Sons, Inc. New York, London. Pg 147

Kowal, J. M. (1968): Some Physical Properties of Soil at Samaru, Zaria, Nigeria Storage of Water and its Uses by Crop (b) Physical Status of soils I.A.R. Samaru Research. Bulletin No.11

Kowal, J. M. and Knabe, D.T. (1972): An Agroclimatological Atlas of the Northern States of Nigeria, with Explanatory Notes, Zaria, Ahmadu Bello Univ. Press pp. 111, 16 Maps.

Lowery B, Hickey W.J,. Arshad. M.A ,and R. Lal. (1996): Soil water parameters and soil quality. In: Doran J.W., A.J. Jones, editors.

Albert, J.C. (1981): evaluation of Infiltration Measurement of Border Irrigation Agriculture Water Measurement Journal Vol. 33, No.4,88, PP. 25 1-268.

Rigging, G.M (1963): The Classification of some Nigeria Soils, Soil Science. 1163: pg 437-443.

Hills, R.C (1970): The Determination of the Infiltration Capacity of Field Soils Using the Cylindrical Infiltrometer; British Geomorphological. Research Group, Technical Bulletin No. 5.

Starr J. L. (1990): Spatial and Temporal Variation of Ponded Infiltration Soil Sd. Soc. Amer. J. 54: 629 - 636.

Walker, W.R.; Skogerboe, G.V. (1987). Surface irrigation: Theory and practice. Prentice-Hall, Englewood Cliffs.

Wiley & Sons, mc, (2005): Water Resources Engineering, 2005 new Edition, Kostiakov, A.N. "On the dynamics of the coefficient of water-percolation in soils and on the necessity of studying it from a dynamic point of view for purposes of amelioration". Transactions of 6th Congress of International Soil Science Society. Moscow. pp. 17-21

Williams, W. A., L. D. (1960): Field Infiltration Studies with Green Manure and Crops Resideues on Irrigated Soils. Soil Science. Socs. Amer. Proc.24:58-61.

Table 4.1 Soil Physical Properties

Soil depth(mm)	Bulk density (g/cm^3)		MC by weight		Textural class
	Plot A	Plot B	Plot A	Plot B	
0 -150	1.794	1.796	1.246	1.302	Sandy loam
150 - 300	1.832	1.918	2.334	1.838	Sandy loam

Experimental Plot A

Table 4.2a: Infiltration Rate (mm/hr)

Cumulative time (min)	Mean Value of Infiltration rate using PHAD (mm/hr)	Mean Value of Infiltration rate using CM (mm/hr)
1	204	600
2	84	234
3	56	144
8	51	118.5
13	51.46	72.92
23	30.78	44.35
33	20.36	25.09
48	14.5	20
63	16.76	17.52
93	11.61	14.58
123	9.17	9.76
183	8.98	13.90

Table 4.2b: Infiltration Rate (mm/hr)
Experimental Plot B

FÞÖ ÞÕMRÒÑ PÒÖ ÑÄÖ ÒÖÅ	Mean Value of Infiltration rate using PHAD (mm/hr)	Mean Value of Infiltration rate using CM (mm/hr)
1	516	732
2	90	252
3	60	160
8	54	151.4
13	40.62	97.06
23	32.35	82.96
33	20.73	56.38
48	14.81	40.75
63	11.47	29.91
93	11.24	23.10
123	13.50	19.52
183	11.21	17.51

Table 4.3; Pool Value Of Cumulative Depth And Infiltration Rate Using PHDA and CM.

Cumulative time (min)	PHDA plot A		CM plot A		PHDA plot B		CM plot B	
	Cum. Depth (mm)	Infiltration rate (mm/hr)	Cum. Depth (mm)	Infiltration rate (mm/hr)	Cum. Depth (mm)	Infiltration rate (mm/hr)	Cum. Depth (mm)	Infiltration rate (mm/hr)
1	3.4	204.000	10.0	600.000	3.2	192.000	12.20	732.000
2	6.2	84.000	17.8	234.000	6.2	90.000	20.60	252.000
3	9.0	56.000	25.0	144.000	9.2	60.000	28.60	160.000
8	15.8	51.000	40.8	118.500	16.4	54.000	48.80	151.500
13	25.0	42.462	56.6	72.923	25.2	40.615	71.00	102.462
23	36.8	30.783	73.6	44.348	37.6	32.348	102.80	82.957
33	48.0	20.364	87.4	25.091	49.0	20.727	134.80	58.182
48	59.6	14.500	103.4	20.000	60.4	14.250	167.40	40.750
63	77.2	16.762	121.8	17.524	73.6	12.571	198.80	29.905
93	95.2	11.613	144.4	14.581	92.2	12.000	234.60	23.097
123	114.0	9.171	164.4	9.756	116.6	11.902	274.60	19.512
183	141.4	8.984	206.8	13.902	150.8	11.213	328.00	17.508

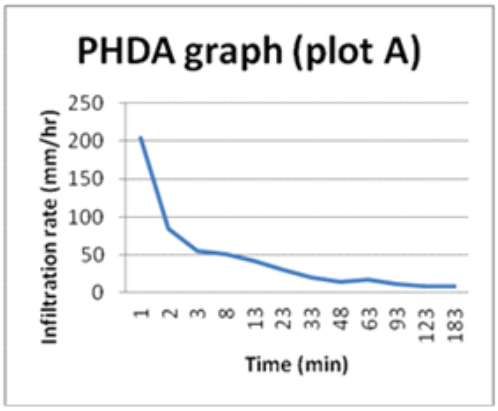


Fig.4.1a

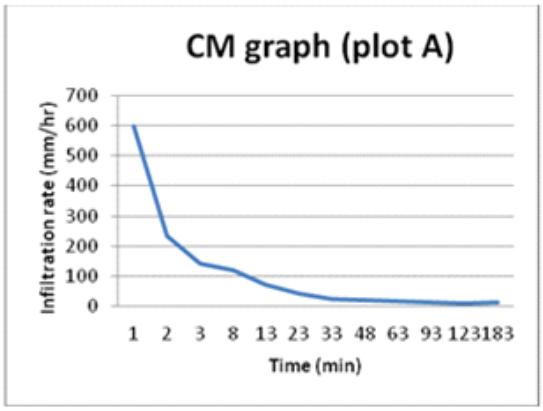


Fig. 4.1b

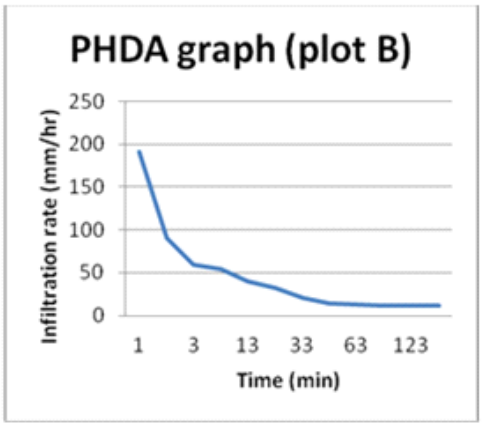


Fig. 4.2a

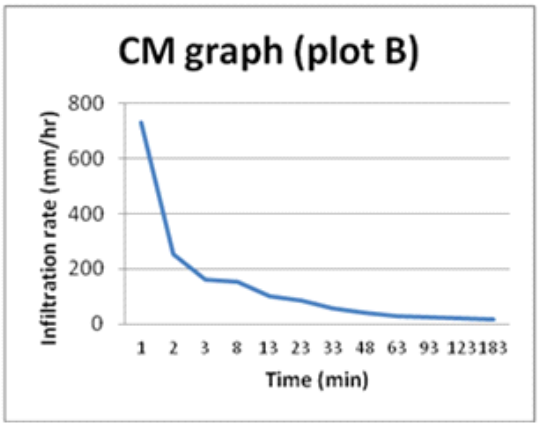


Fig.4.2b

IRRIGATION PRACTICES IN TARABA STATE: PROBLEMS AND PROSPECTS

[1]Istifanus, A. B., [2]Nsukka and Chukwuma, G.O.
[1]Department of Agricultural and Bioresources Engineering University of Nigeria, bardey2013@gmail.com
[2]Department of Agricultural and Bioresources Engineering
Nnamdi Azikwe University, Awka

ABSTRACT
Irrigated agriculture has remained an integral part of Nigeria agricultural development strategies with the whole aim of ensuring adequate and sustainable economic prospect and crop production. The study examines the level of dry season farming operations obtainable in the study area while accounting for the participatory roles of all the players concerned. Field surveys were employed through direct contacts with farmers who were preferably traced to their sites. There is a massive involvement particularly of small-scale irrigation farmers who are constrained by several factors including the availability of water, location, distribution and variation in its occurrence, competing demands and socio-economic limitations. In spite of all these, the farmers are not giving up, rather, they were found to be exhibiting 99.23% satisfaction and overall interest in the venture. A careful adherence to the recommendations provided here will spur Taraba farmers into a great and ambitious future agriculturally. It is therefore left for the government and non-governmental organizations, philanthropic organizations and well-to-do individuals to rise to the occasion.

Keywords: Irrigation Practices, Problems, Prospects.

1.0 INTRODUCTION
The option of irrigated agricultural production to many communities in Nigeria especially the Northern axis of the country is inevitable. This fact is based on the evidence of the amount of rainfall experienced and of course large data of these rainfall values. In most cases therefore, rainfall is inadequate to meet the requirements of the crop, and it is also not readily available at the time it is desired, making irrigation necessary.

Irrigation practice in Taraba State is necessitated by some geographic and hydrological patterns such as erratic rainfall and at times colossal floods with the tendency of causing serious crop failure. The hazardous consequences of 'crop failure' makes it duty bound to embark on irrigation activities to supplement food production.
In line with this considerations the level of participation in dry reason farming vis-à-vis at farmer- government levels the journey no far is put under study.

According to Michael 1978, the origin, distribution and utilization of water resources of any country are profoundly affected by its physical features. He further revealed that the positioning of India across some lines of latitudes and longitude with an area of land of 328 million hectares and other diversity of land-forms of India is matched by the diversity of climate, its people and cultures. Taraba State lies roughly between latitude 6°30" and 9° and 36" north and longitude 9° 10"and11°50" east. It is bounded on the north by Bauchi State and Gombe State in the north-east and Adamawa State on the east by Plateau State in the north-west. The State is further bounded to the west by both

Nasarawa and Benue State while it shares an international boundary with the Republic of Cameroun to the south and south-east.

The dry and rainy seasons common to tropical regions are also the dominant climatic features found in Taraba state. Rainy season starts in April and ends in October, while the dry season begins in November and terminates in March. The dry season reaches its peak in January and February when the dusty north east trade winds blow across the state. The climate, soil and hydrology of the state provide a conducive atmosphere for the cultivation of most staple food crops, grazing land for animals and fresh water for fishing and forestry.

As a result of its agrarian nature, the predominant population of the state engages in farming as an occupation. About three quarter (i.e. 75%) of the people are farmers while an estimated one quarter (25%) are engaged in other economic activities.

1.1 Objective of the Study

- To study understudy the practice of irrigation in Taraba state with respect to the level of involvement of both farmers and government
- To discover the problems of irrigation farmers and recommend appropriate measures with a view to promoting irrigational activities
- To highlight the prospects of irrigation farming in the state

2.0 RESEARCH METHODOLOGY

Intensive dry season farming actively kicks off immediately at the elapse of the rainy season across Taraba State by various farmers who are strategically located along river banks, *fadama* areas, ponds and streams.

A survey work was employed as a means of obtaining data using a structured questionnaire that served as a guide for oral interview. Ten (10) copies of the questionnaires were served per local government to farmers randomly selected through direct contact while working at their fields. This figure simply represents a sample of the population and not the entire population. Furthermore the work was restricted to those farmers who cultivated at least 750mm^2 of landed area: smaller farmers constituted the entire population. A total number of one hundred and thirty (130) questionnaires were therefore distributed and retrieved in thirteen out of a total of sixteen local government areas of Taraba state representing a coverage of 81.25 percent. The predominantly uneducated respondents/irrigation farmers made their responses mostly in vernacular(Hausa language) with much interest while the researcher documented the translated version appropriately.

The data used in this study therefore were obtained from farmers who relied on their memory for answering questions relating to their general practices such as investment, inputs water sources, problems government involvement and so on.

3.0 RESULTS AND DISCUSSION

3.1 Results

The results are generally highlighted in tables 1and 2, as well as figures 1 and 2 respectively and consequently discussed alongside.

These sections therefore generally contain the opinions of respondents on various aspects of pictorially their practices of dry season farming.

Table 1: Sources of Irrigation Water Used

LGA	Well	Dam	River	Pond	Others	Total (10)
Ardokola	8	2	-	-	-	10
Donga	8	2	-	-	-	10
Gassol	3	-	7	-	-	10
Ibi	8	-	-	2	-	10
Jalingo	10	-	-	-	-	10
K/Lamido	2	1	5	2	-	10
Lau	7	1	2	-	-	10
Sardauna	-	2	3	5	-	10
Takum	2	1	7	-	-	10
Ussa	4	-	6	-	-	10
Wukari	2	-	8	-	-	10
Yorro	10	-	-	-	-	10
Zing	7	-	3	-	-	10
	71	9	41	9	-	130
%	54. 62	6.92	31.54	6.92		
ì ÑMŌÆ $\bar{x}$	5.46	0.69	3.15	0.69		
Std Dev., ??	3.41	0.85	3.11	0.85		

Table1 above shows the responses and details of the sources of irrigation water used by farmers in the state. Here the breakdown shows that 54.62% used open or tube wells, 31.54 lift water from rivers and a bracket of 6.92% depend on either dam or pond for their sources of irrigation. Taking the case of Ardo –Kola for instance, 8 farmers out of the 10 served with questionnaires, used wells as sources; the same applies to the rest of Local Government Areas.

Also comparing the farmers inclination to source of irrigation water commonly adopted, we found out from the values of standard deviation where more utilized wells with the highest deviation of 3.41 followed by the use of rivers as sources of irrigation water representing the standard deviation of 3.11. The remaining part of the population used a correlated deviation of 0.85 for both dams and ponds as sources of irrigation water.

In most of these cases the reality on ground discovered is that the farmers use only what is available at their domain. Looking at the figure for Lau, Donga, K/Lamido and Ibi local governments we could see that they utilize water from the river more because they have the privilege of having the perennial river Benue right at their domain: although they use pumps to lift water just like those using boreholes (wells), they all the same do not spend to dig wells but rather insert the suction end of their pump (tube) into the deep body of abundantly available water.

Conversely places like Ardo-Kola, Jalingo, Yorro, Wukari, Takum and Zing areas show higher levels from the bar chart of well patronage because they have no big rivers but seasonal streams that leave behind *fadama* banks with relatively high water tables which are easily explored into boreholes for irrigation work.

Also evident in Tabie1 is a diminished status of Dam and pond features. It reveals the total absence of rivers and high water table sources. Large/small ponds are relied on as well as simple earth dams for mostly low scale irrigation farming.

In the course of the survey it was discovered that greater/larger farms are only

found with people in the river and well category; hence correspondingly higher production. This fact suggests that insufficient water sources stand as bottle necks to irrigation farming.

Table 2 Methods of Water Conveyance

LGA	Water pump	Gravity flow	Scooping and throwing	Total
Ardokola	10	-	0	10
Donga	9	0	1	10
Gassol	8	-	2	10
Ibi	9	-	1	10
Jalingo	9	-	1	10
K/Lamido	8	2	-	10
Lau	10	-	0	10
Sardauna	6	-	4	10
Takum	10	-	0	10
Ussa	0	-	10	10
Wukari	10	-	0	10
Yorro	7	-	3	10
Zing	4	2	4	10
?	98	6	26	130
%	75.40	4.62	20	
ì ÑMŌÆ $\bar{x}$	7.69	6.20	2.00	
Std Dev, ÄÄ	2.93	0.96	2.83	

Table 2 above gives a picture of the various methods employed by different people who practice irrigation farming across Taraba State. Based on this analysis 75% are engaged water pump generating sets, 20% use the shadoof, and only 4.6% adopt gravity flow which is the water that gets to an irrigated area from a spring.

The reason for the choice of water pumps across the state is accounted on the fact that this method is more reliable and economical; reliable because it commands the quantity of water required within a reasonable time frame unlike the other methods; and, economical because larger fields can be irrigated at the right time with the right quantity of water without muscular stress or fatigue.

Gravity flow occurs in a similar way irrigation was said to have started in the Nile valley of Egypt. Crops are planted immediately after the departure of rains on the flood plain: there are found in very few areas in Taraba state along major rivers like Rivers Benue (in the case of Karim lamido), Donga and some seasonal streams in Zing local government area as potrayed in table 2.

Based on the classifications of Arora (2007) the direct irrigation system is used for the perennial rivers to have adequate flow throughout the year. Water is directly diverted to the canal or border without creating a storage reservoir.

Those twenty percent (20%) who adopted the scooping and throwing method generally have small farm holdings of a quarter hectare or less in most cases. They use buckets, pans, watering can to pick and throw water either through constructed channels or generally on the entire flat beds. They are mostly constrained by economic factors and if given the resources will doubtless expand their businesses.

3.2 Crops Grown

The study found out that farmers across the state cultivated crops like maize, rice, wheat, tomatoes, onions, pepper, and vegetables (carrot, lettuce, cabbage, melon, okra, spinach etc) at varying degree under irrigation. Few variations however exists in some cases, for instance, farmers in Lau, Ibi and K/Lamido Local Governments particularly those along the river Benue distinguishingly cultivate more of cereal crops like wheat, rice and corn and smaller quantities of vegetables and spices. Virtually all farmers are involved in the production of vegetables.

With these crops the markets across the state and the neighbouring states are supplied with assorted vegetables.

3.3 Irrigation Extents

In most cases irrigation has been discovered to commence by many farmers from the month of October, the beginning of the dry season and end in May/June the following year when the rains usually resume. Depending on the life cycle of a crop some slight variations have been found to exist, for example, vegetable crops like amarantus, sorel, spinach can mature within 6-8weeks so they are planted anytime and many times within the dry season repeatedly. This view agrees with that of Benjamin and Maigida (1998).

From figure 1,below the characterization of land particularly in Taraba state could simply be identified broadly into two, viz "*Fadama*" and upland. *Fadama* land are those lands located along streams or river which are flooded in the wet season which also are otherwise water-surfaces of ponds and swamps left behind as flood water retreat from the floodplains of the large rivers. This agree with the definition given by Macaver and Kutus (1998) who also stated that the word *fadama* is a derivative of Hausa language referring to the land that is flooded in the wet season; and Musa (2001) who describe fadama as river valley areas that are seasonally flooded or have medium to high water tables for all or larger part of the year.

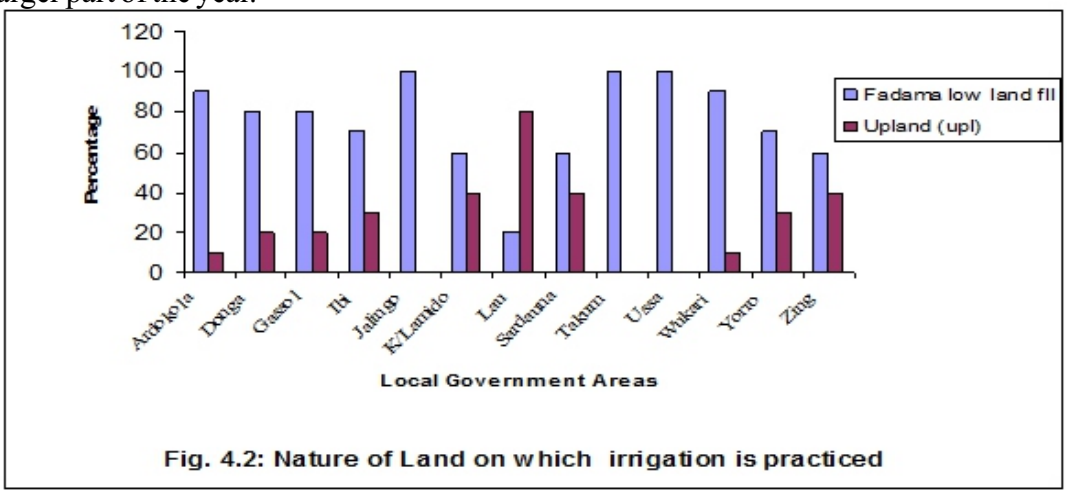
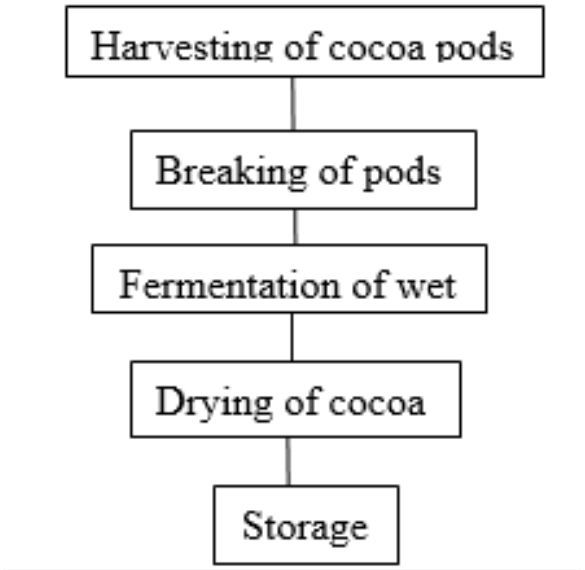


Figure 1: Nature of Land on Which Irrigation is Practiced

Also considering figure 2, it implies that most of those who practice irrigation farming concentrate their work on *fadama* land; infact 66% of the farmers are involved and this is attributable to the fact that water used for irrigation here is much more available. The loamy soil always associated with *fadama* known for its high and rich manure content form flood too counts on the index for this concentration. This is in consonant with Arora (2009) who established that the floods contain silt with large amounts of nutrients required by the plant; it is quite useful especially for a virgin soil of the agricultural land. Such soils usually have low contents of plant nutrients and a very

low water holding capacity. When silt water is applied to such soils, gradual accumulation of silt occurs and the fertility is improved. The bar charts also show that all the local governments except Lau engage in *fadama* irrigated farming to the tune of between 60% -100%.

The uniqueness of Lau local government in terms of irrigated land is not farfetched. In fact, most of the land along the River Benue running across Lau local government is clayey in nature and an upland in pattern particularly Lau town and its environs where most of the survey work was conducted the water table in an upland area is generally far below and is not easily accessed by water pumping sets bored into the ground. The situation that exists here is that of direct insertion of the suction end of the horse (pump) into the River Benue which pumps out water for several hours without any sign of exhaustion on the water. This also goes on for the entire period of irrigation from year to year.



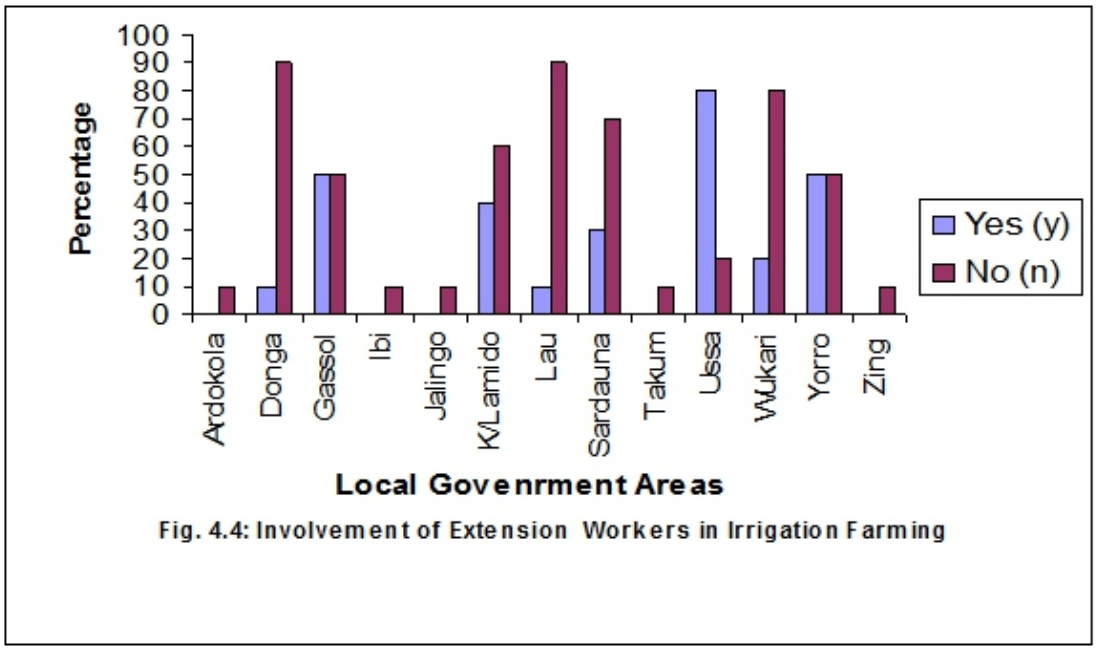


Figure 2: Involvement of Extension Workers in Irrigation Farming

Table 3 however reveals that only an average of 22% of those involved in irrigation farming have the privilege of enjoying the services of agric extension workers. A higher percentage of almost 78% do not have the encouragement of these important personnel. Perhaps the impact as regards participation, acquiring and utilization of inputs as well as geometrical difference in production would have been the results; supposing only, the reverse were the case between the affirmative percentages of the "yes" and "no" in the figure.

Besides the encouragements through extension work for farmers to venture into dry season farming for the economic benefits therein other critical aspects also exists. Diseases and pest prevention and control is one. Many farmers in those areas like Ardo-Kola, Ibi, Jalingo, Lau etc that have total absence of extension workers also prominently have cases of disease infestation which they grapple with on yearly basis without been able to eradicate

No doubt, the predicaments of the farmers may be traced to their backgrounds which reveal that the entire business of irrigation farming has been left into the hands of unskilled and generally uneducated settlers who migrate seasonally to some parts of the country to earn their living through this neglected veritable and noble industry.

3.4 Problems of Dry Season Faming in Taraba State

The scenario here is that of the fact that traditional farmers have been left to dominate the agricultural activities of the local populations which to some extent have been seen to be of negligible significance to the national economy. The problems highlighted below were synthesized from the responses of the one hundred of thirty respondents interviewed

- Lack of initial capital to set up and start up irrigation farming projects e.g. purchase of pumps and accessories
- High costs of inputs like improved seeds, fertilizers, chemicals (insecticides and herbicides).
- Insecure land tenure which has discouraged peasant investments of labour and capital in irrigated agriculture.
- Scarcity of farm inputs and tractors to plough fields during the dry season
- Lack of technical know how to assist in the design and maintenance of irrigation systems and broken down and low efficiency pumps/ systems
- Prevalence of diseases and insect pest as well as animal pests that stigmatized hard earned farm lands by peasant farmers from time to time.
- Inadequate, reliable and dependable sources of irrigation water often forestalls irrigation activities of farmers whereby extincting their high expectations
- Too little encouragement from government and non-governmental bodies due to non-provision of loan facilities and other necessary grants.
- Little or non-participation of enlightened farmers who in few occasions concentrate only on rain fed agriculture.
- High lease rate on farm lands fixed by land lords and constant relocation of farmers uncontrolled floods and/or on the other hand uncontrolled loses. Often times farmer fall victims of floods towards the tail end of the dry season when the next rainy reason breaks in so suddenly. Instance also abound where irrigation water is helplessly lost without immediate remedy.
- High poverty rate amongst farmers
- Inadequate/absence of extension services for guidance and proffering solutions to difficult situations like disease conditions is one major setback suffered by dry season farmers in Taraba State
- On the overall, lack of storage and transport facilities has worsened the

situation. This views adequately concurs with the findings of Yahaya (2002)

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Recommendations

Over 95 percent of dry season farmers of Taraba State incidentally share the same opinions on their expectations from the government. The following is an abridged summary of their call.

- Government should identify and provide inputs such as fertilizer, herbicides and insecticide at government rates and at the right time directly to dry reasons farmers groups through the state farmers association.
- Train more extension workers who in turn should be sent out to all parts of the state to create awareness and encourage irrigation farming at all levels
- Organize workshops on dry season farming at the grass root.
- Government should install irrigation pumps by way of loaning in kind payable at least within five years.
- Provide improved varieties resistant crops suitable to dry reason conditions for increased yield.
- Government should come out with agricultural policies focusing on the exploitation and development of *Fadama* land through irrigation practice.
- Government should support individual farmers with loans, grants etc.

4.2 Appeals to the Public

The public is advised to embark on this exercise of dry season farming to eradicate poverty; Those with enough land should assist tenants by giving them at affordable rates; People should shun idleness and engage themselves in the productive venture of irrigation farming.

4.3 Prospects of Future Dry Season Farming in Taraba State

Agricultural production generally whether rain fed or dry season farming, it is all in the hands of small scale farmers, those who were interviewed during this survey. With irrigation farming supplementing rain fed agriculture, these farmers can make Taraba State self-sufficient in food crop.

It is empirical to note that despite the impediments to irrigation farming particularly as contained in this document, there is a good prospect, there is certainly a bright future here. The current practice where 95.38% are constantly, engaged in irrigation farming; 99.23 percentage of traditional farmers are comfortable, satisfied and happy with their profession, so much is therefore ambitious in terms of sustainable and appreciable supply of crop production and increased food security.

Policy formulators on agriculture should beam their search lights with a view of diversifying the output of irrigated agriculture. According to IPTRID (1983; Ingawa, 1998). It is widely recognized that improvements of irrigation performance critically depends on the following.

Suitable micro-economic and political environment

i. Development and utilization of suitable irrigation technologies.
Improvement in irrigation management and
Recognition that irrigation is a service and with customers and providers requiring accountability for performance.

All these ideas point towards their applicability to the problems already highlighted ranging from lack of inputs, inadequate extension services, lack of skilled personnel as well as management/maintenance culture, market incentives, to mention but a few. Professionals in the field of agriculture should feel encouraged to invest in irrigation farming and down load their wealth of knowledge into this venture just in the same magnitude with which they participate in the regular seasonal agricultural exercise. The involvement of few of this category of people is indeed changing the horizon with a promises of greater crop quality and quantity just in the nearest future.

4.4 CONCLUSION

Irrigation practice is usually aimed at the natural supply of water to the land using any suitably available method to enhance crop production. This study took cognizance of the approach devoted to irrigation farming in the study area, taking particular note of the methods used, common design management of resources and also looking at the factors affecting the pace of dry season farming in the area. These all reveal a position.

Precisely speaking, the situation is that of a high potential which holds a promise of being readily transformed in the near future. Taking note of the fact that there is the abundant natural land and water resources which if actually harnessed will lead to the maximization of food production within and beyond the borders of the "agrararian entity" called Taraba State

REFERENCES

Arora, K.R. 2009. Irrigation Water Power and Water Resource Engineering; Standard Publishers Distributors, 1705-B, NAI SARAK DELHI-110006 8th Edition, Pp1-11; 1033-1049.

Benjamin, A. and D.N. Maigida. 1998. Cost and Benefits of Group Vegetable Production under Irrigation in Nigeria Proceeding of the 12th National Irrigation and Drainage Pp202-204.

Ingawa, S.O. 1998. National *Fadama* Development Project: Achievements and Prospects. Irrigation in Sustainable Agriculture. 188-191.

IPRTID, 1983. Small holders Irrigation in West Africa; opportunities and constraints, priorities for Research. July, 1983.

Macaver, O.J. and A.B. Kutus, 1998. Cost and Return, of Irrigated and Non-Irrigated Vegetable Farms in Four Selected Areas of Gombe State. Proceedings of the 12th National Irrigation and Drainage Seminar on Irrigation in Sustainable Agriculture. Pp217-221.

Michael, A.M.1978. Irrigation Theory and Practice. Vikas Publishing House PVT Ltd New Delhi, Bomboav Bangalore Calcuta Kanpur 2nd Edition.

Musa, I.K. 2001. Challenges and Opportunities for Sustainable Irrigation

Development in Nigeria. Proceeding of the International Conference and Annual General Meeting of the Nigerian Institution of Agricultural Engineers Vol.23, Pp13 -20.

Taraba State Government Diary 2010 Edition.

Yahaya, M.K. 2002 Development and Challenges of Bakolori Irrigation Project in Sokoto State Nigeria. Nordic *Journal of African Studies 11 (3)* 411-430.

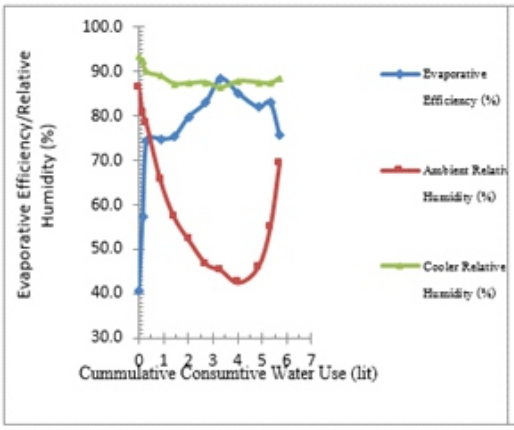


Figure 4: Relationship between consumptive water use, evaporative efficiency, ambient relative humidity and cooler relative humidity during vegetable storage.

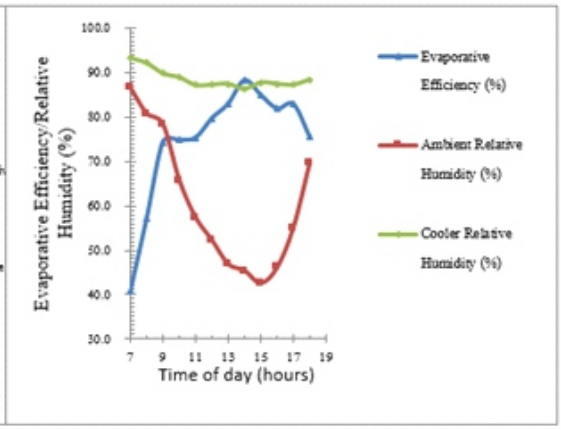


Figure 5: The relationship between evaporative efficiency, cooler relative humidity and ambient relative humidity with time of day.

EFFECTS OF SALINE WATER ON PHYSICO-CHEMICAL PROPERTIES OF SOIL, GROWTH AND YIELD OF PEPPER (*Capsium Spp*) VARIETIES

A. Ibrahim[1*] I. A. Udo[2] and S. Ibrahim[3]
[1]Agricultural Engineering Unit
Department of Soil Science, University of Calabar, Cross River State
e-mail: aijada@yahoo.co.uk
*corresponding author: Tel:08037654611
[2]Department of Crop Science
University of Calabar, Cross River State
[3]Department of Agricultural Engineering Technology
Adamawa State College of Agriculture, Ganye
Adamawa State.

ABSTRACT
The effects of using saline water as irrigation water source on the physico-chemical properties of soil and yield of Nigerian pepper varieties were evaluated in a green house at the University of Calabar. Eight pepper varieties were planted and irrigated with saline water at three different levels (0.08, 2.0 and 4.0dS/m). Soil samples were collected before and after the experiment for laboratory analysis. Data on plant growth parameters and yield attributes were also collected. The results showed that the texture of the soils were sand and loamy sand. The results (means) for pH, electrical conductivity, organic carbon, total nitrogen, available phosphorus and base saturation ranged from 5.2 - 6.6(5.8), 0.12-1.50 (0.9dS/m), 1.77-2.15 (2.0%), 0.15-0.19(0.2%) 23.62-111.37 (59.37mg/kg) and 93.5-96.0 (94.36%), respectively. While calcium, magnesium, potassium, sodium, effective cation exchange capacity and exchangeable acidity, respectively were 13.6-17.4(15.96), 0.4-3.8 (1.5), 0.09-0.13 (0.112), 0.07-0.11 (0.09), 17.64-20.06 (18.76) and 0.84-1.28(1.08), all in cmol/kg. The growth and yield attributes of the plants indicate that increase in salinity level reduced shoot length, root dry weight, number of fruits and weight of fresh fruits per plant. However, increase in salinity level from 0.08dS/m to 2.0dS/m tended to have had no significant effect on the growth and yield of pepper. At 4.0dS/m, the growth and yield of most of the pepper varieties were significantly ($P \leq 0.05$) reduced compared with the control. *Atanukwu* appeared to have tolerated this high level of salinity as there was no significant fresh fruit reduction relative to the control.

Keywords: Saline water, Irrigation, Soil proprieties, Pepper, Tolerance.

1.0 INTRODUCTION.

The presence of soluble salts in water or soil is known as salinity. Depending on the concentration of these salts in water or soil, it may have an adverse effects on soils and plants (Tanji, 1990). Some of the effects on physico-chemical properties of soils include imbalance in soil water relation, reduction in pH, nutrient elements and increase in the concentration of sodium ion (Michael, 1992; Khan, 1998; Folorunso *et al*., 2004).
Pepper is sensitive to salinity (Rhoades et al., 1992). Salts may cause severe reduction in plant growth, yield and imbalance in mineral composition (Savvu *et al*., 2005). Under green house condition, pepper particularly when irrigated with saline water, may accumulate salt in the soil and cause severe hazard especially under water deficit and

over fertilization (Gunres *et al*., 1996). This may lead to over absorption of some specific ions by plants and imbalance of mineral elements with subsequent membrane destabilization (Hasegawa *et al*., 2000), photosynthesis inhibition (Munns and Termatt, 1986) and general nutrient imbalance (Munns, 1993; Adiku *et al*., 2001).
Salinity, regardless of its source has remained a major problem for sometime now and substantially limits crop productivity especially vegetables like pepper. Researches on varietal screening of pepper irrigated with saline water in Nigeria are very scanty. Therefore, this work was conceived with the aim of screening some indigenous pepper varieties in Nigeria for their salinity tolerance. The objectives were to evaluate the effects of using saline water as irrigation water source on the physico-chemical properties of soils, growth and yield of Nigerian pepper varieties under green house condition.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was carried out at the green house of the University of Calabar. Calabar lies within latitudes 4°5' and 5°2'N and longitudes 8°0' and 8°3'E with an altitude of 39 m above sea level. The climate is influenced and marked by wet and dry seasons. Wet season starts from March to October with the dry season following from November to late February. Calabar soils are mainly coastal plain sand belonging to tertiary and alluvial deposit and classified as typical palendult in the Ultisols order using the USDA taxonomy (Enwerzor et al., 1981).

2.2 Experimental Materials, Treatments and Layout

The experimental materials used were eight (8) pepper varieties namely: *Atangtang, Attarugu, Atanukwu Dangarawa, Sombe, Oshosho, Nsukka Yellow and Ntokon-okpo*. Top soil (0-15cm) collected from the University of Calabar Botanical Garden, eight (8) plastic baskets for raising of seedlings in the nursery, 72 perforated plastic buckets as planting medium, industrial salts (NaCl and $CaCl_2$) obtained from a chemical shop, poultry manure, water and other miscellaneous. Three kilogram (3kg) of the soil was weighed and emptied into each perforated plastic buckets.
The treatments consisted of the combination of eight (8) pepper varieties and three (3) levels of saline water used as irrigation water sources. The three levels of salinity were 0.08 dS/m (tap water which served as control), 2dS/m and 4dS/m, respectively. The 2dS/m concentration was obtained by dissolving 10.4lg of each of NaCl and $CaCl_2$ in 18 litres of tap water. For the 4dS/m salinity level, 20.82g each of NaCl and $CaCl_2$ were dissolved in 18 litres of tap water. The salinity level of each salt water and the tap water (control) was ascertained with the aid of an electrical conductivity meter measured at 25°C in the laboratory.

The experiment was laid out as 8x3 factorial in a completely randomized design (CRD) fashion. This gave 24 treatment combinations each replicated 3 times to obtained 72 experimental units. The 72 buckets were then labeled appropriately to represent each treatment combination.

2.3 Raising of Nursery, Transplanting and Management

The top soil collected from the botanical garden was mixed with sharp sand and poultry manure in the ratio of 3:2:1 by volume. The soil mixture was filled into the 8 medium plastic baskets where each of the respective pepper variety seeds were planted and managed up to seedling stage. After 4 weeks, the seedlings were respectively transplanted into the 72 perforated buckets. Irrigation commenced immediately with the

three levels of the saline water. The first one month after transplanting, each pot was watered with 150ml of the respective irrigation water in alternate days. Then, the volume of water use increased to 250ml from the second month but was reduced to 200ml at the unset of fruiting and maintained till harvesting.

2.4 Data Collection

At maturity and before harvest, plant heights were measured. Ripe fruits were picked on a daily basis. Data on the total number and weight of fresh fruits per plant were obtained by summation over the entire period of harvest. After harvest, plants were carefully uprooted and the roots were thoroughly washed. The roots were separated from the shoots and put into a labelled envelope for oven drying at 80^{o}C for 48 hours. Then, the dry weights of roots and shoots were obtained by using electric weighting balance.

2.5 Soil Sampling and Analysis

Before planting, two soil samples were collected. The initial composite sample collected at 0-15cm from the botanical garden using soil auger, and the soil sample mixed with poultry manure before planting. After harvest, soil samples were taken by sampling from each of the buckets irrigated with the three levels of saline water. The samples from each level were thoroughly mixed together and three (3) composite samples were obtained. The soils were taken to the soil science laboratory for analysis.

The soil samples were air-dried in the laboratory, ground and sieved with 2mm sieve. Particle size analysis was determined by Bouyoucos hydrometer method (Day, 1965) and the texture determined on the USDA textural triangle. pH was determined in a 1:2.5 soil: Water suspension using glass electrode pH meter. Electrical conductivity was measured in a 1:5 soil: Water extract at 25^{o}C on a conductivity meter. Organic carbon was by dichromate oxidation method of Walkley and Black (Jackon, 1969). Total N was by macro-kjeldahl method (Jackson, 1969). Available P was extracted by Bray No. 1 solution (Bray and Kurtz, 1945) and estimated by molybdenum blue colour technique (Murphey and Riley, 1962). Exchangeable bases (K^{+}, Na^{+}, Ca^{2+}, Mg^{2+}) were extracted with the neutral normal NH_4, OAC. In the extract, the former two were obtained by flame photometry while the later two by EDTA titration using IN KCl and IN NaOH (McClean, 1982). ECEC was obtained by the summation of the exchangeable bases and acidity. Base saturation was by taking the summation of exchangeable bases as a percentage of ECEC.

2.6 Statistical Analysis

Data on plant parameters were subjected to statistical analysis using the analysis of variance (ANOVA). Detection of difference among means for significance was done by using Fisher's least significant difference (F-LSD) at 5% probability level (Wahua, 2010). Data on soil parameters were also subjected to statistical analysis using descriptive statistics such as range, mean, standard deviation and coefficient of variability.

3.0 RESULTS AND DISCUSSION

3.1 Physico-Chemical Properties of the Soils

The physico-chemical properties of the soils are presented in Table 1. The soil texture varied from sand to loamy sand, with ranges (means)for sand, silt and clay separates as 85.3-94.3 (87.9), 4.7-11.7(10.1) and 1.0-3.0(2.0) percent, respectively. The results revealed that there was no much effect of salinity on the particle size distribution, probably due to the short period of irrigation with the saline water (Dubey and Mondal,

1994). pH values ranged from 5.2 to 6.6 with a mean of 5.6, implying that the soils varied from strongly acidic to slightly acidic (Landon, 1991). The pH value of the initial soil increased from 6.2 to 6.6 when poultry manure was added and later decreased with increased levels of saline water. This indicates that increased in a salinity level decreases soil pH (Michael, 1992). Electrical conductivity values ranged from 0.12 to 1.5 dS/m with a mean of 0.9dS/m. It is obvious that the EC values increased as the saline water levels increases from 0.08 to 4 dS/m.

The ranges (means) for organic carbon, total N and available P, respectively were 1.77-2.7% (2.0%), 0.15-0.18%(0.2%) and 23.62-111.37 mg/kg (59.37mg/kg). The values for these nutrient elements increased when poultry manure was added to the soils and later decreased when the soils were irrigated with 0.08dS/m saline water. This decreased might be attributed to up-take by plants. It was also observed that the values consistently increased at 2 and 4 dS/m salinity levels, implying that the salinity had suppressed the plants from taking up these nutrient elements. This findings corroborate the work of Grewal and Maheshwari (2013).

Exchangeable calcium, magnesium, potassium and sodium ranged from 13.6-17.4, 0.4-3.8, 0.09-0.13 and 0.07-0.11 cmol/kg, with a mean of 15.96, 1.8, 0.11 and 0.09 cmol/kg, respectively. It was observed that the values for calcium and sodium were high and obviously increased with an increased in the saline water levels. Magnesium and potassium were respectively moderate and low (Landon, 1991). A similar trend was also noticed in the values of ECEC and base saturation where the values increased with an increased in saline water levels (from 0.08 to 4 dS/m).

3.2 Effects of salinity on Growth and Yield of Pepper

The growth of pepper plant was significantly ($P \leq 0.05$) impaired with increase in the salinity level (Table 2). Varietal differences in height existed among the pepper. *Ntokon-Okpo* was the tallest while *Attarugu* and *Atanukwu* were the shortest. Interaction between the two factors was significant ($P \leq 0.05$). Growth inhibition was not significant when the salinity level was increased to 4dS/m compared with the control in almost all the pepper varieties except *Atanukwu*.

Root and shoot dry weights significantly decreased with increase in salt concentration (Tables 3 and 4). Dry matter accumulation differed significantly ($P \leq 0.05$) amongst the varieties of pepper. *Nsukka yellow* and *Ntokon-Okpo* had the highest root and shoot dry weight, respectively. Interaction between the factors was not significant ($P > 0.05$). However, increase in salinity level from 0 to 2 dS/m led to an increase in root dry matter of *Nsukka Yellow* and *Ntokon Okpo*. There was a general decrease in root dry weight in all the pepper varieties at 4dS/m salt level relative to control (0.08dS/m). In all the varieties, there was a decrease in shoot dry matter as the salinity level was increased. The results obtained clearly illustrated the adverse effects of salts on the growth of pepper plant. Physiologically, there could have been impaired nutrient absorption due to reduced osmotic potential in the soil solution (Hasegawa et al., 2000; Adiku et al., 2001; Mitter, 2002). Also, the problem of specific ion toxicity like Na^+ or Cl^- could have accounted for reduced growth and dry matter accumulation in the pepper plants exposed to higher level of salinity (Munns, 1993; Grewal and Maheshwari, 2013).

The number of fruits set and the total weight of fresh fruits per plant were significantly reduced with increase in salinity level (Tables 5 and 6). *Atangtang* and *Ntokon-Okpo* had the greatest fruit set while the highest fresh fruit weight was obtained in *Atanukwu*. Interaction of pepper variety with salinity level was significant. There was a significant inhibition in fruit setting and reduction in fruit weight as salinity level was increased in all the pepper varieties except for the *Atanukwu* and *Atangtang*. There was a significant increase in fresh fruit weight at 2dS/m in *Atanukwu* and *Atangtang*. Also, among all the pepper varieties tested, there was a significant ($P \leq 0.05$) reduction in fresh

fruit weight at 4dS/m compared with the control (0.08dS/m) excepting *Atanukwu*. This result illustrates the case of tolerance. Similar findings were reported elsewhere (Udo and Ittah, 2006; Grewal and Maheshwari, 2013). Thus, different plant species and cultivates of a species employ different mechanisms to counter the adverse effects of salt (Lauchi, 1984). Therefore, from this trial, there is evidence that variety *Atanukwu* tolerated moderate level of salt stress and could be used as a planting material in salt-prone areas. It could also be incorporated into pepper breeding programme for salinity tolerance.

4.0 CONCLUSION

The use of different levels of saline water as irrigation water source on the physico-chemical properties of the soils showed that there was no significant effect of salinity on the particle size distribution of the soils. The study also revealed that all the soil chemical properties increased with an increase in the level of saline water used except for the pH, magnesium and potassium. This increase could be attributed to the accumulation of salts in the irrigated soils that led to the suppression of the plants from taking up the necessary nutrients elements needed for its normal growth and yield. Therefore, irrigation water source use for agricultural production should be analyzed for Salinity before being applied to the soils. Increasing levels of salinity adversely affected the growth and yield of the pepper varieties. However, the pepper varieties differed in their responses to salinity. At 4.0 dS/m, the growth and yield of all the pepper varieties with the exception of *Atanukwu*, were significantly reduced. Thus, this pepper variety could be used as a planting material in areas with mild salinity problem or in pepper breeding programme for salinity tolerance.

REFERENCES

Adiku, G., Reager, M., Wessolek, G., Facklam, M. and Hech-Bischoltz, C. (2001). Simulation of dry matter production and seed yield of common beans under varying soil water and salinity conditions. Agricultural water management. 47:55-68.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorus in soils. Soil Science 59: 39-45.

Day, P. R. (1965). Particle fraction and particle size analysis. In C. A. Black (Ed.). Methods of soil analysis. Part 1. Am. Soc. Agron. 9:545-567.

Dubey, S. K. and Mondal, R. C. (1994). Effects of amendments and saline irrigation water on soil properties and yield of rice and wheat in a highly sodic soil. 56:201-207.

Enwerzor, W. O., Udo, E. J. and Sobulo, R. A. (1981). Fertility status and productivity of the acid sands: In Acid Sand of Southern Nigeria. Soil Sci. of Nigeria. Special Publication Monograph No. 1: 56-73.

Folorunso, O. A., Chiroma, A. M. and Dauda, A. (2004). Response of groundnut (Arachris hypogaza L.) to sodium chloride salinity in semi-arid Northeastern Nigeria. Environtropica 1(2):96-103.

Grewal, H. S. and Maheshwari, B. L. (2013). Treated effluent and saline water irrigation influences soil properties, yield water productivity and sodium content of Snow Peas and

Celery. J. of Plant Nutrition 36(7): 1102-1119.

Gunres, A., Inal, A. and Alpalsan, M. (1996). Effect of salinity on stomatal resistance, praline and mineral composition of pepper. J. Plant Nutr. 19:389-396.

Hasegawa, P. M., Bressan, R. A., Zhu, J. K. and Bohnert, H. J. (2000). Plant cellular and molecular response to high salinity. Ann: Rev. plant physiol. Plant Mol. Biol. 51:463-499.

Jackson, M. L. (1969). Soil chemical analysis. Advanced Course 2nd Ed. Department of Soil Science, United State Department of Agriculture (USDA). Pp 217-224.

Khan, G. S. (1998). Soil salinity and sodicity status in Pakistan. Soil Survey of Pakistan, Lahore. 59p.

Landon, J. R. (1991). Booker Tropical Soil Manual. A handbook of Soil Survey and agricultural land evaluation in the tropics and subtropics. Booker Tete Ltd. England 474p.

Lauchi, A. (1984). Salt exclusion: An adaptation of legumes for crops and pastures under saline conditions. In: Salinity Tolerance in Plants: Strategies for crop improvement. R. C. Staples and G. A. Toenmessen (eds.). New York, Wiley. Pp 171-187.

McClean, E. O. (1982). Chemical and microbiological analysis. In Page, A. L. (Ed.). Methods of Soil Analysis Part 2. Second Edition. ASA-SSA, Agronomy Monograph 9:199-224.

Michael, A. M. (1992). Irrigation theory and practice. Vikas Publication, New Delhi pp. 686-740.

Mitter, R. C. (2002). Oxidative stress, antioxidants and stress tolerance. Trends in Plant Science 7:405-410.

Munns, R. (1993). Physiological processes limiting plant growth in saline soils. Some dogmas and hypothesis. Plant cell Environ. 16:15-24.

Munns, R. and Termatt, M. L. (1986). Whole plant response to salinity. Australian J. of plant physiol. Plant Mol. Biol. 51:463-499.

Murphey, J. and Riley, J. P. (1962). A modified single solution method for the determination of phosphorus in natural waters. Annal. Chem. Acta. 27:31-36.

Rhoades, J. D., Kandiah, A. and Marshall, A. M. (1992). The use of saline waters for crop production. FAO Irrigation and Drainage paper No. 48. FAO, Rome, Italy.

Savvu, D., Pappa, V. A., Gizas, G. and Kotsiras, A. (2005). Sodium chloride accumulation in a cucumba crop grown in a completely closed hydroponic system as influenced by $NaCl_2$ concentration in irrigation water. Europ. J. Hort. Sci. 70: 217-223.

Tanji, K. K. (1990). Agricultural salinity assessment and management. Manual of Engineering Practice No. 71. Am. Soc. Civil Engrs. Reston, VA.

Udo, I. A. and Ittah, M. A. (2006). Performance of five swamp rice (Oryza Sativa L.) varieties at different sodium chloride levels. Global J. of Agricultural Sciences 5(2): 117-121.

Wahua, T. A. T. (2010). Applied statistics for Scientific Studies. Transparent Earth Nig.

Table 1. Physico-Chemical Properties Of Soils Irrigated With Three Different Concentrations Of Saline Water

Physico-chemical properties	ISS	SSPM	SSS_o	SSS_1	SSS_2	Min	Max	Mean	SD	C.V
Sand (%)	85.3	94.3	86.3	87.3	86.3	85.3	94.3	87.9	3.64	4.14
Silt (%)	11.7	4.7	11.7	10.7	11.7	4.7	11.7	10.1	3.04	30.10
Clay (%)	3.0	1.0	2.0	2.0	2.0	1.0	3.0	2.0	0.71	35.5
Texture	Loamy sand	Sand	Loamy sand	Sand	Loamy sand					
pH	6.2	6.6	5.5	5.3	5.2	5.2	6.6	5.8	0.61	10.51
Electrical conductivity (dS/m)	0.12	0.60	0.38	1.18	1.50	0.12	1.50	0.9	0.73	81.11
Organic carbon (%)	1.77	2.07	1.99	2.00	2.03	1.77	2.07	2.0	0.14	7.0
Total Nitrogen (%)	0.15	0.18	0.16	0.17	0.18	0.15	0.18	0.2	0.03	15.0
Available phosphorus (mg/kg)	23.62	111.37	34.5	37.12	90.25	23.62	111.37	59.37	38.88	65.50
Exchangeable Cation										
Calcium (cmol/kg)	17.0	13.60	15.6	16.2	17.4	13.6	17.4	15.96	1.50	9.40
Magnesium (cmol/kg)	2.0	3.8	0.8	0.6	0.4	0.4	3.8	1.8	1.41	94.0
Potassium (cmol/kg)	0.12	0.13	0.12	0.09	0.10	0.09	0.13	0.11	0.02	17.90
Sodium (cmol/kg)	0.07	0.09	0.09	0.10	0.11	0.07	0.11	0.09	0.02	22.20
Exchangeable Acidity										
Aluminum (cmol/kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydrogen (cmol/kg)	0.84	1.00	1.20	1.28	1.08	0.84	1.28	1.06	0.17	15.74
ECEC	20.06	18.64	17.64	18.41	19.07	17.64	20.06	18.76	0.90	4.80
Base saturation (%)	96.0	95.0	93.0	93.5	94.3	93.0	96.0	94.36	1.20	1.30

ISS = Initial soil sample
SSPM = Soil sample + Poultry manure
SSS_o = Soil sample irrigated with saline water (0.08dS/m)
SSS_1 = Soil sample irrigated with saline water (2.00dS/m)
SSS_2 = Soil sample irrigated with saline water (4.00dS/m)

Table 2. Effects of Different Levels of Salinity on Shoot Length (Cm) of Eight Pepper Varieties

Varieties	Salinity levels			Mean
	0.08dS/m	2.00dS/m	4.00dS/m	
Atangtang	53.00	51.33	47.70	50.67
Attarugu	50.00	44.00	40.00	44.66
Atanukwu	60.00	47.00	39.70	45.33
Dangarawa	62.00	56.70	47.33	55.34
Ntokon-okpo	101.33	91.70	83.00	92.01
Nsukka yellow	94.70	75.70	80.00	83.46
Sombe	71.00	65.00	60.70	65.56
Oshosho	58.00	53.70	48.33	53.34
Mean	67.50	60.64	46.8	

L.S.D Salinity (P=0.05) = 2.01
L.S.D Variety (P=0.05) = 3.66
L.S.D (VxS) (=0.05) = 20.01

Table 3. Effects of Different Levels of Salinity on Root Dry Weight (G)/Plant of Eight Pepper Varieties

Varieties	Salinity levels			Mean
	0.08dS/m	2.00dS/m	4.00dS/m	
Atangtang	1.41	1.20	1.02	1.21
Attarugu	0.98	0.74	0.50	0.74
Atanukwu	1.24	1.10	0.80	1.31
Dangarawa	1.82	0.96	0.80	1.19
Ntokon-okpo	1.80	1.84	1.05	1.56
Nsukka yellow	1.90	2.12	1.10	1.70
Sombe	1.52	1.10	1.01	1.21
Oshosho	1.65	1.30	0.98	1.31
Mean	1.54	1.29	0.90	

L.S.D Salinity (P=0.05) = 0.71
L.S.D Variety (P=0.05) = 0.29
L.S.D (VxS) (=0.05) = NS

Table 4. Effects of Different Levels of Salinity on Shoot Dry Weight (G)/Plant Of Eight Pepper Varieties

Varieties	Salinity levels			Mean
	0.08dS/m	2.00dS/m	4.00dS/m	
Atangtang	2.70	2.04	1.80	2.18
Attarugu	1.90	1.63	1.00	1.51
Atanukwu	3.30	3.14	2.23	2.89
Dangarawa	4.20	3.20	2.20	3.20
Ntokon-okpo	3.40	3.30	3.00	8.23
Nsukka yellow	5.41	5.00	2.70	4.37
Sombe	3.40	3.20	3.00	3.20
Oshosho	3.50	2.10	1.91	2.50
Mean	3.48	2.95	2.23	

L.S.D Salinity (P=0.05) = 0.49
L.S.D Variety (P=0.05) = 0.81
L.S.D (VxS) (=0.05) = NS

Table 5. Effects of Different Levels of Salinity on Number of Fresh/Plant Produced By Eight Pepper Varieties

Varieties	Salinity levels			Mean
	0.08dS/m	2.00dS/m	4.00dS/m	
Atangtang	11.00	12.00	9.33	10.77
Attarugu	8.33	7.70	6.70	7.57
Atanukwu	8.70	10.30	8.33	9.11
Dangarawa	7.70	6.33	5.33	7.77
Ntokon-okpo	14.00	9.70	8.33	10.67
Nsukka yellow	9.33	7.33	6.70	7.78
Sombe	6.70	5.33	4.33	5.45
Oshosho	4.70	3.70	3.00	3.8
Mean	8.80	7.79	6.50	

L.S.D Salinity (P=0.05) = 0.62
L.S.D Variety (P=0.05) = 0.38
L.S.D (VxS) (=0.05) = 0.58

Table 6. Effects of Different Levels Of Salinity On Total Fresh Weight (G)/Plant of Eight Pepper Varieties

Varieties	Salinity levels			Mean
	0.08dS/m	2.00dS/m	4.00dS/m	
Atangtang	12.63	14.64	10.03	12.43
Attarugu	42.60	41.10	31.70	33.46
Atanukwu	70.60	76.50	70.90	72.39
Dangarawa	65.50	54.60	40.40	53.50
Ntokon-okpo	32.41	25.81	17.71	25.31
Nsukka yellow	28.71	21.55	20.60	19.62
Sombe	51.50	48.80	34.27	44.85
Oshosho	19.30	15.74	11.45	15.49
Mean	40.40	37.34	24.38	

L.S.D Salinity (P=0.05) = 0.06
L.S.D Variety (P=0.05) = 0.16
L.S.D (VxS) (=0.05) = 0.50

EVALUATION OF WATER AND SOIL QUALITY UNDER SMALL SCALE IRRIGATION AT OBUFA ESUK IN CALABAR, CROSS RIVER STATE

A. Ibrahim[1*] S. Ibrahim[2] A. Y. Gambo[3] E. A Obio [4]
[1]Agricultural Engineering Unit
Department of Soil Science, University of Calabar, Cross River State
e-mail: aijada@yahoo.co.uk
*corresponding author, Tel: 08037654611
[2]Department of Agricultural Engineering Technology
Adamawa State College of Agriculture, Ganye
Adamawa State.
[3]Department of Soil Science, University of Calabar
[4]Department of Agricultural Engineering, Cross River University of Technology, Calabar,
Cross River State.

ABSTRACT
Water and soils used for small-scale irrigation/production of vegetable crops at Obufa-Esuk Community in Calabar were evaluated in order to ascertain their quality. Standard method (APHA, AWWA, WEF, 1998) was used for the water analysis and for the soil analysis, standard methods as edited by klute(1986) and sparks(1986) were used for the physical and chemical properties, respectively. The results showed that with mean values of EC(0.08dS/m), TDS (37.33mg/l) and SAR (8.13), the water sources were classed in C_1S_1-low salinity and sodicity category. However, they appear to be free from salinity but have potential threat of sodicity due to the high concentration of Na^+ (mean = 15.06mg/l) in relation to Ca^{2+} (mean=4.80mg/l) and Mg^{2+} (mean = 1.97mg/l). Other ionic constituent indicators had mean values all in mg/l as: Cl^-(25.75), $HC0^{3-}$ (9.11), NO_3^- (4.41), $P0_4^{3-}$(0.13) and K^+ (0.54). The waters were slightly acidic with mean pH of 6.09 and free from boron (Mean = 0.00mg/l) toxicity. In relation to FAO irrigation water quality standards, all the measured water quality indicators were low and fall below the maximum recommended limits for irrigation. The soil texture was loamy sand. Bulk density, porosity and infiltration rate were moderate and averaged 1.48g/cm^3, 43.33% and 1.34cm/min, respectively. As for fertility status, the soils were averagely rated low in OM(2.01%), total N(0.15g/kg), Ca(3.34cmol/kg), K(0.1cmol/kg), Na (0.08cmol/kg), ECEC (6.75cmol/kg), EA (1.75cmol/kg), moderate in Mg(1.09cmol/kg), high in available P(61.96mg/kg) and BS (70.41%). The soils were moderately acidic (mean pH=5.8) and low in ECe (0.13dS/m) indicating low salinity. With respect to soil fertility, judicious application of organic manure/compound fertilizer may be advantageous. The water quality indicators as compared to the FAO standards suggest that the water sources are still suitable for use as irrigation water.

Keywords: Water, Soil, Quality, Irrigation, Calabar.

1.0 INTRODUCTION

Surface water, groundwater and treated wastewater constitute the major water sources used for irrigation (FAO, 1998). Over 67% of the available amount from these sources is used mainly in agriculture (UNESCO, 2000). Regardless of the water sources being used, irrigation water normally contains some dissolved substances that may

impact negatively on its quality for use as irrigation water source (Shainberg and Oster, 1978). The major substances are the dissolved salts which commonly present a problem known as salinity and sodicity (FAO, 1994).

The presence of these excess salts in irrigation water may pose a potential threat to the soils or crops being irrigated. It is well acknowledged that excess salts in irrigation water (salinity) increased osmotic pressure in the soil solution and causes water stress on crops (Rhoades *et al*., 1992), while sodic water causes dispersion and flocculation of the soil particles with subsequent reduction in the permeability of water and air into the soil (Kandiah, 1990; FAO, 1994). Other potential threats include Boron and Chloride toxicities which normally impair crop growth and reduce yield (Lazarova *et al*., 2005).

It is also well reported in many literatures that some physico-chemical properties of the soils were adversely affected as a result of prolonged use of poor irrigation water quality (Hoffman and Van Genuchten, 1983; Ibrahim and Garba, 1995; Anikwe *et al*., 2002). Some of these effects are the destruction of soil texture and structure leading to reduction in infiltration rate, aeration, fertility degradation and decrease in overall productivity (FAO, 1994; Graham and Singh, 1997; Krista *et al*., 2003).

The small scale irrigation practice at Obufa Esuk near University of Calabar Staff Quarters has been on for over two decades. Peasant farmers outside and within the University Community are engaged in dry season irrigation farming every year. The major crops cultivated are vegetables such as pumpkin, waterleaf, green (amaranthus) and sometime maize and cassava. Hence, there is need to assess the sources of water used for the irrigation as well as the soil in order to ascertain their quality status. Therefore, this work was carried out with the objectives of evaluating the quality of water and soil resources under small scale irrigation in the area.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study area is located at Obufa Esuk Community near the University of Calabar Teaching and Research Farm. The area is situated between latitudes 4°5' and 5° 2'N and longitude 8° 0' and 8° 3'E with an altitude of 39 m above sea level. The area is characterized by humid tropical climate with a mean annual temperature range of 27 – 33°C, while relative humidity ranges between 70% and 80% (Bulktrade, 1989). Calabar has distinct wet and dry seasons. The wet season starts from March to October following the dry season from November to February. The annual rainfall is variable, ranging from 3000 to 4500mm with a bimodial distribution (Bulktrade, 1989). The soils are underlain by coastal plain sand belonging to tertiary and alluvial deposits, usually on low lying area (Jungerius, 1964). The soil is capable of supporting a variety of crops such as pumpkin, waterleaf, amaranthus, cassava, maize, banana, etc.

2.2 Water Sampling and Analysis

The sources of water used for irrigation in the area consist of a running stream, open shallow wells dug locally by the farmers at strategic places and tap water. Water samples were respectively collected from the mid-stream after diversion, tap and two shallow wells with reasonable yield representing other shallow wells. The samples were collected in the month of January being the peak period of dry season.

From each source, water sample was collected at the depth of 10-30 cm, using one-litre sterilized polyethylene bottle. The bottle was rinsed with the water source before being filled. All the samples collected were stored on ice-packed cooler and transported to the Department of Oceanography laboratory (University of Calabar) for analysis.

In the laboratory, standard methods (APHA, AWWA, WEF, 1998) were used to analyzed the water for some quality parameters. pH and electrical conductivity (EC_w) were

respectively determined using pH meter and conductivity meter measured at 25°C. Total dissolved solids (TDS) were gravimetrically determined at 105°C, major cations (Na^+, Mg^{2+}, Ca^{2+}, K^+) were determined by flame atomic absorption spectrophotometer, chloride ion (Cl^-) was determined by agentometric method, bicarbonate (HCo_3^-) was by volumetric method, nutrients (NO_3-N, $P0_4$-P) were also determined by spectrophotometer and boron (B) was by colorimetric indigo-caramine method. Sodium adorption ratio (SAR) was calculated as follows:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

2.3 Soil Sampling and Analysis

Twenty soil samples were randomly taken across the entire field which is about 2-3 hectares. The samples were collected at the depth of 0-20 cm using the dutch-type bucket auger. Undisturbed soil samples were also taken with cores for bulk density determination. Infiltration rates were measured in the field at each point of sampling using double-ring infiltrometer.

In the laboratory, the samples were air-dried, crushed and passed through a 2mm diameter sieves for analysis. Particle size analysis was determined by the Bouyoucos hydrometer method (Day, 1965) and the texture determined on the USDA triangle. Bulk density was determined gravimetrically by cylindrical core method (Blake, 1965). Electrical conductivity (ECe) was measured in a 1:5 soil: water extract at 25°C on a conductivity meter. pH was determined in a 1:2.5 soil: water suspension using glass electrode pH meter. Organic carbon was by dichromate oxidation method described by Walkley and Black (Jackson, 1969) and organic matter obtained by multiplying organic carbon values with a constant 1.72. Total nitrogen was by Macro-kjeidahl method (Jackson, 1969). Available P was extracted by Bray No. 1 solution (Bray and Kurtz, 1945) and estimated by molybdenum blue colour technique (Murphey and Riley, 1962). Exchangeable bases (K^+, Na^+, Ca^{2+}, Mg^{2+}) were extracted with the neutral normal NH_4OAC. In the extract, the former two were obtained by flame photometry while the later two by EDTA titration method. Exchangeable acidity was by titration using 1N KCL and 1N NaOH (McClean 1962). ECEC and Base saturation was by calculations as follows:

$$ECEC = Na^+ + K^+ + CA^{2+} + Mg^{2+} + H^+ + Al^{3+}$$

$$BS = \frac{Na^+ + K^+ + Ca^{2+} + Mg^{2+}}{ECEC} x100$$

3.0 RESULTS AND DISCUSSION

The results for the irrigation water quality parameters are reported in Table 1, alongside with the FAO (1994) recommended irrigation water quality standards. Important irrigation water quality indicators describing a number of relevant specific parameter of water in relation to the yield of crops and maintenance of soil productivity are discussed as follows:

3.1 Salinity Indicators

The main indicators used to evaluate the salinity hazard of any irrigation water are the electrical conductivity (EC_W) and total dissolved solids (TDS) values. Electrical conductivity values of the analyzed water sources range from 0.05 to 0.08 dS/m, with a mean of 0.08 dS/m. All the values recorded (Table 1) are by far less than the permissible limit of 3 dS/m given by FAO (1994). Based on the criteria set by Richards (1954), the water from these sources belongs to the class C_1-low salinity. The critical limit set for C_1-

low salinity water category is EC_w<0.25dS/m (Richards, 1954; Wilcox, 1955; Landon, 1991).
Total dissolved solids (TDS) values range from 25.00 to 42.00mg/l, with a mean of 37.33 mg/l. The values recorded also were far less than the maximum recommended standards (200 mg/l) for irrigation water (FAO, 1994). This confirms the low values obtained for the electrical conductivity, as the result validates the fact that electrical conductivity is an indicator of the TDS (Johnson and Zhang, 2012).

3.2 Major Ion Indicators

Sodium was the dominant cation in all the water sources and ranges from 9.23 to 18.5mg/l, with a mean of 15.06mg/l. Calcium and magnesium range from 2.78 to 6.21mg/l and 1.21 to 2.61mg/l with a mean of 4.80 and 1.97mg/l, respectively. The mean values obtained (Table 1) for the sodium, calcium and magnesium were respectively far below the recommended maximum of 920, 408 and 60.80mg/l. This implies that the water sources might be safe for the use as irrigation water with respect to these cations.

Chloride was the dominant anion and range between 20.00 and 33.00mg/l, with a mean of 25.75mg/l. Bicarbonates ranged from 6.10 to 12.20mg/l, with a mean of 9.11mg/l. The mean values recorded for the chloride and bicarbonate were respectively lower than 1065 and 610 mg/l recommended by FAO (1994) standards. This is an indication that the water sources might not cause toxicity problems especially with respect to the chloride ion concentration.

3.3 Nutrient Indicators

The major nutrient indicators evaluated are the nitrate-nitrogen, phosphate-phosphorus and potassium. Ranges (means) for $N0_3$-N, PO_4-P and K were 3.62 to 5.62 (4.41 mg/l), 0.03 to 0.26 (0.13mg/l) and 0.34 to 0.68 (0.54 mg/l), respectively. The respective mean values were lower than the permissible limit of 10, 2 and 2 mg/l, stipulated by FAO (1994) standards. Although the values were low, the nutrient indicators in all the water sources have the potential of fertilizing the irrigated land over a long period of application (Ibrahim *et al*., 2010).

3.4 Sodicity Indicator

One of the major tools used in evaluating the sodicity hazard of irrigation water source is the sodium adsorption ratio (SAR) value. It was observed that the SAR values range from 6.50 to 9.40 with a mean of 8.13, which was less than 15.00 as given by FAO (1994) standards. The SAR value of 0-9, is the limit for S_1-low sodicity water category (Richards, 1954; Wilcox, 1955). The results obtained revealed that all the water sources fall in the low sodium class (S_1) except for the well number 2 with SAR value of 9.4, which was just very slightly above 9. However, in view of the high sodium content and moderate SAR values (Table 1), the water sources might have potential threat of sodicity hazard. In fact, sodium made up about 67% of the total cations in the water sources. The exchangeable sodium might begin to accumulate in the irrigated soils (Kovda, 1980) if appropriate measures were not taken.

3.5 pH and Boron Indicators

The mean value recorded for the pH (6.09) was slightly less than the minimum standard of 6.5 recommended by FAO (1994) (Table 1). This indicates that the water sources were slightly acidic. There were no traces of boron concentrations in all the water samples analyzed (Table 1). Thus, this means that the water is might be free from boron toxicity.

3.6 Soil Quality Indicators

3.6.1 Physical Properties of the Soil

The physical properties of soils analyzed are presented in Table 2. The texture of the soils were loamy sand. In terms of individual fractions, the ranges (means) for sand, silt and clay, respectively were 81.3-96.3(84.8), 6.7-15.7 (9.64) and 2.0-9.0(6.94) percent. Bulk density values were moderate and range from 1.25 to 1.62g/cm^3 with a mean of 1.48g/cm^3 and coefficient of variability of 6.08%. Porosity values varied from low to moderate (23.96 to 53.02%) with a mean of 43.33% and C.V of 14.17%. The textural class, bulk density and porosity of these soils imply that the soils might not likely to have drainage and aeration problems.

Infiltration rate ranges from 1.14 to1.74 cm/min with a mean of 1.34cm/min and C.V of 13.42%. This is considered to be moderately rapid (Landon, 1991) probably due to the high content of sand fractions and moderate porosilty values obtained for the soils.

3.6.2 Chemical Properties of the Soil

The soil chemical properties are summarized in Table 3. pH ranged from 4.5 to 6.4 with a mean of 5.8 and C.V of 9.48%. This indicates that the soils were strongly to moderately acidic in reaction. This might be as a result of leaching/erosion of bases due to poor water application during irrigation (Michael and Ojha, 2003). Electrical conductivity of the soil (ECe) ranges from 0.03 to 0.29 dS/m with a mean of 0.13dS/m and C.V of 61.54%. All the soils had values less than 4 dS/m and can be classified as non-saline (Abrol *et al*., 1988). This is also evidenced by the low electrical conductivity values of the irrigation water used.

Organic matter, total nitrogen and available phosphorus ranged from 1.32 to 3.63%, 0.06 to 0.8g/kg and 32.0 to 96.50mg/kg with a mean of 2.01%, 0.15g/kg and 61.96mg/kg, respectively. According to Landon (1991) rating values for the organic matter content varied from very low to low, total N (low to high) and available P (medium to high). These soils can be described as soils having medium to high nutrient fertility in terms of total N and available P (Enwerzor *et al*., 1981). The organic matter contents need to be supplemented through the application of organic manure.

Exchangeable calcium, magnesium, potassium and sodium ranged from 2.0 to 4.6, 0.4 to 2.6, 0.08 to 0.12 and 0.05 to 0.10 cmol/kg with mean values of 3.34, 1.09, 0.10 and 0.08 cmol/kg, respectively. Based on Landon (1991) rating, exchangeable Ca and Mg varied from very low to moderate, while K and Na had values that varied from very low to low. The low value of these exchangeable bases in the soils implies that the soils might also be free from salinity and sodicity, hazards as earlier observed in the irrigation water sources used. However, the fertility of the soil could be improved through the application of organic and inorganic fertilizers.

4.0 CONCLUSION

The water quality analysis reveals that all the irrigation water sources were free from salinity and sodicity hazards and belong to the class C_1S_1-low salinity and sodicity category. The water sources were also free from toxicity problems except for the potential threat of sodium cation which predominates other cations. The nutrient indicators has the potential of adding nutrient elements to the soil over a long period of irrigation. However, all the water quality indicators were just within the recommended FAO limits. For the soil quality indicators, the soils were well drained, aerated and moderately rapid in infiltration rate. In terms of soil fertility indicators, the soils were found to have varied from medium to high in nutrient status. The soils were also non-saline and free from sodicity problems. Thus, the water and soil quality of Obufa Esuk under small scale irrigation are still suitable for sustainable crop production, but need

constant monitoring so as to ascertain necessary ameliorative measures to be taken as at when due.

REFERENCES

Abrol, I. A., Yadav, J. S. P. and Massoud, F. I. (1988). Salt-affected soils and their management. FAO Soils Bulletin 39, Rome.

Anikwe, M. A. N., Ofoke, P. E. and Mbah, C. N. (2002). Relationship between irrigation water quality and salinization of selected irrigated soils in Abakaliki, South Eastern Nigeria. Nig. J. Soil Res. 3: 58-62.

APHA, AWWA and WEF (1998). Standard methods for the examination of water and wastewater 20th Edn. APHA, AWWA and WEF, Washington, DC: ISBN: 0875532357.

Blake, G. R. (1965). Bulk Density. In C. A. Black (Ed.). Methods of Soil Analysis, Part I. AM. Soc. Agron 9: 374-390.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorus in soils. Soil Science 59: 39-45.

Bulktrade Investment Company Limited (1989). Main report on soil land use survey of Cross River State, Nigeria. Ministry of Agriculture and Natural Resources, Calabar. 376p.

Day, P. R. (1965). Particle fraction and particle size analysis. In C. A. Black (Ed.). Methods of Soil Analysis. Part I. Am. Soc. Agron. 9: 545-567.

Dellehay, T. D., Eling, H. Jr. & Rossen, J. (2005). Preceramic irrigation canals in the Peruvian Andes. Proceedings of the National Academy of Sciences, 102 (47):1724 – 1734. PMIP 16284247.

Enwerzor, W. O., Udo, E. J. and Sobulo, R. A. (1981). Fertility status and productivity of the acid sands: In Acid Sand of Southern Nigeria. Soil Sci. Soc. Of Nigeria. Special Publication Monograph No. 1: 56-73.

FAO (1994). Water Quality for Agriculture. Irrigation and Drainage Paper 29 Rev. 1, by Ayers, R. S. and Wescot, D. W., Rome, Italy.

FAO (1998). Irrigation Practice and Water Management. L. D. Doneen and D. W. Wescot. Irrigation and drainage paper L, Rev. 1, FAO, Rome. 71P.

Graham, W. R. and Singh, B. R. (1997). Soil and water quality under large-scale irrigation in a semi-arid ecosystem II. The Bakolori Irrigation Project Area, Zamfara State. Proceedings of the 23rd Annual Conference of Soil Science Society of Nigeria, 2-5 March, 1997. Usman Danfodio University, Sokoto.

Hoffman, G. J. and Van Genuchten, M. J. (1983). Soil properties and efficient water use: Water Management for Salinity Control, In Limitations to Efficient Water Use in Crop Production. Tylor, H. M., Jordan, W. and Sinclair V. (Eds.). Am. Soc. Agro. Madison, INI, 73.

Ibrahim, A., Onoja, S. B., Agunwamba, J. C. and Idike, F. I. (2010). Implications of prolonged wastewater irrigation on some selected soil properties. Global Journal of Engineering Research 9(1): 39-44.

Ibrahim, S. A. and Garba, A. M. (1995). Evaluation of the soils in Wurno Irrigation Project Area,

Sokoto, Nigeria with respect to Salinity/Sodicity hazards. 3rd All African Soil Science Society Conference, 19-26 August, 1995. Univ. of Ibadan, Ibadan.

Jackson, M. L. (1969). Soil Chemical Analysis. Advanced Course 2nd Ed. Department of Soil Science, United State Department of Agriculture (USDA). Pp 217-224.

Johnson, G. and Zhang, H. (2012). Classification of Irrigation Water Quality. Oklohoma Cooperate Extension Service Fact Sheets. Available online at http://www.osuextra.com.

Jungerius, P. D. (1964). The Soils of Eastern Nigeria. Publication Service Geological du Luxemburg XIV: 185-198.

Kaudiah, A. (1990). Environmental impacts of irrigation development with special references to saline water use. In water, soil and crop management relating to use of saline water. ACIL/M.Sc/16 FAO, Rome 152p.

Kovda, V. A. (1980). Land Aridization and Drought control: Westview Press Inc., Boulder, Colorado, USA.

Krista, E., Pearson, G. A. and Bauder, J. W. (2003). The basic of Salinity and Sodicity Effects on Soil Physical Properties. In Nihos, J. W. (ed.). Water Quality and Irrigation Management. USA.

Landon, J. R. (1991). Booker Tropical Soil Manual: A handbook of soil survey and agricultural land evaluation in the tropics and subtropics. Booker Tete Ltd., England 474p.

Lazarova, V., Bouwer, H. and Bahri, A. (2005). Water quality considerations. In: Lazarova, V. and Bahri, A. (Eds.). Water reuse for Irrigation Agriculture, Landscape and Turf Grass. CRC Press, London, New York and Washington DC., pp. 31-63.

McClean, E. O. (1982). Chemical and microbiological Analysis. In Page, A. L. (Ed.) Methods of Soil analysis Part 2, Second edition. ASA-SSA, Agronomy Monograph 9: 199-224.

Michael, A. M. and Ojha, T. P. (2003). Principles of Agricultural Engineering. Volume II. Jain Brothers Pub. New Delhi, 888p.

Murphey, J. and Riley, J. P. (1962). A modified single solution method for the determination of phosphorus in natural waters. Anal. Chem. Acta. Vol. 27: 31-36.

Rhoades, J. D., Kandiah, A. & Marshall, A. M. (1992). The use of saline waters for crop production. FAO. Irrigation and Drainage Paper NO. 48.. FAO, Rome, Italy.

Richards, L. A. (1954). Diagnosis and Improvement of Saline-Alkaline Soils. IBH Publishing Co. Ltd. New Delhi, India, pp 98-99.

Shainberg, I. and Oster, J. D. (1978). Quality of Irrigation Water. International Irrigation Information Centre, Bet Dagan, Israel, 65p.

United Nations Educational Scientific and Cultural Organization (UNESCO) (2000). Water Use in the World: Present Situation/Future Needs (Online) Available from http://www.unesco.org.

Wilcox, L. V. (1955). Classification and use of irrigation waters. US. Department of Agriculture Circular No. 969, 19p.

Table 1. Irrigation Water Quality Indicators Of Obufa Esuk Small-Scale Irrigation Scheme And FAO (1994) Recommended Water Quality For Irrigation (All In Mg/L)

Water Quality Indicators	Irrigation Water Sources					FAO (1994) Standards
	Shallow wells		Stream	Tap water	Mean	
	1	2				
SALINITY						
[1]Electrical conductivity (ECw)	0.05	0.09	0.08	0.08	0.08	3.00
Total dissolved solids (TDS)	42.00	44.70	37.60	25.00	37.33	2000
MAJOR IONS						
Calcium (Ca)	2.78	5.57	4.64	6.21	4.80	408
Magnesium (Mg)	1.21	2.22	1.85	2.61	1.97	60.80
Sadium (Na)	9.23	18.5	15.4	17.1	15.06	920
Chloride (Cl)	20.00	33.00	30.00	20.00	25.75	1065
Bicarbonate (HCO_3)	9.00	12.20	9.15	6.10	9.11	610
NUTRIENTS						
Nitrate-Nitrogen (NO_3-N)	3.62	4.88	3.88	5.62	4.41	10.00
Phosphate-phosphorus (PO_4-P)	0.10	0.26	0.11	0.03	0.13	2.00
Potassium (K)	0.34	0.68	0.57	0.58	0.54	2.00
MISCELLANEOUS						
[2]Sodium adsorption ratio (SAR)	6.50	9.40	8.5	8.1	8.13	15.00
[2]pH	5.86	6.01	5.98	6.49	6.09	6.5-8.5
Boron (B)	0.00	0.00	0.00	0.00	0.00	2.00

[1]Electrical conductivity of water samples (ECw) measured in dS/m
[2]pH and SAR values has no unit

Table 2. Statistical Summary of Some Physical Properties of the Soil Obtained From 20 Samples

Properties	Unit	[1]n	Min	Max	Mean	[2]S.D	[3]C.V.
Sand	(%)	20	81.30	96.30	84.80	3.37	3.97
Silt	(%)	20	6.70	15.70	9.64	2.52	26.14
Clay	(%)	20	2.00	9.00	6.94	1.77	25.50
Texture			Loamy Sand				
Bulk density	(g/cm^3)	20	1.25	1.62	1.48	0.09	6.08
Porosity	(%)	20	23.96	53.02	43.33	6.14	14.17
[4]Infilltration rate	(cm/min)		1.14	1.74	1.34	0.18	13.42

[1]No of samples collected and analyzed.
[2]Standard deviation.
[3]Coefficient of variability in percentage (%).
[4]Infiltration rate measured at each sampling points (20 points).

Table 3. Statistical Summary of Some Chemical Properties of the Soil Obtained From 20 Samples

Properties	Unit	[1]n	Min	Max	Mean	[2]S.D	[3]C.V.
[4]Electrical conductivity (ECe)	(dS/m)	20	0.03	0.29	0.13	0.08	61.54
pH	-	20	4.5	6.4	5.8	0.55	9.48
Organic matter (OM)	(%)	20	1.32	3.63	2.01	0.68	33.83
Total N	(g/kg)	20	0.06	0.8	0.15	0.18	120.00
Available P	(mg/kg)	20	32.00	96.50	61.96	20.67	33.36
Exchangeable Ca	(cmol/kg)	20	2.0	4.6	3.34	0.78	23.35
Exchangeable Mg	(cmol/kg)	20	0.4	2.6	1.09	0.56	51.38
Exchangeable K	(cmol/kg)	20	0.08	0.12	0.10	0.02	20.00
Exchangeable Na	(cmol/kg)	20	0.05	0.10	0.08	0.01	12.50
ECEC	(cmol/kg)	20	5.51	11.81	6.75	1.72	25.48
Exchangeable Acidity	(cmol/kg)	20	0.16	3.24	1.75	0.91	52.00
Base Saturation	(%)	20	30.23	90.63	70.41	14.95	21.23

[1]Number of samples collected and analyzed.
[2]Standard deviation.
[3]Coeffiicent of variability in percentage (%).
[4]Electrical conductivity of the soil saturation extract (ECe).

VARIATIONS IN QUALITY OF AGRICULTURAL SERVICES AND TRAINING CENTRE'S DAM PLATEAU STATE –NIGERIA

Oiganji Ezekiel *, O.E Nwafor* S. H. Kwarams*, A.A Ahmed**
[*]Forestry Research Institute of Nigeria. Federal College of Forestry,
PMB 2019 Jos- Plateau State
[**]Abubakar Tatari-Ali College of Agriculture Bauchi State.
Corresponding author Email: ezeganji@gmail.com Phone: +2348061279887

ABSTRACT
Water samples were analyzed taken at the Upper, Centre and lower section of the Dam collected between December 2012 – February 2013 at Bi-monthly interval, samples were analyzed at Federal Ministry of Water Resources Gombe State regional water quality laboratory.. The results of the water analyses at the three points showed various ranges of values obtained as follows: pH value (7.28-7.30 mg/L), Electrical Conductivity(20-22.33mg/L) Total Dissolved salts(TDS), Potassium (2.16-2.65 mg/L), Magnesium (1.27-1.53 mg/L), Calcium (37.37 mg/L), Sodium Adsorption Ratio (SAR)(1.07-1.17 mg/L), Sulfate (1.27-2.06 mg/L), Chloride (7.78-8.60 mg/L), Total carbonate Hardness (95-110 mg/L) .The results were within the recommended range in accordance with the standard of National Environmental Standard and regulation Enforcement Agency (NESREA 2011) and World Health Organization (WHO,2004), however there was significant variation in Sulfate and Total carbonate Hardness at the three points during the study period. There should be no restriction on the use of this water for irrigation purposes. Therefore, the water quality of ASTC Dam is good for Irrigation purposes.

Keywords: Water Quality, Irrigation, Salinity, Sodicity, Water

1. INTRODUCTION

The face of irrigated agriculture is changing with respect to water quantity and quality. Water quality problems have intensified through the ages in response to the increased growth and concentration of population and industrial activities have contributed to increasing scrutiny about how water is used and how much water is available to the public for non-agricultural uses, (Ali, 2008, Cobourn and Segale, 2003; Mating *et al*., 2010, Odjugo and Konyeme, 2008; Mustapha, 2008, 2010; Murtala, 2009, Miller and Gardiner, 2007, Babiker *et al*., 2007). Irrigation has been practiced throughout the world for several millennia but it is only in this century that the importance of irrigation water quality has been recognized; increasing world's irrigated land have adversely created problems of water logging ,excessive salinity and Sodicity (WHO, 2004). Water quality can only be defined in relation to some potential use for which the limiting concentration of various parameters can be identified. Water quality guidelines are acceptable concentrations of substances that can be consumed by people and concentrations above which are considered dangerous to human life (Onuoha, 2010; WHO, 2006; Rajendra *et al*., 2009). Water quality criteria include the following: pH, Chemical Oxygen Demand, biochemical oxygen, total dissolved solids (TDS) and electrical conductivity (EC) (WHO, 2006). The quality of water used to irrigate crops has

seed germination, plant susceptibility to pests and diseases (Odjugo and Konyeme, 2008).

Islam and Shamsad (2009) reported that irrigation water that has high sodium($Na^{+)}$ content can bring about a displacement of exchangeable Calcium (Ca^{2+}) from the clay minerals of the soil, followed by the replacement of the Cations by sodium. Sodium saturated soil peptizes and loses their permeability so that their fertility and suitability for cultivation decreases. The quality sustainability of different water sources depend mainly on the status of its chemical composition. The parameter of concern in quality determination of irrigation water include: Electrical conductivity (EC), Total dissolved solid (TDS), Cations and Anions ($Na^{+}mg^{++}$,Ca^{++},Cl^{-}, CO_3^{-}, HCO_3^{-}, SO_4^{-}), others include Ammonium-Nitrogen ($NH_4^{-}N$), Nitrate-Nitrogen (NO^{-}_3-N), Phosphate-Phosphorus (PO^{-}_4-p), Acidity and Basicity (pH) and Boron (B) (Mustapha,2010).

In Nigeria, the total water received from rainfall exceeds the total demands from agriculture, domestic and industrial uses (Othman *et al.*, 2010). Nigeria's water resources have been under increasing stress in recent years due to rapid demographic changes which have coincided with the establishment of human settlement lacking proper sanitary infrastructure. In view of this, the Federal Environmental Protection Agency (FEPA) issued a specific decree to protect, restore and preserve the ecosystem of the Nigerian environment (Chiaudani and Premazzi., 1988). The decree empowered the agency to set water quality standards to protect public health and to enhance the quality of irrigation waters (Chiaudani and Premazzi., 1988). The Plateau State Government under Jonah David Jang in agreement with SEC Equipment and Communications Limited; gave birth to ASTC. SEC Equipment and Communications Limited is an Israeli company with excellent expertise in agricultural development and whose vision is to revolutionize agriculture from its initial traditional method. A Dam is now used as source of water for the Agricultural Services and Training Centre (ASTC) (Oiganji *et al*., 2012). This research work therefore attempts to assess variation in quality of the Dam during the study period.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

A field study between October 2012 and April 2013 to evaluate the suitability of water for irrigated agriculture was conducted at Agricultural Services and Training Center (ASTC) Dam Vom, which is located between latitude $9^{o}44^{l}27.8^{ll}$ longitude $8^{o}44^{l}18.5^{ll}$ with altitude of 1247m above sea level; Jos South Local Government area Kassa-Vom ; Plateau State.

2.2 Water Sampling

Samples were collected bi-monthly in the morning by 7-9am at the upper, centre and the lower sections of the dam during the said period. High density PVC bottles were used for sampling. They were thoroughly cleaned by rinsing with 8N HNO_3 and deionized water followed by repeated washing with water sample as suggested by De (1989). The bottles were kept air-tight and labeled properly for identification, aeration during sampling was avoided by corking the bottle quickly. Samples collected from study area were quickly transported to the Federal Ministry of Water Resources Gombe State regional water quality laboratory. A total of thirty (30) samples were collected, 10 samples from each of the three (3) zones of the dam and the means for each section was estimated as recommended by Kirda (1974).

2.3 Chemical and Physical Analysis

The chemical analysis of water involves the chemical tests which were carried out to determine some chemical parameters and the corresponding chemical characteristics of the water. The chemical tests carried out include total solids, pH, chloride, nitrate, electrical conductivity, Sodium Adsorption Ratio, sulphate, magnesium, sodium, Magnesium, calcium (Modi, 2006); while the physical analysis of water involves the physical tests carried out to determine the physical impurities and corresponding physical characteristics of water. The physical parameters determined were Total dissolved solids (TDS) and total carbonate hardness (TH).

2.4 Water Sampling Analysis

The water samples were analyzed for physical and chemical characteristics, for irrigation purposes; bacteriological analysis is unimportant (Ayers and Westcott, 1985). Standards methods and procedures described by the National Environmental Standard and regulation Enforcement Agency (NESREA 2011) and WHO (2004) were used to analyze the parameters. The parameters analyzed, unit and method used are indicated in the Table 1.The sodium absorption ratio were calculated using equation 1 which quantifies the proportion of sodium, calcium, and magnesium ion in a sample, the Sodium percentage values estimated using equation 2 as reported by Richard (1954).

$$SAR = \frac{N_a}{\sqrt{\frac{C_a + M_g}{2}}} \quad (1)$$

$$N_a = \frac{(N_a + K)100}{C_a + M_g + N_a + K} \quad (2)$$

3.0 RESULTS AND DISCUSSION

3.1 Variation in Levels of Sulphate ion

Sulphate ion concentration were in the range 1.27-2.06 mg/L in the abstracted samples at the different sections of the dam as indicated in Table 1 & Fig 1. However, in the variation of sulphate ion during the study period; sample collected in upper section of the dam showed a highly (2.06) significant variation in Sulfate level, while others collected in center and lower section of the dam are statistically at par. The sulphate ions were within the excellent category when compared to NESREA (2011) and WHO (2004) standard for Sulphate ion, which is an indication that the Dam water does not have possible deficiency problems at the different section of the dam.

Table 1: Variations in Quality During the Month of October, December and February

Parameters	upper	center	lower	SE±	LSD	Remark	NESREA2011	WHO 2004
pH	7.28^{a}	7.40^{a}	7.30^{a}	0.06	0.444	Ns	6.5-8.5	6.5-8.5
EC	22.33^{a}	20.67^{a}	20.00^{a}	1.05	0.367	Ns	1000	0-7
TDS	14.00^{a}	13.00^{a}	13.00^{a}	0.53	0.391	Ns	500	0-450
Potassium(K^{+})	2.16^{b}	2.65^{a}	2.37^{ab}	0.10	0.061	Ns	50	0-2
Magnesium(Mg^{2+})	1.27^{a}	1.33^{a}	1.53^{a}	0.16	0.532	Ns	120	0-9
SAR	1.07^{a}	1.14^{a}	1.17^{a}	0.03	0.139	Ns	-	<10
Sulfate ($S0_4^{2-}$) (Mg/l)	2.06^{b}	1.80^{a}	1.27^{a}	0.09	0.008	S	500	0-140
Chloride(Cl^{-})	7.78^{a}	8.30^{a}	8.60^{a}	0.26	0.190	Ns	350	0-30
TH as ($CaCO_3$)	95.00^{b}	101.67^{ab}	110.00^{a}	2.55	0.035	S	150	0-150

Ayers and Westcott, (1985) WHO (2004) Guidelines for interpretation of water quality:. NESREA (2011) Standard for interpretation of water cited by Adeogun *et al*., (2011) Remarks: Means in the same row having the same superscript are not significantly different ($p>0.05$; S= significant, Ns= not significant

3.2 Variation in levels of Total Carbonate Hardness

The total carbonate hardness where within 95-120 mg/L when compared to the recommended range for NESREA (2011) and WHO (2004) standard 0-150 and 0-150 as indicated in Table 1 & Fig 2; indicating that the dam water is very soft and it may probably be related to lack of some essential nutrients like calcium and bicarbonates; then it is necessary to add essential supplements for the deficiency, though hardness of water prevents formation of sufficient lather with soap. TH as ($CaCO_3$), showed a highly significant variation in sample collected at the lower section (110) while the samples from the other sections do not show any significant effects but samples collected at the upper and center sections of the dam were statistically at par.

3.3 Variation in Levels of Potassium

Potassium (K^{+}) is often present in significant amount in irrigation waters, as an essential nutrient which acts favorably in reducing the harmful effect of saline water on crop growth. The mean potassium content for the upper, Centre and lower sections of the dam were 2.2mg/L, 2.7mg/L and 2.4mg/L respectively as shown in table 1 & Fig 3 which were higher than the WHO (2004) standard which may be as a result of the type of land management practices going on around the Dam. Nevertheless, the range obtained for K^{+} was lower than the recommended range by NESREA (2011). During the study period the concentration of K^{+} at the upper section (2.16) was significantly different from the center section (2.65) but both sections are statistically at par with the lower section of the Dam

3.4 Stability in Levels of Some Other Elements Present in the Dam Water

Some elements present in the dam water were observed to be statistically stable at the three sections considered during the study period. SAR (1.07-1.17 mg/L) of the samples collected at the three different sections of Dam were not significantly different. Electrical Conductivity which is an indication of total quantities of soluble salts in solution, used to determine salinity level of water; values obtained were within the range 20-22.33 µS/cm, which is the permissible range for WHO (2004) and 0-1000 for NESREA standard and not significantly different. The following were observed to be not

significant: pH value (7.28-7.30mg/L), Magnesium (1.27-1.53 mg/L), Calcium (37.37 mg/L), Chloride (7.78-8.60 mg/L); and were within the range recommended by WHO (2004) NESREA (2011) standard.

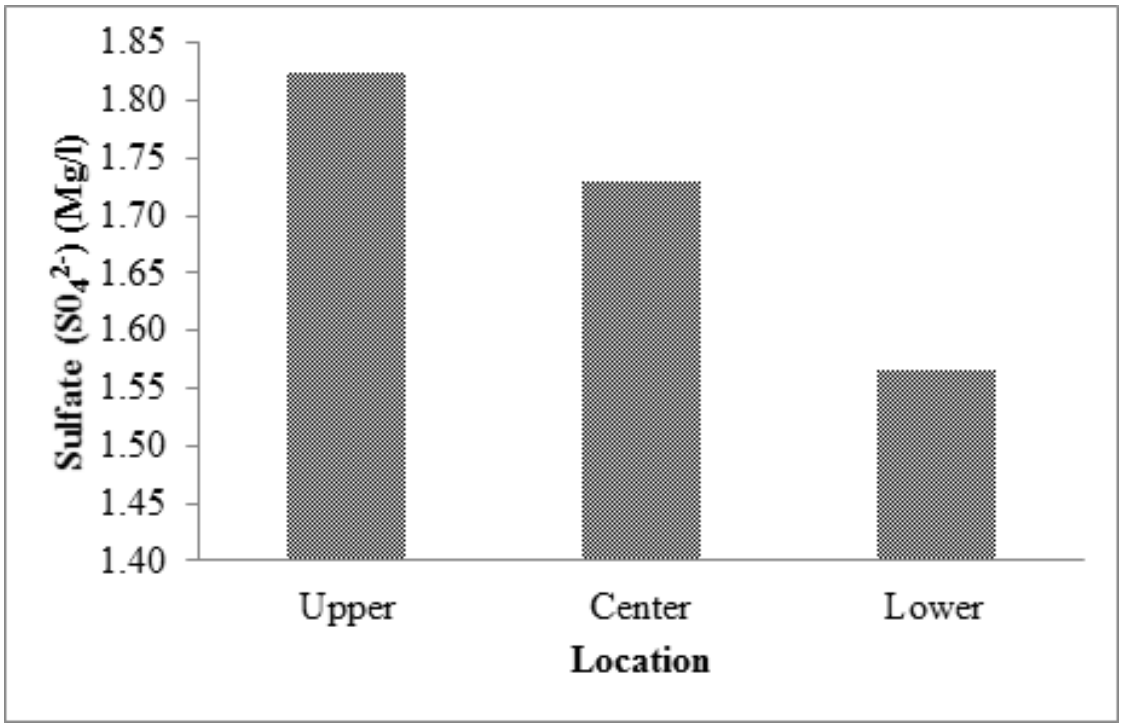


Figure 1: Sulfate ($S0_4^{2-}$) (Mg/l) Level of the Samples Collected From the three Section

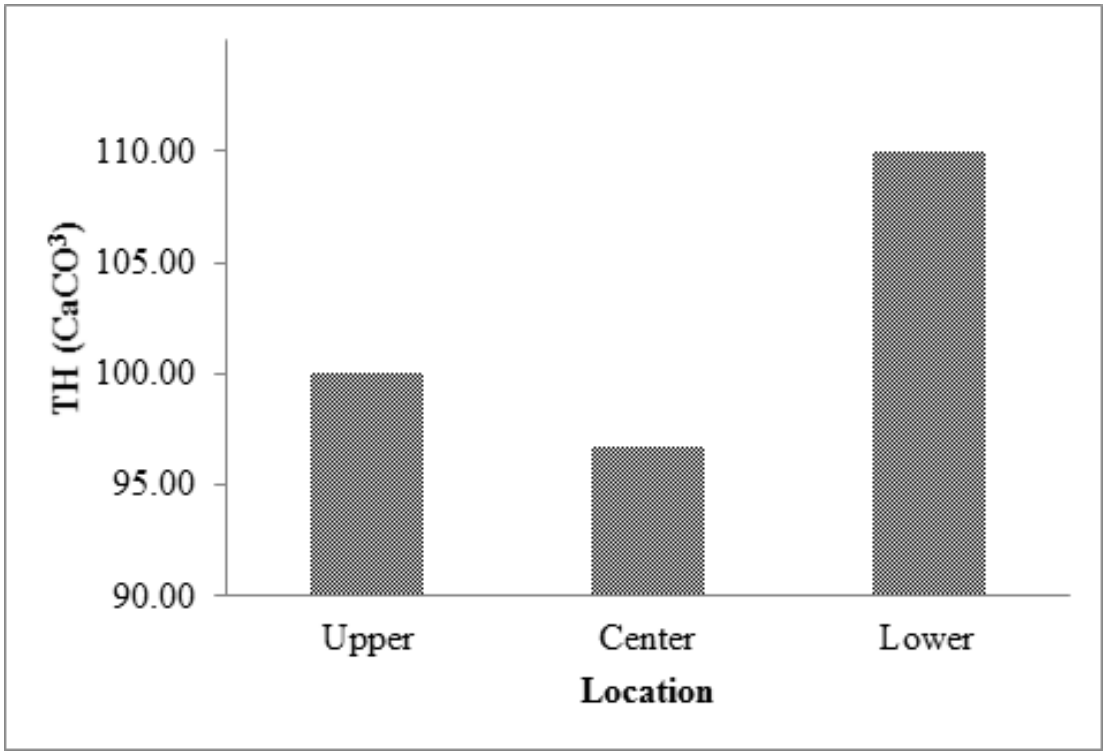


Figure 2: TH as ($CaCO_3$) Level Of The Samples Collected From The Three Section

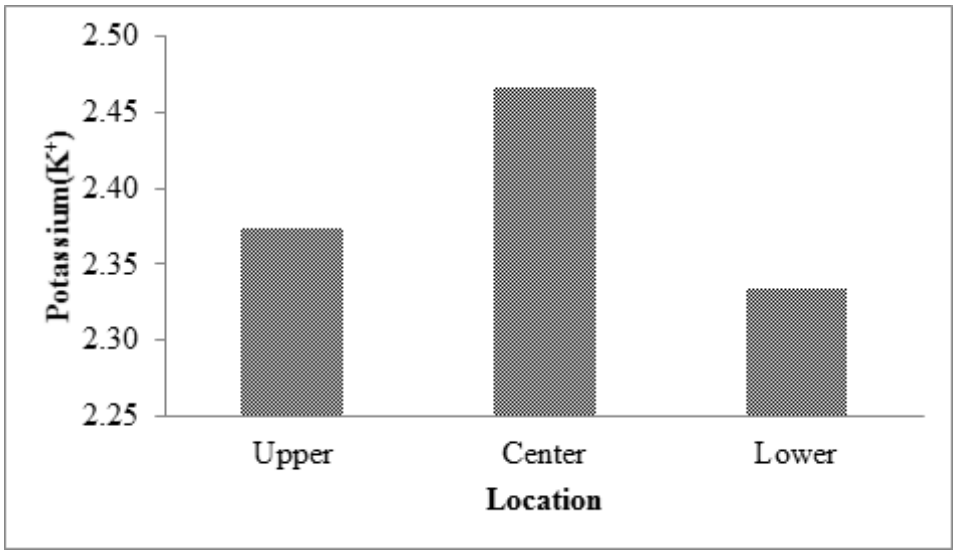


Figure 3: Potassium (K^+) Level of the Samples Collected From the Three Section

4. CONCLUSION

Variation in water quality for Agricultural Services Training Centre was carried out by considering parameters taken at the Upper, Center and Lower sections of the Dam between October 2012– February 2013. The results showed that parameters considered are in compliance with NESREA and WHO standards and TH and sulphate ion were significantly different at the diverse sections considered. To safeguard long-term sustainability, the dam water quality should be monitored continually since it is majorly used for drip irrigation through denitrification and nutrient control to prevent degradation; Also an on-going irrigation water quality monitoring program should be established in order to document changes over time.

REFERENCE

Adeogun, A.O; Chukwuka, A.V and Ibor, O.R (2011). Impact of Abattoir and Saw-mill Effluents on Water Quality of Upper Ogun River. American Journal of Environmental Science,7:525-530.

Ali, M.S. (2008). Land pollution. Edward's College Peshawar. Available at http://en.wikipedia.org. Accessed on the 7th February; 2010.

Ayers, R.S and D.W Wescott (1985). Water Quality for Agriculture. FAO Irrigation and Drainage paper No.29 Food and Agriculture Organization of the United Nations pp1-117

Babiker, I.S., M.A.A. Mohammed, T. Hiyama.(2007). Assessing Groundwater Quality using GIS. Springer: Water Resources Management Vol.21, Issue 4, pp699-715

Chiaudani, G. and G. Premazzi (1988).Water Quality Criteria in Environmental Management Report EUR 11638 EN,Commission of the European Communities, Luxembourg.

Cobourn, J. and Segale, H. (2003). Where does Tahoe's water pollution come from? The Lake Tahoe Report. Tahoe Environmental Research Centre

De, A.K (1989). Environmental Chemistry. Wiley Eastern Limited, New Delhi, India. pp 42-43

FAO, (1990). Guideline, Land Evaluation for Irrigated Agriculture. Soils bull No. 55, FAO Rome, Italy. Pp227-252.

Islam, M.S. and S.Z.K.M Shamsad (2009). Assessment of Irrigation Water Quality of Bogra District in Bangladesh. Bangladesh Journal of Agricultural Research 34 (4):597-608

Kirda,C.(1974). Assessment of Irrigation Water Quality. CIHEAM-options Mediterranean.

Marting,R; Olaleye, A.O and Johanne M. (2010). Assessment of Water Quality in Mohale Dam and Associated Rivers in Lesotho. Second RUFORUM Biennial Meeting 20-24 September 2010, Entebbe, Uganda.

Miller, R.W, and D.T. Gardiner (2007) Soil in our environment 9th edition. Prentice Hall Upper Saddle River, New Jersey 07458.ISBN 0- 13-020036-0, Table 15-6, page 452

Modi, P.N (2006). Environment Engineering-1, Water Supply Engineering. 2nd Edition. Standard Book House, Delhi pp741-790.

Murtala A.A. (2009): Investigation of physical properties of soil for irrigated agriculture. Proceeding of the 2nd National Engineering Conference, Institute of Technology Kwara State Polytechnic Ilorin, Kwara State, Nigeria.

Mustapha, M.K. (2008). Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, Using Selected Physico-Chemical Parameters. Turkish Journal of Fisheries and Aquatic Sciences 8: 309-319 (2008).

Mustapha, H.I (2010). Water Quality Assessment of River Chanchaga for Irrigation purposes, Minna, Niger State, Nigeria. Proceedings of the 31st National Conference of the Nigerian Institution of Agricultural Engineers (NIAE). Vol 31: pp304-309

Odjugo, A.O.P, and Konyeme, J.O. (2008).The Impact of urban, environment and Seasonality on 6he quality of Ikpoba River in Benin City, Nigeria. Journal of Food, Agriculture and Environment 6(2):362-369.

Oiganji, E., O.E Nwafor and A.Ahmed (2012). Review on the Use of Drip Irrigation in Nigeria. Proceedings of the 33rd National Conference of the Nigerian Institution of Agricultural Engineers (NIAE). Vol 33: pp153-156

Onuoha S.N. (2010) Basic Concept of Irrigation and Drainage Engineering, Codat publication university of Ibadan.pp18 -20.

Othman, M.K, A.I Arab, A. Ibrahim and M.S Kallah (2010). Mitigating Desertification through Irrigation: Opportunities and Challenges in Northern Nigeria. Proceeding of the 10th International Conference of Nigerian Institution of Agricultural Engineering .Pp 338 -352

Rajendra Prasad, D.S., Sadashivaiah, C, and Rangnna G.(2009). Hydrochemical

Characteristics and Evaluation of Ground water Quality of Tumkur Am,anikere Lake Watershed, Karnataka, India. E-journal of chemistry, 6(1):211-218.

Richard, L.A (1954).Diagnosis and Improvement of Saline and Alkaline Soils. Agricultural Handbook 60.Washington, DC: USDA,pp.160

WHO.(2004), accessed on the 4th January 2013. www.who.int/water_sanitation-health/publication/facts2004/en/index.html.

WHO. (2006). Guidelines for drinking water quality. Volume 1.Third Edition Geneva WHO Switzerland. . Accessed on 14th August 2010.

TECHNICALITIES OF SOLAR PHOTOVOLTAIC CROP IRRIGATION WATER PUMPING

[1] Nwoke , O.A.,[1] Okonkwo, W, I.,[1]Ugwuishiwu, B. O.,[2] Chukwuma, E.C.,[1].Ezenne, G. I.,[1]Ohagwu,C.J

[1]Department of Agric and Bioresources Engineering, University of Nigeria, Nsukka

[2]Department of Agric and Bioresources Engineering, Nnamdi Azikiwe University, Awka

E-mail:nwoke.oji@unn.edu.ng

ABSTRACT

This paper presents introduction and technicalities of stand-alone Photovoltaic (PV) pumping system, which can be specially designed for crop irrigation. By application of these systems, it is expected to increase agricultural fresh water reuse, and to save labor for water management and also increase agricultural production and productivity and thus help improve livelihood of local communities. One of the main issues with such stand-alone solar PV systems is their maintenance. Basic knowledge of how solar PV systems function. How each component work and what function they play in the whole system needs to be understood by the users. Not only that, but the basic maintenance procedures need to be acquired. As such project needs to be sustained, the users need to understand the following :(i) the general characteristics of PV systems, their performance parameters and principles. (ii) The system operation and maintenance (iii) how demand influences system operation (demand side management.)These technicalities are discussed in this paper.

Keywords: Photovoltaic Pumping Systems, Irrigation, Technicalities, Crop

1.0 INTRODUCTION

Water pumping has a long history; so many methods have been developed to pump water with a minimum effort. These have utilized a variety of power sources, namely: human energy, animal power, hydropower, wind, solar and fossil fuels for small generators. The photovoltaic water pumping systems (PVPS) offer the appropriate solution to supply water for drinking and irrigation in remote regions. Currently, the use of photovoltaic pumps for small-scale irrigation presents a promising option for using solar energy in productivity and income generation. Throughout the world, there are pilot projects and applications to irrigate crops by photovoltaic pumps (Lawrence et al, 1996; Hahn et al, 1998; Hahn et al, 2000; Hamidat, 2000). One of the most promising applications of PV solar power, especially in countries such as Spain which have very high levels of solar radiation, is for pumping the water needed to irrigate certain crops (Cuadros et al, 2004). Stand Alone Design Practices, 1993; Alonso and Chenlo, 1994 detailed studies on the application of solar PV for pumping water both in agricultural and domestic use. Other studies on irrigation technology include see (www.fao.org, 2003; Doorenbos and Pruit, 1997). Allen et al, (1998) discussed appropriate methods to estimate water requirements for a given crop in a place The general objective of this study is to assess the technicalities required for efficient and economic irrigation water supply using solar photovoltaic. The specific objectives are to assess (i) The general characteristics of PV systems, their performance parameters and principles. (ii) The system operation and maintenance (iii) How demand influences system operation (demand side management).

2.0 BASIC PRINCIPLES OF SOLAR PV

2.1 Photoelectric Effect: Particle Nature of Photon

Photovoltaic conversion of solar energy involves a wide range of knowledge: energy problems, properties of solar radiation reaching the earth's surface, photovoltaic effect in the P-n junction, properties of semiconductors which are important in photovoltaic conversion, technology of solar cells, construction of photovoltaic panel modules and arrays, control systems of photovoltaic power station as well as ecological and economic problems of photovoltaic installations (Trykozko, 1997).

(i) Increasing the intensity of the light increased the number of photoelectrons, but not their maximum, kinetic energy.(ii) Red light will not cause the ejection of electrons no matter what the intensity(iii) A weak violet light will eject only a few electrons, but their maximum kinetic energies are greater than those for intense light of longer wavelengths.(iv) Photon is a particle with energy

$$\Delta E = hv \quad \text{----------} \quad (2.1)$$

where h = plank's constant, v = light velocity

(v) Maximum kinetic energy of electron

$$K_{max} = hv - l \quad \text{.....} \quad (2.1)$$

Where l = work function (minimum energy required for the release of electrons)

2.2 Solar PV as a Renewable Energy Source

(i) Absorption of light, photon, creates an electric current thus converts light directly into the electric power, which is the most valuable form of energy (ii) There are no moving parts, unlike the conventional energy sources, this reduces the need of maintenance. (iii)No fuel is necessary, this eliminates any environmental impact.(iv)Long life time(v)Modularity, size of the plant can be increased depending on the requirements(vi)Decentralized power generation (vii)Minimized visual intrusion, can be integrated with structures such as building (Solanki, 2008).

3.0 SYSTEM COMPONENTS

3.1 Photovoltaic System

A photovoltaic system consist basically of (i) the module which converts the solar energy to direct current (DC) electricity (ii) the battery which stores the DC electricity for use when the solar radiation is either poor or non-existent (iii) the charge controlled which regulates the charging and discharging of the battery to preserve its life, (iv) the inverter which converts the DC from the modules or battery into alternating current (AC), (v) wires, (vi) switches (vii) relays mounting structures etc. The following PV cell/ module technologies have been commercialized: (i) Crystalline Silicon Technologies (ii) Thin-film Technologies and (iii) Amorphous Silicon Technologies.

3.2 Photovoltaic Pumping System

Photovoltaic pumping systems consist of three principal components: the photovoltaic panels, a motor, and a pump. Depending on the design, a system may use storage batteries and a charge regulator. Batteries confer the advantage of working when the intensity of solar radiation is low (on cloudy days, or at dawn or dusk). Battery-less systems are, however, cheaper and simpler needing practically no maintenance. In these cases one usually employs cisterns to store the water's potential energy, and if drip irrigation techniques are used, these cisterns serve also to regulate flow and pressure at the irrigation heads (Lorenzo, 1994).

3.3 Comparison of Pumping Techniques

Photovoltaic systems are especially designed to supply water and irrigation in areas where there is no mains electricity supply. Their main advantages over hand pumps or internal combustion engine pumps are: (i) their practically zero maintenance, (ii) their long useful life, (iii)that they do not require fuel,(iv) that they do not contaminate, and (v)finally that they are straightforward to install. Another important characteristics is that, as they use the sun as their energy source, the periods of maximum demand for water coincides with the periods of maximum solar radiation. Their disadvantages are their high initial capital costs, and the variability of the yield of the solar panels according to the prevailing weather conditions, although this latter problem can be at least partially solved by storing the water in a cistern at a certain height. The relative merits of these are laid out in table 3.1 below

4.0 APPLICATION OF SOLAR PV IN IRRIGATION WATER PUMPING

4.1 Applications

Solar pumps are used principally for three applications:

(i) Village water supply (ii) Livestock watering (iii) Irrigation

A solar pump for village water supply is shown schematically in fig 4.1 with voltage water supply, a constant water demand throughout the year occurs, although there is need to store water for periods of low insolation (low solar radiation). Typically in sahelian Africa the storage would be 3 – 5days of water demand. In environments where rainy season occur, rain water harvesting can offset the reduced output of the solar pump during this period. The majority of the two or more solar pumping systems installed to date are to village water supply or livestock watering (Kenna and Gillet, 1985)

A solar irrigation system needs to take account of the fact that demand for irrigation water will vary throughout the year. Peak demand during the irrigation seasons is often more than twice the average demand. This means that solar pumps for irrigation are underutilized for most of the year. Attention should be paid to the system of water distribution and application to the crops. The system should minimize water losses, without imposing significant additional head on the pumping system and be of low cost (Rentch, 1982). The suitability of irrigation systems for use with solar pumps is shown in table 4.1. On a clear, sunny day, a medium-size PVP system with an installed power of 2 kWp will pump approximately 35 m^3 of water per day to a head of 30 meters. That amount of water is sufficient for communities with populations up to 1400. It takes a 3.5-kWp PV generator to deliver water at the rate of 30 m^3/d at a head of 50 m for a daily total global irradiation of 5 $kWh/(m^2*d)$. This gives the planner an instrument for estimating the size of the PV generator and, hence, the cost of the planned system at the time of site selection.

4.2 The Technology

Systems are broadly configured into 5 types as described below:

(i) Submerged Multistage Centrifugal Motor Pumpset (ii)Submerged pump with surface mounted motor (iii) Reciprocating Positive Displacement Pump (iv)Floating Motor Pump Sets (v) Surface Suction Pump Sets

4.3 Performance

A pumping system demands is defined as the product of a mean depth from which the water must be raised and the daily flow that is needed. The unit of measurement is M^4day-1.Solar pumping technology continues to improve. In the early 1980s the typical solar energy to hydraulic (pumped water) energy efficiency was around 2% (Barlow et al. 1993) with the photovoltaic array being 6 < 8% efficient and the

motor pumpset typically 25% efficient. Today, an efficient solar pump has an average daily solar energy to hydraulic efficiency of more than 4%. Photovoltaic modules of the monocrystalline type now have efficiencies in excess of 12% and more efficient motor and pumpsets are available. A good sub-system (that is the motor, pump and any power conditioning) should have an average daily energy throughout efficiency of 30 – 40%.

4.4 Costs

A photovoltaic pumping system to pump 25m^3/day through 20m head requires a solar array of approximately 880Wp in the Sahelian region. Such a pump would cost approximately $6,000 FOB (free on board). A range of price is to be expected, since the total system comprises the cost of modules, pump, motor, pipework, wiring, control system, array support structure and packaging systems with larger array sizes generally have a lower cost/Wp. The cost of the motor pumpset varies according to application and duties; a low lift suction pump may cost less than $800 whereas a submersible borehole pumpset cost $1500 or more.

4.5 Procurement

(i) Assessing requirement

The output of a solar pumping system is very dependent on good system design derived from accurate site and demand data. It is therefore essential that accurate assumptions are made regarding water demand/pattern of use and water availability including well yield and expected drawdown. Domestic water use per capita tends to vary greatly depending on availability. The long term aim is to provide people with water in sufficient quantities to meet all requirements for drinking, washing and sanitation. Present short-term goals aim for a per capita provision of 40 litres per day, thus a village of 500 people has a requirement of 20 cubic metres per day. Most villages have a need for combined domestic and livestock watering. Irrigation requirement depend upon crop water requirements, effective groundwater contributions and efficiency of the distribution and field application system. Irrigation requirement can be determined by consultation with local experts and agronomists or by reference to FAO document on crop water requirements (J. Dorrenbos, W. O. Pruitt –FAO Rome, Italy – 1997).

(ii) Assessing water availability

Several water source parameters needs to be taking into account and where possible measured. These are the depth of the water source below ground level, the height of the storage tank or water outlet point above ground level and seasonal variation in water level. The drawdown or drop in water level after pumping has commenced also needs to be considered for well and borehole supplies. This will depend on the ratio between pumping rate and the rate of refill of the water source. The pattern of water use should also be considered in relation to system design and storage requirements. Water supply systems should include sufficient covered water storage to provide for daily water requirements and short periods of cloudy weather. Generally, two to five days water demand is stored.

4.6 Procedure to Size Solar Powered Irrigation (photo-irrigation) Schemes

Due to increase in population and to climatic factors, water resources are tending to become depleted in many parts of the world. It is in this context that one understands the need to pump water from wells and rivers (Cuadros et al, 2004). The optimal use of photovoltaic pumping system (PVPS) requires a good understanding of the system characteristics as well as a precise estimation of water needs (Hamidat et al, 2003).

4.6.1 PV pumping system models

A PV water pumping system combined with remote control system of water level in paddy field is as shown in figure 4.2. A mathematical model is used to stimulate the current versus voltage of the photovoltaic module. This model is deduced from theoretical study and form existing modules (Suehreke et al, 1997; Had et al, 1999; Kou et al, 1998). The relationship between current, I and voltage V, is written as follows:

$$I = L_L - I_O\,(T_J)\left[e^{\frac{q(T_J)(V+RsI)}{An\,KT_J}} - 1\right] - \frac{V}{RsT} \qquad \text{.....4.1}$$

Where I = the module output current, V= the module voltage, IL = the light induced module current, I_O = the saturation current, R_s = the series resistance, Rsh = the shut resistance, q = electron charge, K = Boltzmann's constant, A = dimensionless ideality factor, n = number of cells in module, T = the temperature of the solar cell

4.6.2 Pumping Subsystem Model

A mathematical model of the pumping sub-system is deduced from an experimental study. The model simulates the characteristic flow power of the inverter - motor pump for each total dynamic head (Hamidat, 1999). The input electrical power P_w versus water flow rate (Q) is given by:

$$P_w = \alpha Q^3 + \beta Q^2 + rQ + \delta \qquad \text{----------} \qquad \textbf{(4.2)}$$

where , , and are constants parameters for each total dynamic head.

4.6.3 Photovoltaic pumping system efficiencies

The total efficiency of the PV pumping system is defined as the product of the efficiencies of the PV array and the pumping sub system.

$E_{tot} = E_{PV}\,E_{sub}$ ---------- (4.3)

where E_{PV} is the PV array efficiency, which is defined as the ratio between the operating electric power and the incident power radiation on the tilted surface of a photovoltaic module.

$$E_{PV} = \frac{P_w}{GA\text{mod}\,M_s\,M_p} \qquad \text{----------} \quad (4.4)$$

Where P_w is the operating electric power of the system.(w), G is the global irradiance on the PV array. [w/m^2], A_{mod} is the area of one module [m^2]. M_s is the number of the modules in series and M_p is the number of the modules in parallel in the PV array.

E_{sub} is the pumping sub system efficiency that is defined as the ratio between the output hydraulic power required for lifting a volume of water and the input electric power of the subsystem.

$$E_{sub} = \frac{2.725Q\,h_T}{P_w} \qquad \text{----------} \quad (4.5)$$

where Q is the water flow rate (m^3/h) and h_T is the total dynamic head (M).

4.6.4 Water needs and calculation of irrigated surface

The vegetative cycle of the crop generally includes: initial phase, development, flowering

and maturity phase. Water needs of crops during each phase are commonly estimated using the evapotranspiration concept, which results from soil evaporation and crop transpiration. The evapotranspiration (E_p) is empirically related to a reference evapotranspiration (Et_r) as follows (Sha and Edling, 2000).

Et = Kc Etr ---------- (4.6)

Where Kc is the crop coefficient Etr is determined by the daily corrected model of Penman (Doorenbos and Kassan, 1981).

$$E_{tr} = C[W(Rns - Rnl) + (1+W)f(u)(e_a - e_s)] \quad \text{---------- (4.7)}$$

where C is a correlation factor depending on day and night, wind and moisture conditions, W is a factor which depends on the irradiance at a given temperature and altitude, Rns is a conversion factor function of the extraterrestrial day irradiance to clear day irradiance in the short wave range, and Rnl is the clear day irradiance in the long wave range.The intermediate terms Rns and Rnl of equation (4.7) are calculated using equation (4.8) and equation (4.9) respectively.

$$Rns = \left(1 - \alpha \left(0.25 + 0.50\frac{n}{N}\right)\right)Ra \quad \text{---------- (4.8)}$$

where α is the reflection coefficient of the crop, area, n is the monthly average daily hours of sunshine, N is the monthly average of the maximum possible daily hours of sunshine, Rn is the extra terrestrial irradiance. The second intermediate term of Eq. (4.7) Rnl is gen by the following relationship:

Rnl = f(t) f(ed) f(n/N) ---------- (4.9)

Where f(t), f(ed) and f(n/N) are the corrections, respectively, for ambient temperature, water vapour pressure and fraction of sunshine.

The wind speed function f(u) in equation (4.7) is defined as follows

$$f(u) = 0.27\left(1 + u/100\right) \quad \text{---------- (4.10)}$$

Where u is the speed of the wind at 2 meters height. The last two terms e_a and e_d of eq. (5.7) represent respectively, the saturation vapour pressure and the average vapour pressure. The crop water needs per vegetative phase quoted as Wph, equals the product between evapotranspiration during this phase and the number of days per phase: The last two terms e_a and ed of Eq. (4.7) represent, respectively, the saturation vapour. The total water needs over the vegetative cycle of the crop W tot is the sum of the water needs of the four vegetative phases of the crop. The holding relationship is;

$$W_{tot} = \sum_{k=1}^{4} Wph(K) \quad \text{---------- (4.11)}$$

Where Wph (K) is the water needs for the vegetative phase Ka. The irrigated area S is the ratio between the volume of the pumped water during all the vegetative season and total water needs. The relationship is given as follows:

$$S = \frac{D_{tot}}{W_{tot}} \quad \text{---------- (4.12)}$$

The presented model (Hamidat et al, 2003) was run to evaluate water needs of potatoes, tomatoes, wheat and sunflowers on the basis of the previous knowledge on the crop coefficient. This work showed that for low heads it is possible to use photovoltaic water pumping system for small scale irrigation of crops in Algerian Sahara regions. Thus the photovoltaic water pumping system could easily cover the daily water needs rates for small-scale irrigation with an area smaller than 2ha. Also the PVPS(photovoltaic pumping systems) could improve the living conditions of the farmer with the help of the development of the local farming. And thus the rural depopulation will be brought to an end.

4.7 Economics

In general photovoltaic pumps are economical compared to diesel pumps up to approximately 3KWp for village water supply and to around 1KWp for irrigation (Barlow et al, 1993).

In economic analysis of photovoltaic and gasoline pumping system in North Eastern Brazil using the following equations

$$PC_K = \frac{ALCC_K}{PV_K} \qquad \text{----------(4.13)}$$

$$PHC_K = \frac{ALCC_K}{PV_K \; x \; H_K \; N} \qquad \text{---------- (4.14)}$$

$$ALCC_K = Io \; + \; \sum I_i \; x \; CRF(Ii, \; i) \; + \; 0 \; \& \; m \; + \; FC \; - \; J \; = \; 1 \qquad \text{---- (4.15)}$$

$$CRF \; = \; \frac{i \; x \; (1 \; + \; i)^{\ell i}}{(1 \; + \; i)^{\ell i} \; - \; 1} \qquad \text{----------(4.16)}$$

Where PC_K = pumping cost (US$/m^3) system K ,$ALCC_K$ = Annualized lifecycle cost system K (US$/y), PV_K = Pumped volume per year (m^3/y),PHC_K = Pumping Head cost (US/m^4) system K
,H = Head (m),Io = Initial investment (US$) I = Investment through life, i = Discount rate,ℓ = Time period of year (y),O & M = Maintenance and operation cost (US$/y),FC = Fuel cost (US$/y) ,CRF = Capital recovery factor

Fedrizzi et al, 1996 concluded that "PV system competes favourably with gasoline system when Wp international market prices are used. However domestic PV systems economic viability, when compared to the gasoline system depends basically on decreasing of Wp national industry price, or yet, on the existence of subsidies for PV module procurement. The high cost of domestic PV system could also be reduced through a financing policy based and low interest rates. If transportation cost and the reliability of fuel (gasoline) delivery is considered in such comparison, the tendency of reduction of PV system costs and the risks of fossil fuels cost increase, count positively for the prospects of solar energy conversion for irrigation in the semi-arid region of north-eastern Brazil".

5.0 CONCLUSIONS AND RECOMMENDATIONS

Users of installed solar PV system for irrigation water pumping should have knowledge of the following:i) the importance and benefits of solar PV systems as renewable energy resource (ii) the basic maintenance procedures needed to be carried out on the systems.(iii)The basic scientific knowledge on how solar PV systems operates.Moreover,for connection between the irrigation system and PV solar powered pumping equipment to be energetically and economically efficient, the following points have to be taken into account (i) efficient use must be made of the water resource. This

means that only the amount of water needed for the crop should be raised. This amount should in turn take into account the soil's rainwater retention capacity during the wet season; (ii) the water should be raised to the minimum height above ground level needed to stabilize the pressure at the irrigation heads. On a clear, sunny day, a medium-size PVP system with an installed power of 2 kWp will pump approximately 35 m^3 of water per day to a head of 30 meters.; and (iii) the most efficient irrigation system for that particular crop should be adopted.

REFERENCES

Allen, R., Pereira, L.S., Raes, D., Smith, M., 1998. Crop evapotranspiration – guidelines for computing crop water requirement. FAO Irrigation and drainage, paper 56, Rome.

Alonso, M., Chinelo, F., 1994. Testing results of PV pumping for stand alone installation. Paper presented to 12th European Photovoltaic Solar Energy Conference. Amsterdam.

Barlow. R. McNelis, B., Derrick, A., 1993. Solar Pumping. An introduction and update on the technology, performance, costs and economics. Intermediate Technology Publications and The World Bank, Washington, D.C.

Cuadros, F., Lopez – Rodriguez, F., Marcos, A., Coello, J., 2004. A procedure to size solar – powered irrigation (photoirrigation) Schemes. Solar Energy 76 (2004) 465 – 473.

Doorenbos, J., Pruitt, W.O., 1997. Guideline for predicting crop water requirements. F.A.O Irrigation and Drainage Paper 24, Rome.

Doorenbos, J., W. O. Pruitt ,1997. Crop water requirements. Food and Agriculture Organization of the United Nations (FAO), Rome.

Fedrizzi, M.C., Sauer, I.L, Ziles, R 1996. Economic analysis of photovoltaic and gasoline pumping systems. WREC 1996.

Fraenkel, P, 1997. Water Pumping Devices. A handbook for users and choosers. ITDG publishing, 1997.

Hadj Arab A, Chenlo, F, Mukadem, K, Balenzategui, J.L., 1999. performance of PV water systems. Renewable energy 1999; 18 : 191 – 204

Hahn A., Condori, C.F., Schmidt, R., 1998. photovoltaic water pumps – lessons learned from demonstration and fields testing projects supported by GTZ. Proceedings of international workshop on PV – water supply, Marrakech, Morocco, 1998.

Hahn, A., Schmidt, R., Torres Ar, Torres Am., 2000. Resource conserving irrigation with photovoltaic pumping systems. Proceedings of 16th European photovoltaic solar energy conference and exhibition, 1 – 5 May 2000, Glasgow Scotland.

Hamidat A, 2000, Simulation des performances d' irrigation du pompage PV dans un milieu saharien proceedings of the collogue sur I' Heliothermuque 1 Environment et al Maistrise des systems solaires. ISSN 1112 – 2880, 13 – 15 Mai 2000, Algiers, Algeria.

Hamidat, A., Benyoucef, B., Hartam, T. 2003. Small-scale irrigation with photovoltaic water pumping system in sahara regions. Renewable Energy 28 (2003) 1081 – 1096.

Handbook on solar water pumping, 1984. IT Power Ltd and Partners.

Hishop, D, 1992. Energy options: an introduction to small scale renewable energy technologies. ITDG London.

Kenna, J., Gillett, B., 1985. Solar water pumping. A handbook. IT publications, 1985.

Kou, Q., Klein, S.A., Beckman, W.A., 1998. A method for estimating the long term performance of direct coupled PV pumping systems. Solar Energy 19998., 64 (1 – 3): 33 – 40

Lawrence, W., Wichert B, Langridge D., 1996. Design of photovoltaic pumping systems for small scale irrigation. Proceedings of Eurosun 96. Freibury Germany.

Lorenzo, E., 1994. Electricidad solar ingenieriade los sistemas photovoltaicos. Un Rentch, U.R.S., 1982. Solar photovoltaic for irrigation water pumping. SKAT, St. Gallen 1982.

Sha, S.B., Edling, R.J., 2000. Daily evapotranspiration predicting from Louisiana flooded rice field. Jrumal of irrigation and drainage engineering, ASCE, 2000, Jan/Feb: 12611) pp. 8 – 13.

Solanki, C.S., 2008. Solar photovoltaic technologies, Lecture series IIT Bonbay.
Stand alone photovoltaic systems. A Handbook of Recommended Design Practices, 19993. Sandia National Laboratories.

Suehrcke, H., Appelbaum, J., Reshef, B., 1997. Modelling a permanent magnet dc motor – centrifugal pump assembly in a PV energy system. Solar energy 1997; 59 (1 – 3): 37 – 42

Trykozko, R., 1997. Principles of photovoltaic conversion of solar energy. Presented at the 12th school of Optoelectronics: photovoltaic – solar cells and infrared detectors Kazimiez Dolny May 22 – 24, 1997.

Table 3.1 Comparison of Pumping Techniques

Type of Pump	Advantages	Disadvantages
Hand pumps	(i) local manufacture is possible (ii) easy to maintain (iii) low capital cost (iv) no fuel cost	(i) loss of human productivity (ii) often an inefficient use of boreholes(iii) only low flow rates are achievable
Animal driven pumps	(i) more powerful than humans(ii) lower wages than human power(iii) dung maybe used as cooking fuel	(i) animals require feeding all year round(ii) often diverted to other activities at crucial irrigation periods
Hydraulic pumps (e.g. rams)	(i) unattended operation (ii) easy to maintain (iii) low cost (iv) long life (v) high reliability	(i) require specific site condition (ii) low output
Wind pumps	(i) unattended operation (ii) easy maintenance (iii) long life (iv) suited to local manufacture (v) no fuel requirements	(i) water storage is required for low wind period (ii) high system design and project planning needs (iii) not easy to install
Solar PV	(i) unattended operation(ii) low maintenance (iii) easy installation (iv) long life	(i) high capital costs (ii) water storage is required for cloudy periods (iii) repairs often require skilled technicians
Diesel and gasoline pumps	(i) quick and easy to install (ii) low capital costs (iii) widely used (iv) can be portable	(i) fuel supply erratic and expensive (ii) high maintenance costs (iii) short life expectancy (iv) noise and fume pollution

Source: Frankael (1997)

Table 4.1: Suitability of Major Irrigation Methods for Use with Solar Pumps.

Distribution method	Typical application efficiency	Typical head	Suitability for use with solar
Open channels	**50 – 60%**	**0.5 – 1m**	**Yes**
Sprinkler	**70%**	**10 – 20m**	**No**
Trickle/drip	**85%**	**1 – 2m**	**Yes**
Flood	**40 – 50%**	**0.5m**	**No**

Source: Frankael (1997)

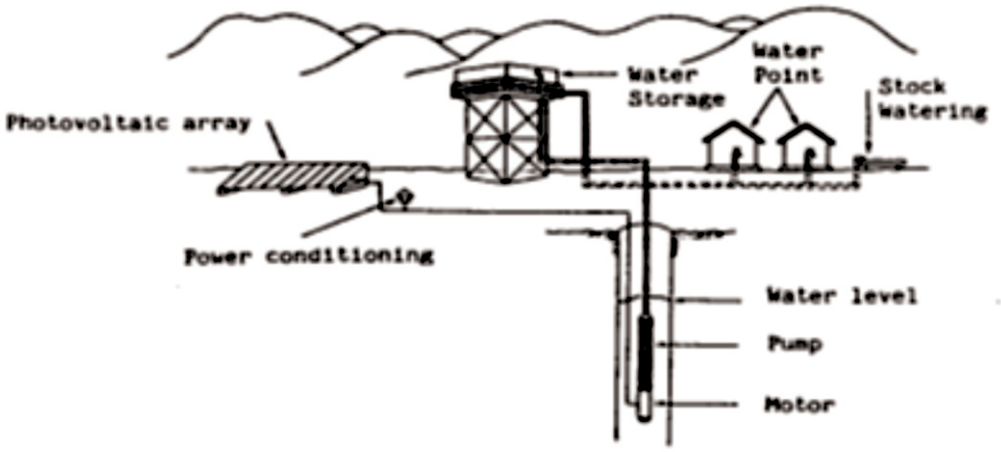


Figure 4.1: Village Water Supply (Source: Handbook on Solar Water Pumping, 1984.)

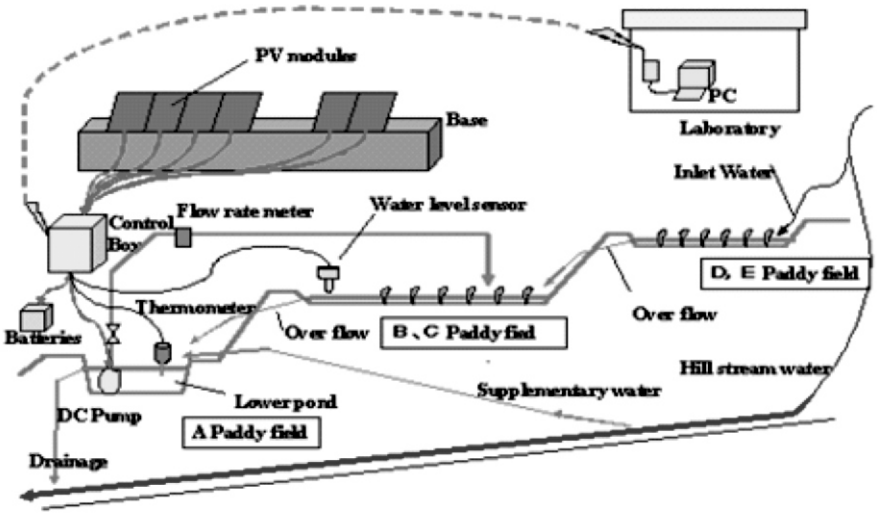


Figure 4.2 Remote Control System Of Water Level In A Paddy Field. Source: Sato,M. et.al.,2007

DEVELOPMENT OF AN APPROPRIATE ONION STORAGE STRUCTURE FOR HUMID TROPICAL ENVIRONMENT

Falayi F.R. and J. Isa
Department of Agricultural Engineering, The Federal University of Technology, Akure, Ondo State, Nigeria
Email: folayanrichard@yahoo.com.
johnisa4u@yahoo.com.

ABSTRACT
Onion is an important vegetable crop whose distinctive flavour is appreciated by people throughout the world. However, large quantities of onion bulbs are lost each year due to poor storage practices and hence, the need for the design and construction of an appropriate storage structure is urgent considering the challenges faced in the supply of onions all year round in Nigeria.
A storage structure capable of storing onions in a humid tropical environment was designed and constructed using locally available materials. The structure was naturally ventilated, has a dimension of 2 m; 1.8 m and 1.9 m in length, width and height respectively and was covered with asbestos roofing sheets. The onions were graded into big, medium and small and placed on specific layers within the structure. Temperature and relative humidity readings within and outside the structure were monitored daily using a thermo hygrometer equipment.
Temperature within the structure ranged from 23.2°C to 29.5°C in the morning, 28.5°C to 39.1°C in the afternoon and from 25.9°C to 32°C in the evening. Physical examination performed on the stored onion bulbs after six weeks reveals minimal deterioration, with big onions recording the highest percentage of weight loss of 3.3%. It is therefore recommended that modification be done on the structure to control the high relative humidity recorded especially in the morning period.

Keywords: Onion, Storage Structure, Relative Humidity, Temperature, Deterioration

1.0 INTRODUCTION

Onion (*Allium cepa*) cultivation is possible in all parts of the world. It belongs to Alliaceae family. World production is about 49 million tonnes per year and annual per capital consumption is 8kg. (Stearn, 2000). Countries producing very substantial quantities in order of production are China, India, Japan, Spain, Italy, United States, Russia, Egypt, Turkey, Netherlands and Poland.(Kochhar, 1998).

Bulbs of *Allium cepa* can be sliced raw for seasoning salads, boiled with other vegetables, or fried with other vegetables and meat. They are an essential ingredient in many African sauces and relishes (Currah, 2002). Onion has many uses as folk medicine and recent result shows that onion plays an important role in preventing heart diseases and other ailment (Augusti,1996). One of the advantages of onion is that the bulbs can be harvested and sold either green in salads (Lannoy, 2001). Mature onion contain approximately: water (86%), protein (1.4%), fat (0.2%), carbohydrate (11%), fibre (0.8%) and vitamins (0.6%). The carbohydrate is principally in the form of sugar (F-A-O., 1998).

The onion bulb is normally harvested at the start of the dormant period (Brice et al., 1997), but in the tropics it is mainly grown as an annual and the bulb is harvested as a vegetable crop. Onions are susceptible to physical damage during harvesting and

postharvest handling. Bulb damage by bruising and shattering can be reduced by packaging in boxes, but this may require substantial investment. In addition to the lowering of appearance quality, bruising and splitting resulting from mechanical damage also affect bulb internal-quality attributes (Isenberg, 1990).

However, bulb size affects both sprouting and water loss during storage (Adjei-Twum, 1980) but Babatola and Lawal (2000) is of the opinion that depending on variety, the dormancy and storage period ranges from a few days to several months. He asserted that storage life depends also on climatic conditions, especially temperature and that dormancy is shortened by external stimulation such as mechanical stress during harvest and handling, lighting during storage, and fluctuation of storage temperature and humidity.

Onions can also be packed in jute (hessian) bags for transporting to yard or brought as loose (Babatola and Lawal 2000). Currah (2002) observed that for safe handling, 40 kg open mesh jute bags having 200-300g weight should be used in domestic market. Proper storage of bulbs is necessary both for consumption and also for seed production. Onions should not be stored unless adequately dried either in the field or by artificial means. Sprouting in onion is controlled by temperature. The temperature between 10-25°C increases sprouting (Subbaram, 1999). Rooting is influenced by relative humidity (RH) (Kochhar, 1986). Powell (1996) demonstrated that onions could be stored for 5 months at 22°C to 25°C and relative humidity of 70% with a total loss of saleable onions of only 14%.

The problem encountered by farmers in the storage of onions in the tropics cannot be overemphasized. Larger percentage of the crop is wasted as a result of inadequate storage structure. During the wet season; sprouting, deterioration and weight lose are major problems to contend with in order to reduce losses. The objective of the work is to develop an appropriate storage structure for onions in a humid environment.

2.0 MATERIALS AND METHODS

2.1 Design Considerations

The design of various structural elements such as the roof structure and columns is very important as it ensures that a befitting structure that will be able to stand the test of time and protect the stored onions from forces of nature is constructed.

2.1.1 Design of the roof structure

i. Live loads

The live load was estimated using (Kazim and Jindal, (1989)) which stated that where access to roof is not provided, except for maintenance, for roof slope greater than 10 degrees, a live load of 75kg/m^2 less than one kg/m^2 for every degree increase in slope up to and including 20 degrees and 2 kg/m^2 for every degree increase in slope over 20 degrees should be allowed.

The calculated Live load/meter length of purlin = 72.45 kg/m or 710.3 N/m

ii. Dead load

Weight of corrugated galvanized sheet per length of the purlin = 6 x 1.8 = 10.8 kg
Weight of wooden purlin per meter length = 2.5 kg
So dead weight / meter length of purlin = 10.8 +2.5 = 13.3 kg/m = 130.34 N/m

iii. Wind load

Basic wind pressure was calculated from the equation given by Jack (2007), i.e. wind pressure, $P = C_c C_q q_s I$. Where C_c = wind load combine height, exposure and gust factor
C_q = wind load pressure coefficient = 0.7 leeward roof

I = moment of inertial of members = 1.0 for non essential buildings
For wind velocity = 31.5m/s, C_c = 1.2 for height 0-6m, q_s = 0.62 kN/m^2.
P = 0.52 kN/m^2 or 53.06 kg/m^2.

2.1.2 Design of Purlins

The maximum permissible span for galvanized iron roof is 1.8m and the following two load combinations was considered for the design of purlins and the greater value of total load was adopted (Kazim and Jindal, 1989).

i. Dead load + live load= 84.95 kg

ii. Dead load + wind load= -63.91 kg(Negative sign indicates that there would be suction or uplift pressure on the roof of the truss)

Dead load + live load was used for the design of members.

2.2 Construction of the Structure

The onion storage structure was constructed in the space of two weeks. It was constructed using locally available materials which include: Hardwood; Plywood; Asbestos; Nails; Wire Guaze and Hinges. Hard wood was used for the columns and beams, ply wood was used for the side walls, Asbestos sheets were used for roofing because of their slow absorption of heat and their ability to regulate the temperature. Wire gauze was used to create a platform for the stored onion to rest and ensure that the stored onions are well ventilated. Nails were used to join the various structural members together.

2.3 Description of the Structure

The storage structure is as shown in Plate 1 to 3. It consists of a roof structure and the storage chamber. The structure which is a naturally ventilated shed has a dimension of 2 m in length, 1.8 m wide and 1.9 m in height. It was constructed primarily with wood and is divided into 2 compartments with a walkway between them as shown in Plate 2; this walkway is 0.4 meters while the two compartments are 0.7 m wide. These compartments consist of 3 layers each made with wire gauze upon which the stored onions will rest. The structure is supported by 8 columns made of hard wood. The side walls of the structure which is covered with plywood has 4 regular cut sections of 0.2 m and covered with wire gauze as shown in Plate 3, these sections allow for proper ventilation within the structure. The roof has a long overhang and the roofing material used is asbestos. The various views of the storage structure are as shown in figure 1.

2.4 Testing of the structure

The experiment was carried out between the months of May and July, 2011 which was rainy season in south west Nigeria. The onion bulbs were monitored daily to observe any physiological changes taking place.

2.4.1 The Stored product

Onion (*Allium cepa*) was used for the experiment. The onion bulbs were purchased at Iloro market, Akure, Ondo state, Nigeria. The onion obtained were the Kano breed which are reddish in colour.

2.4.2 The Storage environment

The onions purchased were divided into six different portions and placed on the 3 layers. A total of 25 pieces with high quality were picked, graded into big, medium and small onions and placed on the different layers in the following order; the big onions were placed on the 1st layer (lowest), the medium placed on the 2nd layer and the small onions

placed on the 3rd layer.

2.4.3 The Measured Parameters

The parameters measured daily during the course of the experiment include temperature, relative humidity, physical appearance of the onions. While parameters measured weekly include weight and size of the 25 random samples.

i. Temperature and Relative Humidity Measurements

A digital thermo–hygrometer equipment with model No HT 642 was used to measure both the temperature and relative humidity inside and outside the structure.

ii. Weight Measurement

The weight of the 25 random samples were taken weekly with the use an electric balance.

iii. Physical Appearance Observations

Observations made daily on the physical appearance of the onion bulbs include sprouting, black spot and rottening. All these observations were made visually.

3.0 RESULTS AND DISCUSSION

3.1 Temperature Analysis

Figures 2 to 4 shows the graph of temperature gradient from inside to outside the structure in the morning, afternoon and evening period. From the graphs it was observed that the temperature of both inside and outside the structure ranged from 23.2°C to 29.5°C in the morning period, 28.5°C to 43.3°C in the afternoon period and 25.9°C to 31.8°C in the evening period. The highest temperatures were recorded in the afternoon period while the lowest temperature was recorded in the morning period. Temperatures inside were lower than the ambient temperature in the afternoon while it was higher inside the structure in the evening. This was due to the slow rate of heat dissipation by the asbestos roofing sheets. This result agrees with the work of (Subbaram, 1999).

3.2 Relative Humidity Analysis

Figures 5 to 7 shows the graphs of relative humidity gradient from inside to outside of the structure in the morning, afternoon and evening period. From the graphs, it was observed that the relative humidity of both inside and outside the structure ranged from 62% to 95% in the morning, 44% to 92% in the afternoon and 73% to 93% in the evening. The highest relative humidity readings were recorded in the afternoon period.

Relative humidity was higher within the structure in the afternoon period but it didn't pose any serious challenge as temperature and the steady rate of air flow within the structure removed the moisture. The results gathered agree with the work of Subbaram (1999).

3.3 Weight Loss During Storage

Fig 8 shows the graphs of the average unit weights of the big, medium and small onions against time (six weeks). From the graphs, it was observed that the average unit weight of big onions reduced from 173.33g at the start of the experiment to 167.69g at the end, that of medium onions reduced from 90.20g to 88.02g at the end and that of small onions reduced from 69.72g to 67.72g at the end of the experiment. The weight loss of small onions was 2.9%, while that of medium onions was 2.42% and that of big onions was 3.3%. From the results obtained over the six weeks storage it is observed that the rate of weight loss was highest in big onions and lowest in medium onions. The high relative humidity recorded in the morning period contributed significantly to high rate of weight

loss in big onions. The rate of weight loss as observed in big, small and medium onions agrees with those observed by Subbaram (1999).

3.4 Physical Appearance Observations

The onion bulbs on the very first day of storage were aparently in a very good physical condition because there were no observed cracks, no greenish colouration due to deterioration and sprouting. During the first week of storage the onions were still in a very good condition, cracking of the outer skins at all levels in the structure began from this point on. After two weeks of storage, the onion bulbs still in good condition recorded further cracked outer skins at all levels. After three weeks of storage, colour variations from light green to deep green were noticed. Black spots began to appear on the onions from the 4th week while after five weeks of storage, almost all of the stored onion bulbs have lost their outer skins. Significant weight loss was recorded after six weeks of storage with the onion bulbs still in good physical condition. In general minimal physiological changes which included weight loss, shrinkage and appearance of greenish colours and black spots were observed over the six weeks storage period but without sprouting. This agrees with the work of Subbaram (1999) and Methanada (1989).

4.0 CONCLUSION

The onion storage structure has been constructed and tested. Based on the results obtained during the study, the following conclusions are made.

1. Design elements like ventilation and type of roofing sheets might have contributed positively in the control of temperature within the structure.
2. The temperature inside the structure ranged from 23.2°C to 29.5°C in the Morning, 28.5°C to 39.1°C in the afternoon, 25.9°C to 32°C in the evening.
3. The high relative humidity observed in the morning period significantly affected the onions and was the primary cause of cracked outer skins.
4. Overall, weight losses recorded by the onions after 6 weeks of storage were minimal.
5. Physical observations made on the stored onion bulbs showed minor changes.

REFERENCES

Adjei-Twum, D.C. 1980. The influence of bulb size and bulb cutting on the growth and yield of shallot (*Allium cepa*var. Aggregatum G. Don) in Ghana. Journal of Horticultural Science, 55 (2), 139-143.

Augusti, K. 1996. Therapeutic values of onion (*Allium cepa L.*) and garlic (Allium sativum L.), Indian J Exp Biol 34 pp. 634–640

Babatola, L. A. and Lawal, O. L. 2000.Comparative yield and storability of two tropical onion (*Allium cepa* L.) cultivars under different storage structures. Proceedings of 18th Horticultural Society of Nigeria Conference, IAR/ABU, Zaria, May 28th- 1st June.

Brice J, Currah L, Malius A, and Bancroft R. 1997. Onion Storage in the Tropics*: A* Practical Guide to Methods of Storage and Their Selection, Chatham, U.K. Natural Resource Institute. p. 120

Currah, L. 2002. Onions in the tropics: cultivars and country reports. In: Rabinowitch, H.D. & Currah, L. (Editors). Allium Crop Science: Recent Advances. CAB International, Wallingford, United Kingdom. pp. 379–407.

F.A.O. 1998. Food composition table for use in Africa. F.A.O and U.S.A
Isenberg, F. M. 1990. The effects of height of fall on onion bruising. Proc. Amer. Soc. Hort. Sci. 66:331–333.

Jack, M.C. (2007). Structural Analysis using classical and matrix methods. John Willey and sons, Inc. USA. P. 117-128
Kochhar, S. L. 1986. Onion storage in the tropics. Tropical science, Malawi. 14: 19-34

Kochhar, S.L., 1998. Tropical Crops: a text book of economic botany Macmillian Ltd. Indian, Pg. 236-238.

Lannoy, G. De. 2001. Vegetable Crops in Tropical Africa 395- 511. In: Raemaeks R. H. (Editor). Crop Production in Tropical Africa.1540 pp. Directorate General for International Cooperation (DGIC) Belgium.

Methanada, K. A.1989. Second Research Reports, Agric. Research Station. MakaIllusppallama.

Powell, T. J. 1996. Notes on the Genus Allium in the tropical. Herbertia 11,11-34.

Stearn, M. E. 2000. Onion shortage in the Sudan. Report of the food and Agriculture Organization of The United Nations. Agon. Sud 70/543.PP.6.

Subbaram, M. 1999.Ventilated bamboo structure for onion storage. Onion Newsletter for the Tropics, 2: 38-41.

Kazim S.M.A. and Jindal, R.S. (1989).Design of Steel Structures. Prentice Hall, New



Plate 1. Front View of the Structure (a) (b)

(a) Plate 2. Side View of the Structure (b)The Various Views of the Structure

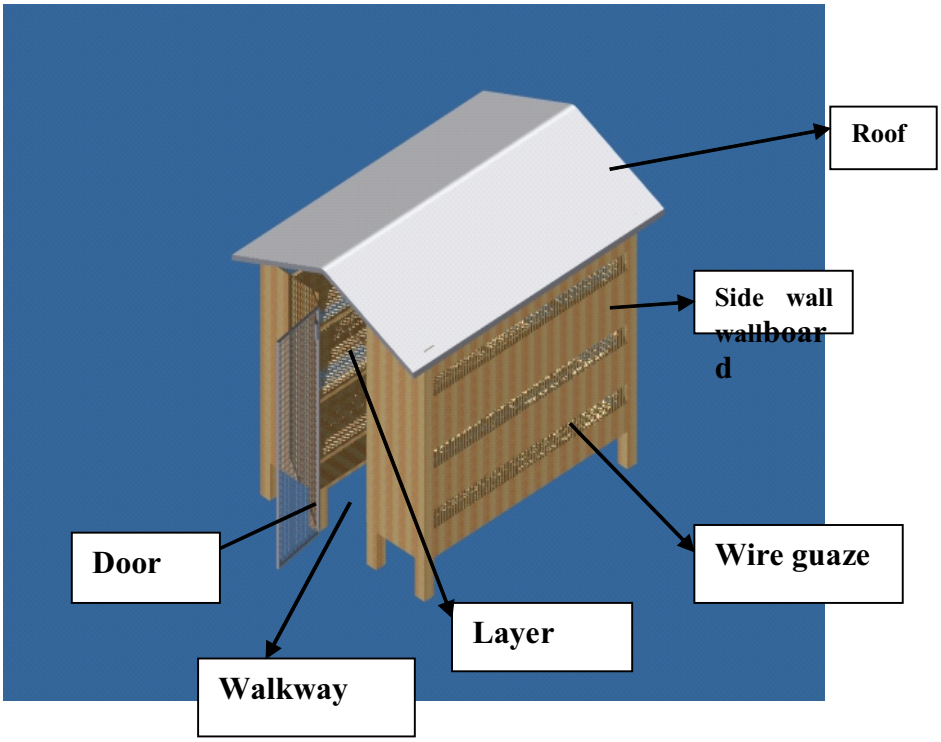


Plate 3. Autodesk Rendered Image of the Structure

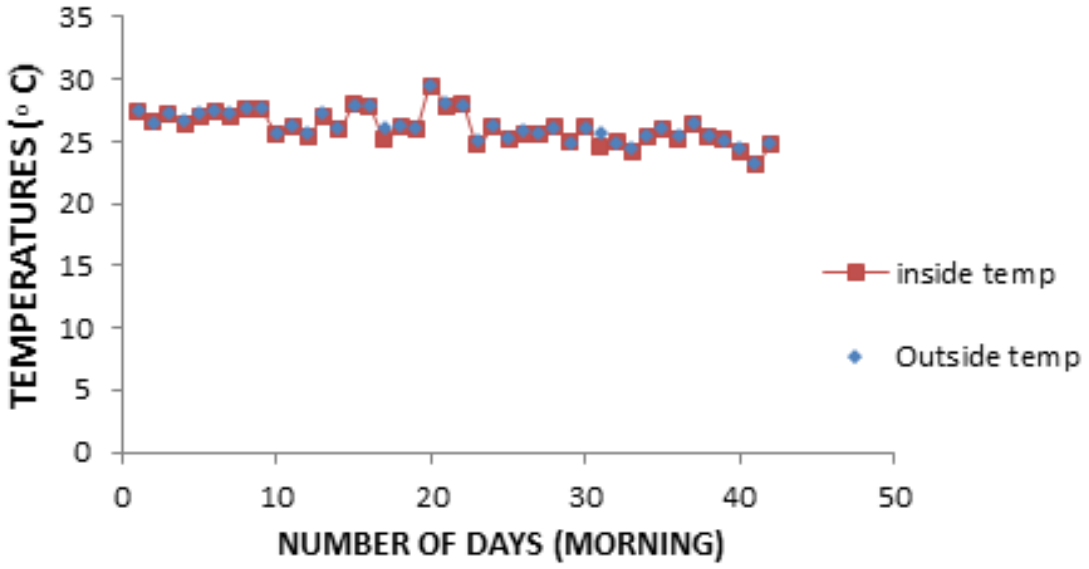


Fig 2. Temperature Gradient From Inside to Outside of the Structure in the Morning

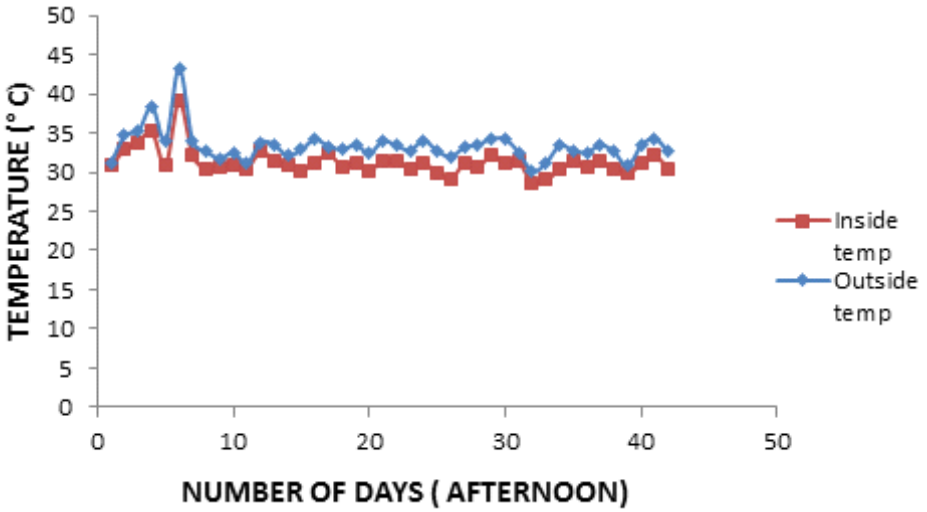


Fig 3. Temperature Gradient From Inside to Outside of the Structure in the Afternoon

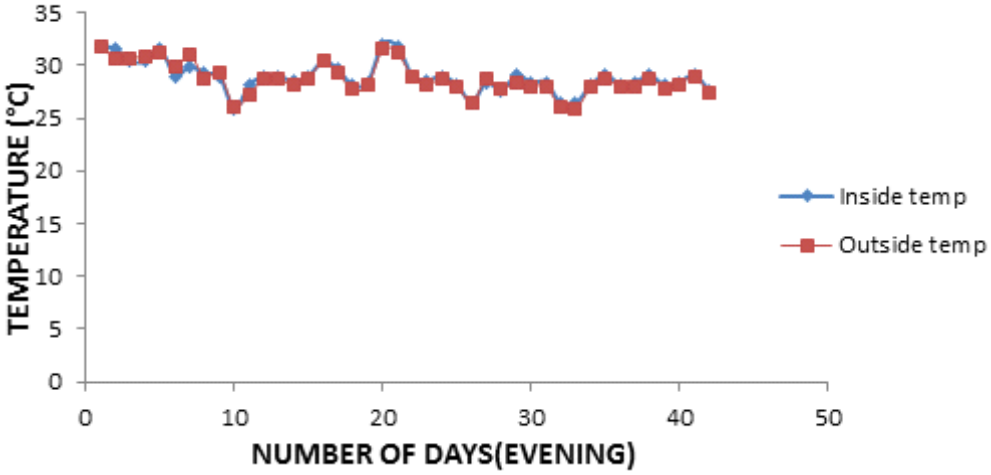


Fig 4. Temperature Gradient From Inside to Outside of the Structure in the Evening

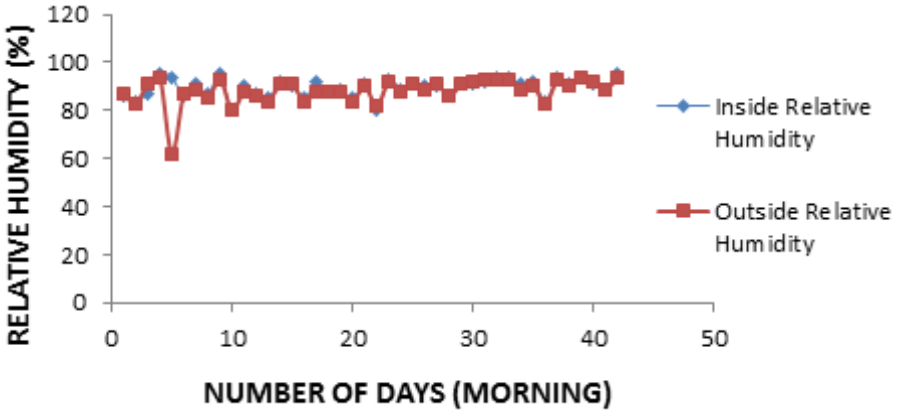


Fig 5. Relative Humidity Gradient From Inside to Outside the Structure in the Morning

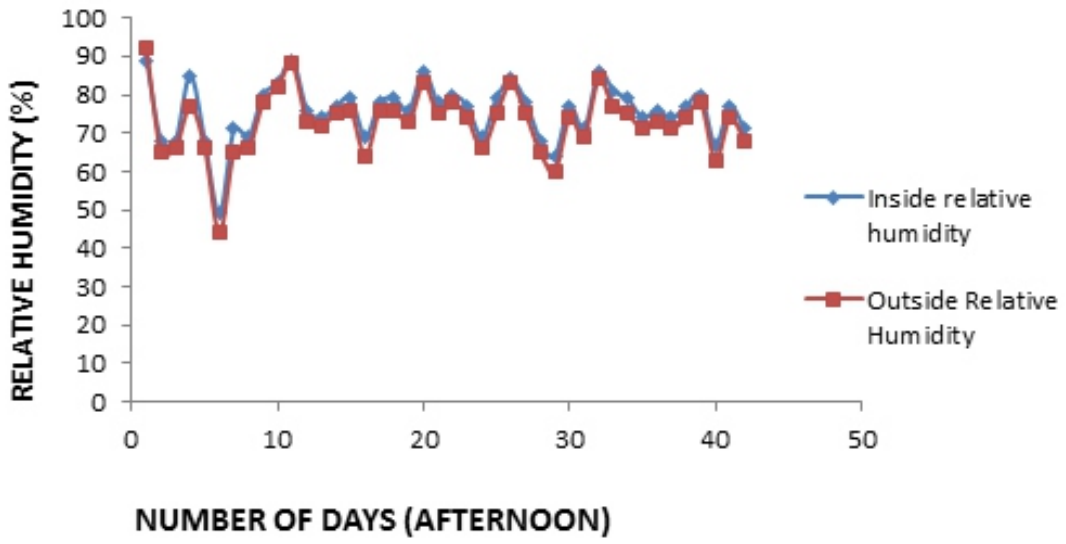


Fig 6. Relative Humidity Gradient From Inside to Outside the Structure in the Afternoon

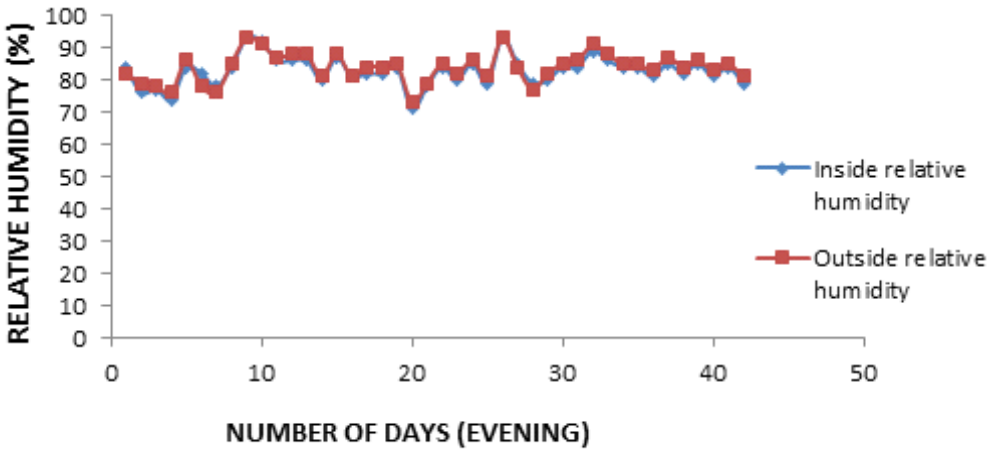


Fig 7. Relative Humidity Gradient From Inside to Outside the Structure in the Evening

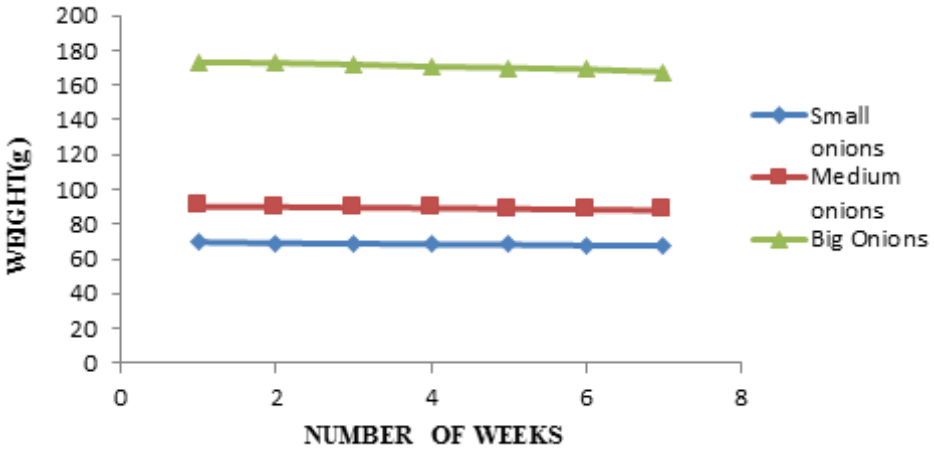


Fig 8 Weight Loss in Big, Medium and Small Onions

0.5% and 1.2% (Longhurst *et al.* 2000).Note that a TS concentration of 10 000 $mg \cdot L^{-1}$ (or 10 $g \cdot L^{-1}$) is equivalent to 1% solids; the density of manure is almost the same as that of water up to around 10% TS (Taiganides 1977).

The volatile solids component is the organic matter or degradable component that must be removed or stabilised during treatment. The VS component of dairy cattle faeces is generally 80% to 86% of TS, the remainder being ash (FS) (Zhang *et al.* 2003, Wright 2005, ASAE 2005). Any extraneous material such as laneway material walked in on hooves, soil washed from earthen pads or sand bedding entering the effluent stream will reduce the ratio of VS to FS. Breakdown of the volatile solids is also responsible for much of the manure odor.

Commonly used mechanical solid separation techniques are screens and centrifuge. The performance of various screening systems was reviewed by Zhang and Westerman (1997). The highest removal of organic matters was reported as 70% in terms of VS with 0.104 mm vibrating screen and 69% in terms of COD with 1.0 mm stationary screen. In general, the removal of organic by means of separation was below 50%.The costs of mechanical solid-liquid separation were estimated on the information reported by Bicudo (2002a). The operation cost of mechanical solid-liquid separator was estimated to be $0.26/finishing pig place/year, about $0.10/finnisher marketed. Fixed cost for a screen separator was estimated between $7,500 and $22,500.The effectiveness of solid-liquid separation is also depending on at what time solid-liquid separation is conducted. Fresh swine manure contains high levels of suspended solids (SS) and low levels of dissolved solids (DS) (Evans et al., 1978). While the manure stored in pits or in storage, it undergoes microbiological decomposition. The microbiological activity breaks down SS particles into small sized colloidal particles and DS particles that are hard to be separated from liquid because of their small sizes and stability or resolvability in a suspension system. In order to make an effective use of solid-liquid separation technology, manure separation should be conducted as soon as manure excretion. The result of a laboratory study conducted by Zhu (2000) showed that the solid-liquid separation technique, if applied to the treatment of liquid swine manure with solid particle sizes equal to or greater than 1.0 mm, should be performed within the first ten days after the manure is excreted in order to improve separation efficiency. The use of separation techniques to treat manure that is older than 25 days may not be a cost effective practice in terms of removing organic solids that have potential for producing odours during storage (Zhu, 2000). These conclusions were drawn at a condition of storage temperature from 18 to 22°C. The storage period before the separation is performed should be shorter if the storage temperature is higher.Hence the objectives of this work were to determine: i) the effects of particle size and time of manure slurry storage on the concentration of both Total Solids and Total volatile solids of cow dung. (ii) The Potential use of the Total Volatile Solid (TVS) as a parameter in determining choice of effluent management system. The second objective is based on the work of Ndegwa et al., (2002) were a strong linear relationship was observed between TS and TVS of stored pig slurry.

2.0 MATERIALS AND METHODS

2.1 Construction of Simulation PVC Columns

In other to simulate manure storage pit, five PVC columns each measuring 16cm diameter and 100cm height were constructed according to Zhu et al. 1997 .Each has a cover and a sampling point at 10cm from the base(Figure 1).

EFFECTS OF PARTICLE SIZE AND TIME OF SLURRY STORAGE ON SOME PHYSICAL PROPERTIES OF COW DUNG.

[1]Nwoke O. A., [1]Ugwuishiwu,B.O.,[1]Asoiro,F.U
[1]Department of Agricultural and Bioresources Engineering
Faculty of Engineering, University of Nigeria, Nsukka.
Email:nwoke.oji@unn.edu.ng

ABSTRACT
Fresh cow dung were collected from Ogige abattoir Nsukka Enugu State, Nigeria and were separated into five different liquid portions with particle size ranges P< 2.0mm, P<1.0mm,P<0.5mm,P<0.25mm and P<0.063mm respectively. Separation was achieved by consecutive sieving of the fresh cow manure through a series of five Canadian Standard wire screen sieves with openings of 2.0mm, 1.0mm, 0.5mm, 0.25mm and 0.063mm. The respective liquid portions which passes through the sieve openings (the filtrate) during separation of manure fractions were stored at an ambient temperature of approximately 25°C in PVC columns (100 cm deep and 16 cm in diameter) to simulate storage in under-floor or in other types of holding pits. Both particle size separation and duration of manure storage were found to have significant effect on Total Solids (TS) and Total Volatile Solids (TVS) respectively at the 5% probability level. The interactions of particle size separation and duration of manure storage were found also to have significant effect on both TS and TVS at the 5% probability level. The particle size fractions P<0.5mm and P<0.06mm had maximum and minimum concentrations of both TS and TVS respectively at probability level of 5%. Linear correlations significant at 1% probability level were observed between Total Solids (TS) and Total Volatile Solids (TVS). It appears that both TS and TVS of Cow dung may be used as parameters in determining choice of effluent management system.

Keywords: Particle-Size; Solids; Time; Cow-Dung; Slurry; Storage

1.0 INTRODUCTION

Collectively, urine and dung are called **excreta**. This excreta is typically mixed with wash water produced by cleaning yards; with wash water, chemicals and residual milk from cleaning equipment; with waste feed or bedding material; and occasionally with rainwater. The resulting liquid is usually referred to as **effluent** (or dairy shed effluent or wastewater). Excreta that dries before being collected (by scraping from feedpads or loafing yards) and is handled as a semi-solid or solid is called **manure**. Manure can also contain waste feed or bedding material and soil removed by scraping non-concrete areas.The characteristics of effluent and manure need to be understood before a suitable option for management can be selected. The relevant characteristics can be described by the physical, biological and chemical parameters. The characteristics of effluent and manure can be described by these components and other biological and chemical parameters..

The choice of effluent management system is constrained by the total solids content of the material to be handled. The TS content of manure 'as-excreted' may range from 8% to 15% and can therefore be described as a liquid or semi-liquid (a slurry). Material of this concentration is usually conveyed by augers or manure tankers. After yard and plant wash is added, the TS content of the diluted effluent is usually between

2.2 Manure Collection and Experimental Procedure

Fresh cow faeces (the content of the rumen) according to Zhu (2000) was collected from Nsukka abattoir (cow) buildings and was diluted The diluted faeces was separated into five different liquid portions with particle size ranges of <2.0mm, <1.0mm, <0.5mm, <0.25mm and <0.063mm respectively. Separation was effected by manual sieving of the fresh cow manure(rumen content) through a series of five Canadian Standard wire screen sieves with openings of 2.0, 1.0, 0.5, 0.25 and 0.063mm.The slurry which passes through each of these sieves was collected and stored in the five constructed storage pit simulation PVC columns respectively.

Each of the five simulation PVC columns (100cm deep and 16cm diameter) was filled up leaving approximately 10cm head space or freeboard . Once all the columns have been filled, each column (total of five) was thoroughly stirred using a motorized paddle stirrer (Janke & Kenkel K.G Fabirk Chem.Pys.Apparate and Machinen. TYp RM14; Nr.17047) and a sample was drawn from the homogenized slurry from a tap attached at 10cm height from the base of each column (Fig.1). This sampling technique was continued for the first 30 days of storage at 5-day intervals. The five columns were each covered at the top and stored in a dark room to simulate the condition in the storage pits.The rooms ambient temperature was between 24 and 25^{o}C throughout the storage period.

2.3 Laboratory Analysis

Using Standard Laboratory Methods (APHA, 1998), the following parameters was determined in triplicate for each collected sample: Total Solids (TS), Total Volatile Solids (TVS).

2.4 Experimental Design and Statistical Analysis

The manure sample was separated into five different size ranges and the change with time of storage in the manure was investigated in terms of TS and TVS. This fit the classical two factor (solids particle size ranges and time) experimental design for the manure sample with responses being TS, TVS.Two way analysis of variances(no blocking) was therefore performed on the responses to determine their respective variations with time and with particle size ranges in the respective manure fractions. Pair wise comparisons were performed using the Least Significant Difference method (LSD) when necessary. All analysis of variance was perfomed using GenStat Realease 7.2 DE (PC/Windows) software. All graphical representations was done using Microsoft Excel 2007 while the Correlation analysis was done using SPSS 16.0 software. A probability level of of 0.05 was used except were otherwise stated.

3.0 RESULTS AND DISCUSSION

The analysis of variance result for total solids at 5% significant level (Table 1) show that: (I) particle size level has significant effect on Total Solids ; (ii) duration of storage has significant effect on Total Solids;(iii) That particle size duration of storage interaction is significant.

The analysis of variance for total volatile solids at 5% significant level (Table 2) show that:(i) particle size level has significant effect on TVS ; (ii) duration of storage has significant effect on TVS ;(iii) particle size. duration of storage interaction is significant. The differences between mean concentration of total solids in different particle size fractions(ranges) using FLSD at 5% significant level showed that:(i) particle size(P<0.5mm) has the highest mean concentration of total solids(52277.1mg/l) and this concentration is significantly higher than mean total solids concentration recorded in

particle size fractions of P<0.063mm,P<1.0mm,P<0.25mm and P<2.0mm.(ii) particle size fraction(P<0.063mm) has the least concentration of TS(19653.4mg/l) and this is significantly lower than that for every other particle size fraction.i.e P<0.5mm,P<2.0mm,P<0.25mm and P<1.0mm.(iii) the concentration of TS in particle size(P<2.0mm) is not significantly different from the particle size fraction(P<0.25mm). Separation of differences between mean Concentration of total solids at different durations of manure Storage using FLSD at 5% significant level showed that: (i)Day 20 has the highest mean concentration of total solids(39615.6mg/l) and this concentration is significantly higher than mean total solids concentration recorded in day 10,30,0,15, 25 and day 5(ii) Day 10 has the least concentration of total solids(29423.2mg/l) and this is significantly lower than that for day 20,5,25,15 and day 0 but not significantly different from day 30.(iii) The concentration of total solids of day 0 is not significantly different from both the concentration of day 15 and day 30 respectively.(iv) Day 25 is also not significantly different from day 5.

The differences between mean concentration of total solids in different particle size fractions(ranges) for each day of manure storage using FLSD at 5% significant levels also showed that:(i) Particle size fraction (P<0.5mm) has the highest concentrations of TS in during the first 30 days.of manure storage except on day 20 and that the respective concentrations are significantly higher than concentrations in other particle size fractions throughout this period.(ii) Particle size fraction (P<0.063mm) has the lowest mean concentrations of TS during the first 30 days of manure storage and that these mean concentrations of total solids are significantly lower than that recorded for in every other particle size fraction throughout tis period except that of Particle size fractions P<1.0mm of day 15 and P<2.0mm of day 20 which show a non-significant difference .(iii) There are no significant difference between mean concentrations of TS in P<0.25mm and P<2.0mm from day 20 to day 30(iv) There are no significant difference between mean concentrations of TS in P<0.25mm and P<1.0mm from day 20 to day 25;(iv) The treatment combination, P<0.5mm.Day 5 gave the highest mean concentration of 64406mg/l of TS while the treatment combination ,P<0.063mm.Day 30 gave the lowest mean concentration of 16472mg/l of TS during the 30 days of manure storage in different particle sizes. The differences between mean concentration of total volatile solids in different particle size fractions(ranges) using FLSD at 5% significant level showed that:(i) Particle size(P<0.5mm) has the highest mean concentration of total volatile solids(12833.1mg/l) and this concentration is significantly higher than mean total volatile solids concentration recorded in particle size fractions of P<0.063mm,P<1.0mm,P<0.25mm and P<2.0mm.(ii) Particle size fraction(P<0.063mm) has the least concentration of total volatile solids(5986.43mg/l) and this is significantly lower than that for every other particle size fraction.i.e P<0.5mm,P<2.0mm,P<0.25mm and P<1.0mm.(iii) The concentration of total volatile solids in particle size(P<2.0mm) is not significantly different from that of particle size fraction(P<1.0mm).

The differences between mean concentration of total volatile solids at different durations of manure storage using FLSD at 5% level on the other hand showed that:(i) Day 20 has the highest mean concentration of total volatile solids(9213.33mg/l) and this concentration is significantly higher than mean total volatile solids concentration recorded in day 10,30,0,15, and 25 but not significantly higher than that of day 5.(ii) Day 15 has the least mean concentration of total volatile solids(7166.4mg/l) and this is significantly lower than that for day 20,5,0,30 and day 25 but not significantly lower than that for day 10.(iii) The mean concentration of total volatile solids of day 10 is not significantly different from that of day 0,30 and 25.respectively.(iv) The mean concentration of total volatile solids of day 25 is not significantly different from that of day 0 and

30. (v) Day 30 has a mean concentration of total volatile solids which is not significantly different from that of day 5 and 0.The differences between mean concentration of total volatile solids in different particle size fractions(ranges) for each day of manure storage using FLSD at 5% significant level showed that: (i) that particle size fraction (P<0.5mm) has the highest mean concentrations of TVS during the 30 days of manure storage and that the respective concentrations are significantly higher than concentrations in other particle size fractions throughout this period.(ii) that particle size fraction (P<0.063mm) has the lowest mean concentrations of TVS during the first 30 days of manure storage and that these mean concentrations of total solids are significantly lower than that recorded in every other particle size fraction throughout this period of 30 days except that of Particle size fractions P<2.0mm of day 15 .(iii) that the concentration of TVS in P<1.0mm and P<2.0mm are not significantly different during the 30 days of manure storage except day 20.(iv) that the concentration of total volatile solids in P<0.063mm and P<2.0mm are not significantly during the 30 days of manure storage.(v) that the concentration of TVS in P<2.0mm and P<1.0mm are not significantly different during the 30 days of manure storage except at day 10 and day 20. The three preceeding deductions, that is (iii), (iv) and (v) strengthens the deduction in (i) that P<0.5mm is significantly has the highest concentration of TVS.(vi) that the treatment combination, P<0.5mm.Day 5 gave the highest mean concentration of 14763mg/l of TVS while the treatment combination ,P<0.063mm.Day 10 gave the lowest mean concentration of 4897mg/l of total volatile solids during the 30 days of manure storage in different particle sizes.

The effect of storage time on the TS and TVS parameters of cow dung is presented in Figs 2and 3. The overlaps in some of the curves are probably because of the inherent problems in obtaining truly representative samples of non-homogenous materials like manure. In general, however, the contents of TS, TVS, in all particle size ranges decrease with an increase in storage time presumably because of the natural anaerobic microbial degradation. The percentage increase or decrease of TS and TVS also indicate that the smaller the particle size of the separated liquid fraction, the greater was the reduction achieved during the period of this study starting from P<0.5mm down.

This observation is consistent with the discussion presented by Zhang and Westerman (1997). The total volatile solids fraction represents the organic component of the solids .The trends of the TVS (Fig 3.2) indicate that all separated liquid fractions with less than 0.5 mm particle size were degraded significantly in approximately 15 days. On the other hand, the reduction in the TVS in the manure fractions with 2.0mm and 1.0 mm particle sizes were gradual throughout the storage period

4.0 CONCLUSIONS AND RECOMMENDATIONS

The analysis so far suggest a relationship between total solids and total volatile solids during the manure storage as both have a similar trend in terms of day of highest and lowest concentrations and also with respect to variation of concentration in the particle size fractions. Both showed a significant highest concentrations on day 20 and in particle size fraction of P<0.5mm.The same trend was also observed on their lowest concentrations respectively. Both showed significant lowest concentration at P<0.063mm and between day 10 and15.

Meanwhile it has been established from the ANOVA results that both particle size and duration of manure storage as well as their interactions have effect on total solids and total volatile solids concentrations of the manure respectively. The treatment combination, P<0.5mm.Day 5 gave the highest mean concentration of 14763mg/l of total volatile(TVS) solids while the treatment combination ,P<0.063mm.Day 10 gave the lowest mean concentration of 4897mg/l of total volatile solids(TVS) during the 30 days of manure storage in different particle size fractions

The treatment combination, P<0.5mm .Day 5 also gave the highest mean concentration of 64406mg/l of total solids (TS) while the treatment combination, P<0.063mm .Day 30 gave the lowest mean concentration of 16472mg/l of total solids during the 30 days of manure storage in different particle size fractions. This suggest that both total solids and total volatile solids increases from day 0 to day 5 and decreases gradually throughout the period and the trend agrees with the work of Ndegwa et. al,(2001) were total solids and total volatile solids were found to decrease during the storage of separated swine manure. A linear correlation was observed between TS and TVS .It appears that both TS and TVS of Cow dung may be used in determining choice of effluent management system. Further research with different manure source and longer duration of manure storage is therefore recommended to authenticate these findings.

REFERENCES

American Public Health Association, American Water Works Association, Water Environment Federation (1998) Standard Methods for the Examination of Water and Wastewater amine emissions from a large cattle feedlot. J. Environ. Qual. 11, 288.

ASAE 2005, 'Manure Production and Characteristics', ASAE Standard, D384.2, American Society of Agricultural Engineers, St. Joseph, Michigan, USA.

Bicudo, J. R. 2002a. Frequently asked questions about solid-liquid separation, www.bae.umn.edu/extens/faq/sol_liqfaq.html, visited February, 2002.

Evans, M. R., R. Hissett, M. P. W. Smith, and D. F. Ellam. 1978. Characteristics of slurry from fatting pigs, comparison with slurry from laying hens, Agriculture and Environment January, 2002.

Longhurst, R.D., A.H. Roberts & M.B. O'Connor 2000, 'Farm dairy effluent: A review of published data on chemical and physical characteristics in New Zealand', *New Zealand Journal of Agricultural Research,* 43, 7–14.

Ndegwa, P.M., Zhu, J., Luo, A. (2002). Effects of solids separation and time on the production of odorous compounds in stored pig slurry. J. Biosysterm Engineering 81(1), 127 – 133.

Taiganides, E.P. (Ed.) 1977, *Animal Wastes*, Applied Science Publishers, London, UK.
USDA-NRCS 1996, 'Agricultural Waste Management Field Handbook', National Engineering Handbook Part 651, USDA-NRCS.

Wright, W.F. 2005, 'Dairy manure particle size distribution, properties, and implications for manure handling and treatment', Paper No. 054105, *ASAE Annual International Meeting*, Tampa, Florida, USA, 17–20 July 2005, American Society of Agricultural and Biological Engineers.

Zhang, R.H. and P.W. Westerman. 1997. Solid-liquid separation of animal manure for odourcontrol and nutrient management. Applied Engineering in Agriculture13 (5): 657-664.

Zhang, R.H., P. Yang, C.A. Collar & L. Ham 2003, 'Treatment of flushed dairy manure by solid liquid separation and lagoon aeration', Paper No. 701P1203, *Proceedings of the*

Ninth International Symposium on Animal, Agricultural and Food Processing Wastes, Raleigh, North Carolina, USA, 11–14 October 2003, ASAE.

Zhu, J. 2000. Early Separation of Fresh Swine Manure May Enhance Separation Efficiency, Minnesota/Wisconsin Engineering Notes, Summer 2000. www.bae.umn.edu/, visited January, 2002.

Zhu, J., P. M. Ndegwa, and A. Luo. 2000. Changes in swine manure solids during storage may affect separation efficiency. Applied Engineering in Agriculture 16(5):571-575.

Table 1: Analysis of Variance (ANOVA) Table for Total Solids (TS)

Source of variation	d.f	s.s	m.s	v.r	F.pr
PARTICLE_SIZE(P)	4	1.179E+10	2.947E+09	264.14*	<.001
TIME(T)	6	1.054E+09	1.756E+08	15.74*	<.001
PARTICLE_SIZE.TIME(PT)	24	2.284E+09	9.518E+07	8.53*	<.001
Residual	70	7.810E+08	1.116E+07		
Total	104	1.591E+10			

*Significant at 5% level(F.pr<0.05)

Table 2: Analysis of Variance (ANOVA) Table for Total Volatile Solids(TVS)

Source of variation	d.f	s.s	m.s	v.r	F.pr
PARTICLE_SIZE	4	6240558516	156014629	205.6*	<.001
TIME	6	41056265	6842711	9.02*	<.001
PARTICLE_SIZE.TIME	24	48006812	2000284	2.64*	<.001
Residual	70	53106925	758670		
Total	104	766228518			

*Significant at 5% level(F.pr<0.05)



Figure 1: Constucted PVC Simulation Columns, Sampling Cans, Five Canadian Standard Wire Screen Sieves, Thermometers and 250mL Beaker.

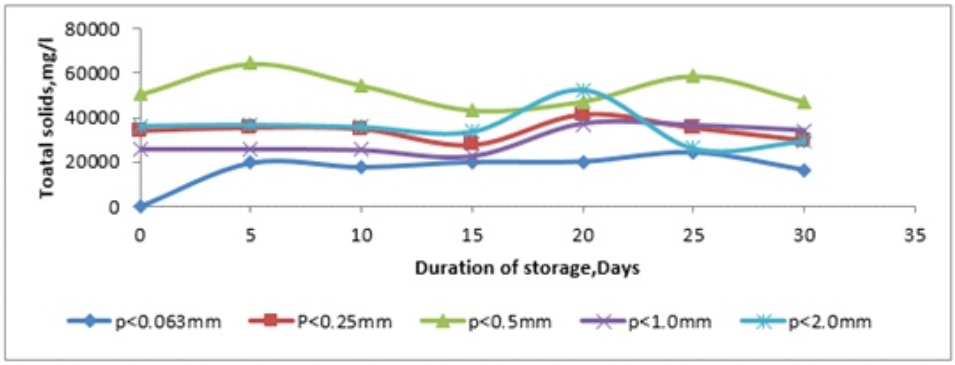


Figure 2:Effect of Time on Total Solids(TS) During the First 30 Days of Manure Storage for Different Particle Sizes.

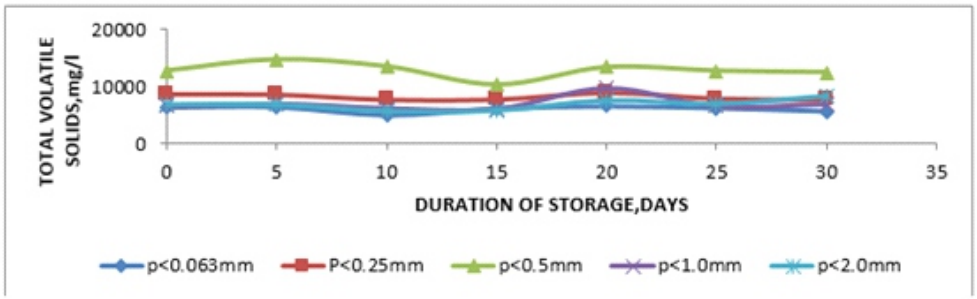


Figure 3:Effect of Time on Total Volatile Solids(TVS) During the First 30 Days of Manure Storage for Different Particle Sizes.

FLOW PROPERTIES OF CASSAVA AND YAM STARCH-GLYCEROL RESINS USEFUL IN THE DESIGN OF SCREW EXTRUDER FOR FILM MAKING

Adeshina Fadeyibi[1], Zinash Delebo Osunde[2], Gbagbo Agidi[3] and Egwim Chidi Evans[4]

[1,2] Department of Agricultural and Bioresources Engineering, Federal University of Technology Minna, Nigeria

[3]Assistant Director, National Cereal Research Institute Badegi, Niger State, Nigeria

[4]Senior lecturer, Department of Biochemistry, Federal University of Technology Minna, Nigeria

ABSTRACT

A research was conducted to determine the flow properties of cassava and yam starch-glycerol resins for their application in the design of screw extruder which can be used in the production of bio-films in the food sector. The strength and flow properties of the bulk materials which include consolidation, shear and unconfined yield stresses were determined at different bulk densities and resin concentrations in the range of 1.5-3.0 g/cm^3 and 15-25 mL glycerol per 100g starch using uniaxial compression test. The flowability of the bulk solids were classified using Jenike's flow specifications. The angles of internal and wall frictions, the friction factors accounting for vibration in the arch thickness and geometric configuration of the resins and the hopper half angles of the bulk solids were determined from their Mohr stress circles and the conical hopper design chart, respectively. The results show that compressive strength of cassava and yam starch-glycerol resins increased significantly with increasing bulk density and resin concentration ($p< 0.05$). The cohesiveness of the resins increase with increasing glycerol concentration, up to 25 mL per 100g starch, because of their increasing flow functions $1 < ff < 2$. The hopper half angle, friction factor and angles of internal and wall frictions of cassava starch-glycerol resin at 3.0 g/cm^3 were 18.0^o, 2.48, 43.0^o and 26.0^o, respectively. The results are important considerations in the design of the hopper part of a single screw extruder for the production of cassava and yam starch-glycerol composites.

Keywords: Flow Properties, Cassava Starch, Yam Starch, Consolidation Stress, Flow Function

1.0 INTRODUCTION

The technology of bio-film making is receiving wider attention in the food and beverage industries the world over. This is in view of the biodegradable nature of such films compared to the films obtainable from petroleum based materials which are non-biodegradable, and as such posed little or no pollution waste hazard to the environment. Therefore, the packaging and preservation of fruits and vegetables with bio-film materials are nowadays, increasingly replacing the use of synthetic polymer materials in the food sector.

A typical bio-film technology involves the use of screw extruder for melting, mixing and homogenization of bio composites for film casting. The flow of the bio composite material through the hopper of the screw extruder depends on the flow properties of the bulk materials. Flowability is not an inherent material property, but the result of the combination of material physical properties that affect material flow and the

equipment used for handling, storing or processing the material. Equal consideration must be given to both the material characteristics and the equipment. The same powder may flow well in one hopper but poorly in another; likewise a given hopper may handle one powder well but cause another powder to hang up. Therefore, powder flowability is defined as the ability of powder to flow in a desired manner in a specific piece of equipment (Bumiller *et al.,* 2012).

The specific bulk characteristics and properties of a powder that affect flow, which can in principle be measured, are known as flow properties. These flow properties refer to the behaviour of the bulk material, and arise from the collective forces acting on individual particles, such as van der Waal, electrostatic, surface tension, interlocking, friction and so on (Bumiller *et al.,* 2012).

Parameters of internal friction and flow properties of powders influence handling and processing operations such as flow from silos and hoppers, transportation, mixing, compaction or packaging (Knowlton, 1994). With increasing scale of industrial operations, there is a growing demand for information about food powder parameters to design reliable processes and efficient equipment. The flow characteristics of food powders have recently gained special importance as measures of quality of final product on-line, as well as during later handling and on-shelf storage (Molenda and Stasiak, 2002). Flow in silos can take the form of one of two patterns: mass or funnel flow (Jenike, 1964). During mass flow, all the particulate is in motion and moving downward towards the discharge opening, while in the case of funnel flow particulate discharges through a flow channel formed within the grain bulk and no sliding along the wall takes place. A serious industrial problem that may occur during technological operations on food powders is cessation of flow. This is usually a result of an arch forming across the discharge opening, which has strength sufficient to be self-supporting.

A number of methods and testers exist in literature for determining the strength and flow properties of bulk solids. Schwedes (2002) reported that choosing the right method for the specific application requires knowledge and some experience in handling bulk materials. Most frequently, the flow properties of bulk solids have been determined by performing a shear test following slightly modified procedure proposed by Jenike (1964) and most recently by Fitzpatrick *et al.* (2004). The testing consists of two stages: consolidation under normal reference pressure and measurement of shear force. Repeatability of the test results may be attained only if the consolidation was identical. Also more direct methods such as the uniaxial compression test had been used with success (Schwedes, 2002). Hence, the idea of investigating the flow properties of bulk solids, using the uniaxial compression test, for use in the design and flow analysis of screw extruder was conceived. Therefore, the objective of this study was to determine the flow properties of cassava and yam starch-glycerol resins for use in the design of screw extruder in bio-film making.

2.0 MATERIALS AND METHODS

2.1 Sample Preparation

250kg each of fresh cassava roots and yam tubers were pealed and soaked in separate clean bowls containing water for 24 hours after which they were grinded. The grinded products were then sieved in muslin sacks and the resulting filtrates were left undisturbed for another 24 hours to allow the starches to settle at the bottom of the separate bowls. The prepared starches of cassava and yam were dried under the sun for one week until a moisture content of 2 % (wb) was achieved in each case.

Glycerol of analytical grade, obtained from Science Equipment and Development Institute (SEDI), Minna Niger State was used to form pastes of the resulting dried cassava and yam starches. This was done by adding 15, 20 and 25mL glycerol in three separate cans each containing 100g of cassava and yam starches, respectively. The mixtures were stirred thoroughly with the aid of spatula and kept for 2 hours for hydration.

The bulk density of the starch pastes was varied as 1.5, 2.0 and 3.0 g/cm^3 by consolidating 30g of the products with the aid of syringe and the stresses were carefully relieved at predetermined volumes. The procedure was repeated three times for each bulk density.

A total of nine samples with three replicas were obtained from cassava and yam starches, respectively. Each sample was completely sealed in a transparent polyethylene bag of low density and kept in the refrigerator at 5^{o}C to prevent further hydration before subsequent experiments.

2.2 Uniaxial Compression Test

The Instron machine (ZDM50-2313/56/18, Germany) was used to carry out compression test on the bulk samples of cassava and yam starches at the Federal Institute of Industrial Research, Oshodi Lagos State. The stress values at peak, break and yield points of compression were obtained from the machine operated at a speed of 020.00 mm/min and in the loading range of 0-500N as testing conditions. The compressive stress at peak gave the consolidation stress of the material under compression in a confined hollow cylindrical ring. On subsequent compression, the specimen (now unconfined) broke at certain critical stress known as the shear stress of the sample under compression. The stress causing the specimen to flow incipiently as a result of further compression with decreasing bulk density in an unconfined state is called unconfined yield stress (Schulze, 2011).The procedure was repeated three times for each of the nine bulk samples of cassava starch-glycerol and yam starch-glycerol resins and the average values and standard deviations were computed.

2.3 Determination of Flow Function, Angles of Internal and Wall Frictions

The flow functions of cassava and yam starch-glycerol resins defined as the ratio of consolidation to unconfined yield stresses were computed from the inverse of the slopes of the straight lines connecting the unconfined yield and consolidation stresses of cassava and starch-glycerol resins, respectively. During consolidation of the bulk solid samples, the vertical normal stress acts on the top of the bulk solid specimens. Another kind of stress called horizontal stress acting perpendicular to the vertical was also found to prevail and the specimen was sheared as the stress continued in an unconfined position. Neither at the top nor at the bottom of the specimen, nor at the interval wall of the hollow frictionless cylinder was the shear stress found in the confined state (Schulze, 2011).

The plots of pair of values of consolidation and shear stresses of cassava and yam starch-glycerol resins at different bulk densities gives straight lines with series of stress circles produced on the consolidation stress axes called the Mohr stress circles. The angle of internal friction of the starch materials were determined from the straight lines tangent to the greater Mohr circle which defines the effective yield locus enclosing the consolidation stress axis and the angle of internal friction on the curves. Hence, the angle of internal friction was regarded as the internal friction of bulk solid at steady-state flow because the largest Mohr circle indicates the steady flow state (Jenike, 1964). The friction angles between the cassava or yam starch-glycerol resins and the surface of the solid, notably the wall of the hopper, called the angle of wall friction were also investigated from the Mohr stress circles. Figure 1 shows the shear stress-consolidation

stress curve with the effective yield locus, angle of internal and wall frictions of cassava starch-glycerol resin determined at 3 g/cm^3. Similar curves were constructed for other thermoplastics at bulk densities of 1.5, 2 and 3g/cm^3, respectively.

The data obtained from the uniaxial compression test were subjected to statistical analyses using a 3^3 full factorial experiment with the compressive stress as the main factor, resin concentration as sub factor and the bulk density as sub-sub factor each with three levels in a randomized complete block design. Further analyses, using the Least Significant Difference (LSD) test, was conducted to access the level of significance at $p < 0.05$ and $p < 0.01$, respectively (Gomez and Gomez, 1984). It was necessary to access the significant level of the compressive strengths at $p < 0.01$ in order to ensure 99% confidence in the measured data free of experimental errors.

3.0 RESULTS AND DISCUSSIONS

3.1 Flow Functions of Cassava and Yam Starch-Glycerol Resins

The uniaxial compression test conducted at different bulk densities leads to different pair of values of consolidation stress and unconfined yield stress (Tables 1 and 2). The plots of these pairs of values and the resulting curves called the flow functions The plots of these pairs of values and the resulting curves called the flow functions (*ff*) are important in the characterization of flowability of cassava and yam starches and their variations (Figures 1 and 2). The compressive stresses of cassava and yam starch-glycerol thermoplastic resins were highly significant ($p< 0.05$) at bulk densities of 1.5, 2 and 3g/cm^3 from 15 mL, 20 mL or 25mL glycerol per 100g starch and their interactions (Table 3). Further analyses, using the LSD test of significance, indicate that the mean compressive stresses of starch glycerol resins were significant ($p< 0.05$) when the treatment effects of 2 and 3g/cm^3 were compared with 1.5 g/cm^3 for all resin concentrations of cassava and yam starch thermoplastics (Table 4). Consequently, the bulk density of 3g/cm^3 can be said to be effective for maximum compression of the two bulk materials. Hence, the bulk density of 3g/cm^3 can be used in the design of their screw extrusion machine.

The ratio *ff* of consolidation stress to unconfined yield stress was used to characterize the flowability of cassava and yam starch-glycerol resins numerically. Jenike (1964) classified the flow behaviour of bulk material as not flowing, very cohesive, cohesive, easy flowing and free flowing when $ff <1$, $1 < ff < 2$, $2 < ff < 4$, $4 < ff < 10$ and $10 < f$ respectively. Schulze (2011) adopted Jenike's idea and stated that the free flowing of starchy material is nearly impossible because of their high cohesion. Now, based on the foregoing, the 25 mL glycerol per 100g cassava or yam starch resin was more cohesive than 15 mL or 20 mL glycerol per 100g cassava or yam starch resin (Figures 2 and 3). Hence, the flow equations that expressed the flow functions of cassava and yam starch glycerol resins with the most cohesiveness are given below:

where:= consolidation stress (kPa), , = unconfined yield stresses of cassava and yam starch-glycerol (kPa), respectively.

3.2 Flow Properties of Cassava and Yam Starch-Glycerol Resins

The angles of internal friction between individual starch molecules obtained from the Mohr Stress circles was found to increase from 34^o to 45^o up to 2 g/cm^3 and then decrease to 37^o at 3 g/cm^3 of yam starch-glycerol resin. The angle increase from 40^o to 43^o between 1.5 to 3 g/cm^3 of cassava starch-glycerol resin (Figure 4). Angle of internal friction data is needed for calculating the lateral pressure on walls of storage bins and for the design of gravity flow hopper (Rao, 1992). The angle is also a requirement, according

to Jenike (1964) and Fitzpatrick *et al.* (2004), in the design of hopper opening of screw extruder for the handling bulk solids.

The angle of wall friction between starch molecules and hopper surface obtained from the Mohr stress circles increases from 22° to 25° between 1.5 to 2 g/cm^3 and then decrease to 21° at 3 g/cm^3 of yam starch-glycerol resin. The angle decrease from 26° to 25° between 1.5 to 2 g/cm^3 and then increase to 26° at 3 g/cm^3 of cassava starch-glycerol resin (Figure 5). The coefficient of wall friction or the wall friction angle was important for hopper design for flow and strength (Schulze, 2011). Bumiller *et al.* (2012) reported that the lower the angle of wall friction the less steep hopper wall need to be for material to flow alone them. Savage (1967) carried out an analysis of gravity flow of cohesionless bulk solids in a vertical converging channel and observed that the wall friction was more influential than the angle of internal friction in reducing the flow rate for small values of cone wall half angle. Therefore, the high angle of wall friction at 3 g/cm^3 requires that the hopper wall be steep enough to allow more resins to flow.

Table 4 shows the flow properties of cassava and yam starch-glycerol resins at different bulk densities. The pair of angles of internal frictions and wall frictions (40°, 26°), (41°, 25°) and (43°, 26°) for cassava starch glycerol resin and (34°, 22°), (45°, 25°) and (37°, 21°) for yam starch-glycerol resin at 1.5, 2 and 3 g/cm^3 bulk densities as shown in Figures 4 and 5, respectively were used to deduce the hopper half angles from the conical hopper design chart (Jacob, 2004). The hopper half angles were slightly constant in both cassava and yam starch-glycerol resins with mean values of 18.33° and 23° in each case. This is probably because of increased angle of wall frictions with increasing bulk densities of the bulk materials.

The actual consolidation stress used in the design of hopper outlet size of screw extruder was computed from the flow equations representing 25mL glycerol per 100g starch having more cohesion than other resin concentrations (Table 4). The actual consolidation stress increased with increase in unconfined yield stresses of both cassava and yam starch-glycerol concentration. This is probably because of increase in bulk densities of the starch materials with increasing time consolidation in an unconfined state. Also the hydration effects of glycerol over time established on the bulk materials induced time consolidation thus increasing the bulk densities in the unconfined state.

The friction factor accounting for hopper half angle, vibration in the arch thickness and geometric configuration of cassava and yam starch-glycerol resins was shown in Table 4. The friction factor increased with increasing angle of internal friction from 40° to 43° for cassava starch-glycerol resin. The factor however, increased between 34° and 45° and then decreased at 37° for yam starch-glycerol resin. The increased friction factors of cassava starch-glycerol resin may be because cassava starch granules are geometrically one-dimensional. The instability in the values of the friction factor of yam starch-glycerol resin can be associated with the non-uniformity of the geometrical size of yam starch granules causing its bulk density to become unstable. These buttress the studies by Fatah *et al.* (1998) and Fatah and Sanchez (2004) on cohesive powders where they reported the existence of two categories of granular sizes as micronic (with particle size = 50μm) and nanometric (with particle size = 500nm) in most powders. They also reported that the nanometric particles are more complex and show a different behavior from the micronic particles under the action of the variation of the external forces.

CONCLUSIONS

The flow properties of cassava and yam starch-glycerol thermoplastics were investigated for use in the design of a single screw extruder suitable for their mixing and

homogenization. The compressive strength of cassava and yam starch-glycerol resins, which include consolidation, shear and unconfined yield stresses, increased significantly

Table 1: Compressive Stress of Cassava Starch-Glycerol Resin

	Compressive Strength (kPa)		
Bulk Density (g/cm^3)	**Consolidation Stress**	**Shear Stress**	**Unconfined Yield Stress**
15 mL glycerol per 100g cassava starch			
1.5	1.0495± 0.0368	1.025± 0.0289	0.9833± 0.0307
2.0	1.3791± 0.0688	1.3473± 0.0527	1.3220± 0.0652
3.0	2.0720± 0.1131	2.0380± 0.1013	2.0157± 0.0816
20 mL glycerol per 100g cassava starch			
1.5	1.0012± 0.0070	0.9872± 0.0152	0.8520± 0.0637
2.0	1.3604± 0.0177	1.3382± 0.0105	1.1993± 0.0942
3.0	2.0853± 0.0244	2.0537± 0.0389	1.9217± 0.0713
25 mL glycerol per 100g cassava starch			
1.5	0.9892± 0.0057	0.9805± 0.0038	0.7920± 0.0611
2.0	1.3547± 0.0126	1.3344± 0.0155	0.9924± 0.2473
3.0	2.0730± 0.0032	2.0393± 0.0163	1.4983± 0.3722

Table 2: Compressive Stress of Yam Starch-Glycerol Resin

	Compressive Strength (kPa)		
Bulk Density (g/cm^3)	**Consolidation Stress**	**Shear Stress**	**Unconfined Yield Stress**
15 mL glycerol per 100g yam starch			
1.5	0.6062±0.0064	0.5942±0.0054	0.5942±0.0026
2.0	0.9504±0.0224	0.9324±0.0144	0.9224±0.0145
3.0	1.5123±0.0217	1.4790±0.0275	1.447±0.0305
20 mL glycerol per 100g yam starch			
1.5	0.5645±0.0099	0.5653±0.0056	0.5487±0.0036
2.0	0.8084±0.0177	0.7876±0.0152	0.7629±0.0144
3.0	1.2223±0.0238	1.2067±0.0323	1.1763±0.0211
25 mL glycerol per 100g yam starch			
1.5	0.5735±0.0019	0.569±0.0033	0.5472±0.0045
2.0	0.7782±0.0046	0.7767±0.0066	0.708±0.0058
3.0	1.192±0.0070	1.189±0.0347	1.095±0.0665

Table 3: Analyses of Variance (ANOVA) of Data in Tables 1 and 2 From a 3×3×3 Factorial Experiment in Randomized Complete Block Design

S/N	Thermo plastic	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 1%	Tabular F 5%
.	Yam Starch	Strength	2	0.00983	0.00492	16.378**	6.226	3.664
		Treatment	8	2.54726	0.31841	1060.7**	3.89	2.591
		Resin Conc. (A)	2	2.30685	1.15342	3842.5**	6.226	3.664
		Bulk density (B)	2	0.16976	0.08489	282.77**	6.226	3.664
		Interaction (A ×B)	4	0.07066	0.01766	58.846**	4.773	3.007
		Error	16	0.00480	0.00030			
		Total	34	2.56190				
.	Cassava Starch	Strength	2	0.21110	0.1055	10.97**	6.226	3.664
		Treatment	8	4.91875	0.6148	63.87**	3.89	2.591
		Resin Conc. (A)	2	4.82793	2.4140	250.78**	6.226	3.664
		Bulk Density (B)	2	0.07891	0.0395	4.0990*	6.226	3.664
		Interaction (A ×B)	4	0.01191	0.0030	0.3092ns	4.773	3.007
		Error	16	0.15401	0.0096			
		Total	34	5.28386				

CV^1, CV^2 = 6.96%, 1.94% for yam and cassava starches, respectively,
** = significant at 1% level, * = significant at 5% level, ns = not significant at 1% level[Z]

Table 4: Flow Properties of Cassava and Yam Starch-Glycerol Resins

Resin and Flow Function	Flow Properties	Symbol/Unit	Bulk Density 1.5	Bulk Density 2.0	Bulk Density 3.0
Cassava Starch-G (ff = 1.53)	Average UYS	Ä„K0°	0.876	1.171	1.812
	Average CS	Ä„K0°	1.223	1.644	2.556
	Hopper half Angle	ÄŞ•ß≤••	18.00	19.00	18.00
	Friction Factor	H (Ä	2.390	2.420	2.480
Yam Starch-G (ff = 1.73)	Average UYS	Ä„K0°	0.563	0.798	1.239
	Average CS	Ä„K0°	0.713	1.043	1.665
	Hopper half Angle	ÄŞ•ß≤••	25.00	19.00	25.00
	Friction Factor	H (Ä	2.480	2.870	2.600

G = Glycerol, UYS = Unconfined Yield Stress, CS = Consolidation Stress

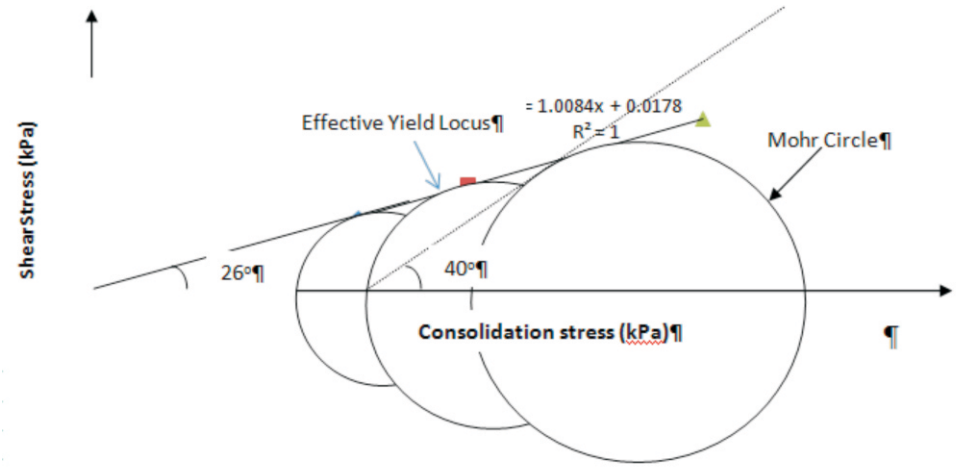


Figure 1: Consolidation-Shear stress Curve of Cassava Starch-Glycerol Resin at 3g/cm ***2.4 Statistical Analyses***

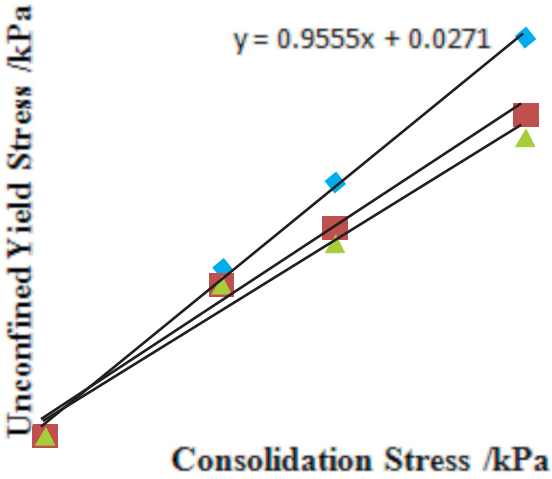


Figure 2. Flow Function of Yam Starch With Glycerol Variability

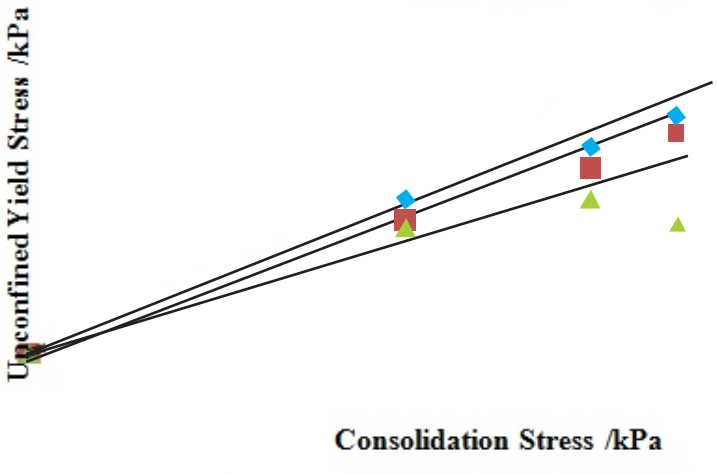


Figure 3 Flow Function of Cassava starch with Glycerol Variability¶

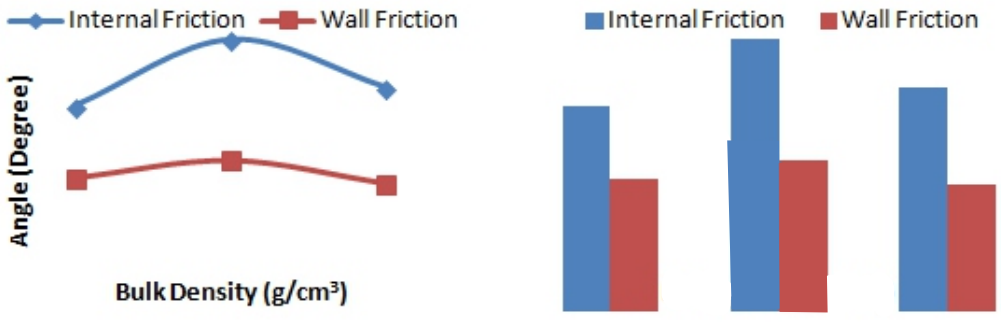


Figure 4 Influence of Bulk Density on Hopper Angle of Yam Starch-Glycerol Resin

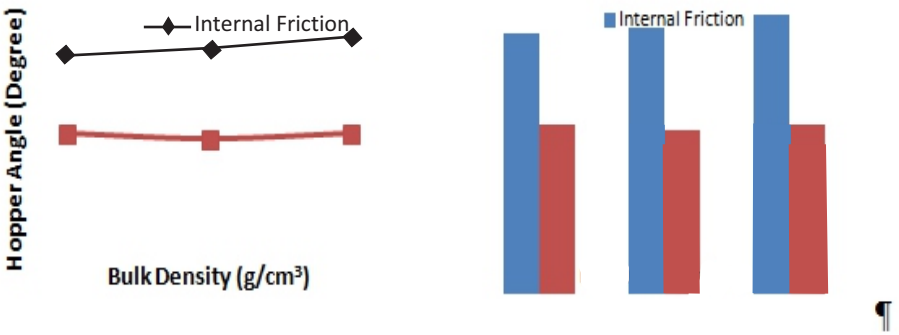


Figure 5 Influence of Bulk Density on Hopper Angle of Cassava Starch-Glycerol Resin¶

DESIGN AND DEVELOPMENT OF A MOTORIZED SCREWED BRIQUETTING MACHINE

*** Onyenwoke C.A.[1] and Simonyan K.J. [2]**
[1&2] Department of Agricultural and Bio Resources Engineering, College of Engineering and Engineering Technology , Michael Okpara University of Agriculture Umudike, P.M.B 7267 Umudike, Abia state.
*Corresponding Author: (maigidaaus@yahoo.com, austynchuka@yahoo.com; phone: +2348068089373)

ABSTRACT
A preliminary experimental motorized screwed briquetting machine was developed using locally available materials. Resized palm kernel shell at 0.175mm, 0.5mm, and 2.63mm mixed with starch gel in proportion of 9:1, 8:2 and 7:3 were used to test the developed briquetting machine. Result showed that the developed briquetting machine capacity was 42 kg/hr and briquetting efficiency 75 %. The briquetting machine produced 8.1 % and 12.6 % broken and deformed briquettes respectively. A mixture ratio of 7:3 palm kernel shell to starch gel and particle size of 0.125 mm forms efficient and quality briquettes.

Keywords: Palm Kernel Shell, Starch Gel, Briquetting, Briquetting Machine, Energy

1.0 INTRODUCTION
Energy is a necessary requirement in everyday life. Its application ranges from cooking, food processing to other more complex industrial and commercial applications. Stout (2001) recommended that a transition to a sustainable energy system is urgently needed in the developing countries such as Nigeria. This should, of necessity, be characterized by a departure from the present subsistence energy usage levels based on decreasing firewood resources to a situation where human and farming activities would be based on sustainable and diversified energy forms (Olorunnisola, 2007).

An energy source that meets such sustainability requirements is fuel briquette. If produced at low cost and made conveniently accessible to consumers, briquettes could complement firewood and charcoal for domestic cooking and agro-industrial operations, thereby reducing the high demand for both, reducing problems of handling, air pollution, erosion, desertification, environmental degradation and increasing the energy calorific value. Besides, briquettes have advantages over firewood in terms of cleanliness, convenience in use, greater heat intensity and relatively smaller space requirement for storage (Olorunnisola, 2004).

Briquettes can be produced from agricultural by-products or waste, pressed into compact patties or pellets. This fuel source can offset the consumption of trees and help to reduce resultant desertification; they are easily stored and easily transported fuel. Briquettes provide more calorific value/kg and save around 30-40 % of fossil fuel cost (Nicholas, 2006). Burning briquette is far more efficient than burning firewood (FAO, 1990). Briquetting technology can be divided into two distinct categories: low and high pressure densification. Low pressure densification uses pressures under 30 bar and has two sub-categories those which use an added material to bind the biomass particles together and those which do not. High pressure briquetting uses a pressure greater than

technologies vary in their capacity (usually expressed in terms of mass of briquettes produced per hour).

In Nigeria, large quantities of agricultural and forestry residues produced annually are greatly under-utilized. The common practice is to burn these residues or leave them to decompose, (Olorunnisola, 1998; Jekayinfa and Omisakin, 2005). Most of these agro-wastes provide supplementary firewood in household or small-scale industries for heating purposes. The direct burning of the loose biomass in conventional grate is associated with very low thermal efficiency, loss of fuel and widespread air pollution. A number of locally available materials which can be briquetted for fuel energy production include sawdust, cowpea chaffs, palm kernel shells, corncobs, and water hyacinth (Faborode, 1988; Adekoya, 1989; Ajayi and Lawal, 1995; Olorunnisola 1998, 1999).

The general objective of the study is to develop a motorized screw briquetting machine while the specific objective is to test the developed machine for machine capacity and efficiency of briquette production.

2.0 MATERIALS AND METHODS

2.1 Design Considerations

The following factors were considered in developing the briquetting machine

i. It should be able to use a wide range of biomass waste
ii. It should be simple to operate and maintain
iii. It should be affordable to the end user.

2.2 Some Engineering Properties of the Palm Kernel Shell

Some of engineering properties of the palm kernel shell samples were considered in the design.

2.2.1 Moisture content determination.

Moisture content of samples was determined using the procedure detailed by Henderson et al (1997). The samples were dried at 105°c for 24 hrs. The weight loss of samples was recorded and moisture determined using equation 1.

$$MC_{wb} = \frac{M_i - M_d}{M_{i1}} X100 \qquad 1$$

Where MC_{wb} = moisture content wet basis,%
M_i =mass of initial sample, g
M_d = Mass of dried sample, g

2.2.2. Angle of repose.

The angle of repose of palm kernel sample was determined using an open box separated into two compartments by a slidable wedge. The small compartment was filled to the top and then the slidable wedge slowly lifted, allowing the material to flow under its own weight forming a triangular shape. By measuring the base and height of the triangle, the angle of repose was calculated:

$$\theta = \tan^{-1} \frac{y}{x} \qquad 2$$

Where Y= height of sample, cm
X= base of sample forming the angle, cm.

2.2.3 Bulk Density

The bulk density was determined by filling a container of known volume with the samples from a height of 150 mm at a constant rate and weighing the contents. The bulk density of the samples was calculated using the expression in equation 3.

$$\beta = \frac{m}{v} \qquad 3$$

Where: β= bulk density, g/cm^3
m = mass of samples (g)
v = volume of container (cm^3)
This experiment was repeated using the starch gel and also the mixture of starch gel and grounded palm kernel shell.

2.3 Design of Components

2.3.1 Design of shaft diameter

A shaft is a rotating machine element which is used to transmit power from one component to another. The shaft being design is considered to be subjected to combined twisting and bending moment.
From maximum shear stress theory given by Khurmi and Gupta (2006).

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{M^2 + T^2} \qquad 4$$

Where M= Maximum bending moment
T= Twisting moment
D = shaft diameter
The expression $\sqrt{M^2 + T^2}$ is known as equivalent twisting moment and is denoted by Te.

2.3.2 Design of Screw Conveyor

The capacity of the screw conveyor

$$Q = \pi\left(D^2 - d^2\right) \times N \times P \times \kappa \subset 60 \qquad 5$$

Where D = diameter of screw conveyor assumed to be equal to inner diameter of barrel (m).
d = diameter of shaft (m)
N = speed of shaft (m/s)
P = pitch (m)
K = material factor

2.4 Description of the Machine

The machine consists of the following component parts: frame, barrel, hopper, rotor shaft, driving mechanism and auger.

i. Frame- The frame is a supporting part of the machine, constructed using a 5 cm by 5 cm angle iron. It has four legs. The vertical height is 75 cm, horizontal length is 75 cm, and the width is 50cm at the top and 60 cm at the bottom. The supporting member of the frame is welded from one end to the other; and the engine seating is welded to the supporting member of the frame.

Ii. Barrel - The barrel is made of 4mm thick mild steel. It is a cylindrical vessel with opening at the top where the hopper is welded and hinged to the main body of the barrel. The barrel has two ends one closed with a thick plate and the other stepped down opening, (extruding point). The length of the barrel is 62 cm and the diameter is 15 cm and stepped down diameter is 6 cm. The barrel is bolted to the frame at four points for easy

conveyance of the machine.

iii. **Hopper -** The hopper was constructed with a 2.5 mm metal plate pyramid shaped. It has a height of 28 cm, top length of 20 cm and base length of 10 cm

iv. **Rotor Shaft -**It is made of mild steel with diameter 30 mm and length 75 cm. The shaft carries a screw of varying pitches, it is tapered at one end and the pulley attached at the other end.

v. **Auger-**The auger is constructed with a grade B steel, the major pitch size is 9cm, the length is 56cm, and the diameter is 10 cm. It has a decreasing pitch; it conveys the material in the direction of the tapered barrel.

vi. **Driving Mechanisms -** These consist of a 5 hp petrol engine mounted on a seat that is welded vertically below the shaft, belt and pulley arrangement. Power is transmitted from the engine to the pulley which is attached to the rotor shaft through the belt. Fig 1 gives the isometric drawing of the briquetting machine.

2.5 Operational Principles of the Machine

The principle of operation of the machine is by conveying and compaction (densification). The biomass material is fed into an auger which transports the materials forward in the direction of the slightly tapered end of the barrel, where the material is forced to form the briquette. The briquette has central hole along the length.

2.6 Test Procedure

The biomass materials used for testing the machine were palm kernel shell and starch, which were gotten within Umudike environment. The palm kernel shell were reduced in size using a hammer mill and sieved into three particle sizes D_1, D_2, and D_3 (2.63mm, 0.5mm and 0.175mm respectively) using sieve sets. The starch was made into gel and mixed with these particles of different sizes in proportion by weight.

The briquetting machine was allowed to run empty, and then digital tachometer was used to determine the speed of the machine running empty in revolution per minute (rpm) and recorded. The mixed material was weighed, and fed into the briquetting machine, the speed was also determined using the tachometer, and the corresponding briquetting time was recorded.

The palm kernel shell and starch mixture were weighed and feed into the hopper of the briquetting machine running. After the briquettes were formed, using different particle sizes at different proportion by weight, the briquetting time was taken using a stop watch and recorded. The experiment was repeated with different weights.

i. $$BMC = \frac{W_m}{t} \qquad 6$$

Where: BMC = briquetting machine capacity,
W_m = total weight of mixed biomass materials
t = time

ii. $$BME = \frac{W_f}{T} \subset 100 \qquad 7$$

Where: BME = briquetting machine efficiency,
$W_{f=}$ weight of briquette effectively formed
Wt= weight of material fed into the machine

Iii. 8

$$BB = \frac{W_B}{W_T} \subset 100$$

Where; BB = broken briquettes
W_B = weight of broken briquette
W_T = weight of materials fed into the machine

iv. **9**

$$DB = \frac{W_D}{W_T} \subset 100$$

Where: D_B = deformed briquette
W_D = weight of deformed briquette
W_T = weight of material fed into the machine

3.0 RESULTS AND DISCUSSION

The test conducted showed that this briquetting machine operates at a optimal speed of 590 rpm when loaded, and 790 rpm when ran empty. The briquetting machine efficiency is 75 % while 8.1 % and 12.6 % of briquettes broke and deformed respectively. The machine was found to have a capacity of approximately 42 kg/hr.

Factors that affect the performance of the briquetting machine are:

- The particle size of the biomass material, the smaller the particle sizes, the easier and faster briquettes are formed.
- The moisture content of mixed biomass materials, the mixing proportion (ratio) of the palm kernel shell and starch gels plays a virtual role in the quality of briquette produced, and the mixing ratio determines the moisture content of the mixed biomass materials.

The effectively formed briquettes are dried either by oven or sun dried method for 3 to 7 days to rescue the moisture content and then stored as solid biomass (briquettes).

4.0 CONCLUSION

From the result obtained during the testing of the briquetting machine, the following conclusions can be drawn. The machine has briquetting efficiency of 75 % at an average speed of 590 rpm. The appropriate mixing proportion of the palm kernel shell and starch gel, which determines major content of the biomass material mixture which is 7:3. This plays an important role in briquettes formation. Particle size of 0.125mm formed briquettes easier, therefore it can be said that, the smaller the particles size of the biomass material the easier the briquettes formation.

The capacity of the machine is 42 kg/hr and the machine produces briquettes with central core hole along length, the average diameter of the formed briquettes is 50 mm and varying length ranging from 20 mm to 50 mm. the moisture content of the briquettes formed is about 54 % which is now reduced by sun drying to about 5 % to 12 % dry basis; to get a solid briquette.

RECOMMENDATIONS

During the development and testing of the briquetting machine, some constraints were encountered; hence the following recommendations are suggested for improvement and future work.

1. The auger should be fabricated to have little clearance within the inner walls of the barrel (top, down and side walls). This will ensure effective conveyance of the materials to the extruding point or compression chamber.
2. The length of the extruder should be increased to reduce breakage and deformation of briquettes formed.
3. A flail should be incorporated at the extruding end of the briquetting machine, a collecting ray should also be incorporated.

REFERENCES

Adekoya L.O. (1989). Investigation into briquetting of sawdust. The Nigerian Engineer 24 (3): 1-10.

Ajayi O.A. and C.T. Lawal (1995). Some quality of sawdust palm oil sludge briquettes. Journal of Agricultural Engineering and Technology (30): 55-65.

Faborode M.O. (1988). Briquetting water hyacinth for domestic and rural agro-industrial fuel application. National conference on utilization of water Hyacinth Lagos. Nigeria. 179-187pp.

FAO (1990). Report on briquettes characteristic.

Henderson S.M.; Perry R.L.; and J.H Young. (1997) Principle of processing Engineering fourth edition

Jekayinfa S.O. and O.S. Omisakin (2005). The energy potential of some agricultural wastes as local fuel materials in Nigeria. Agricultural Engineering International, the CIGR E-Journal of Scientific Research and Development. Vol. VIII Manuscript EE 05 003:10.

Khurmi R.S. and Gupta J.K (2006). A textbook of machine design. Eurasia publishing House (PVT) Limited Ram Nagar, New Delhi, pp 224-260.

Nicholas A.M. (2006). Fuel Characteristics of some selected briquettes. International Journal of Science and Technological Research Vol 3, No 2. Pp 193-201.

Olorunnisola A.O. (2004). Briquetting of Rattan furniture waste. Journal of Bamboo and Rattans 3(2): 139-149.

Olorunnisola A.O (1999). The efficiency of two Nigerian cooking stoves in handling corncob briquettes. Nigerian Journal of Renewable Energy 7(1 and 2) 31-34.

Olorunnisola A.O. (1998). The performance of sawdust briquettes combusted in a conventional coal stove. Nigeria Journal of Forestry 28(1): 15-18.

Olorunnisola A.O. (2007) Production of fuel briquettes from waste paper and coconut husk. Admixtures. Agricultural Engineering International: The CIGR E Journal. Vol iv, 2007.

Table 1: Physical Properties of the Palm Kernel Shell

Particle sizes (mm)	2.63 mm	0.51 mm	0.175 mm
Moisture content wb (%)	12.5 %	10.6 %	11.2 %
Angle of repose (^{0})	42.27^0	43.67^0	44.34^0
Bulk density of palm kernel particles (kg/m^3)	568 kg/m^3	568 kg/m^3	568 kg/m^3
Bulk density of starch (kg/m^3)	874 kg/m^3	874 kg/m^3	874 kg/m^3
Bulk density of starch and mixed particles	961.53 kg/m^3	961.53 kg/m^3	961.53 kg/m^3

Table 2: Machine Efficiency, Capacity And Percentages Of Briquettes Formed

S/N	Weight of Particle size (kg)			Mixed proportion of Palm kernel and starch (ratio)	Briquetting time (min)	Weight of broken briquettes (kg)	Weight of deformed briquettes (kg)	Weight of briquettes effectively formed (kg)
	0.175mm	0.50mm	2.63mm					
1	2.4	3.0	2.6	9:1	13.55	1.2	0.6	6.2
2.	6.0	4.7	5.8	8:2	21.53	1.8	4.1	10.6
3.	8.5	6.2	7.6	7:3	32.14	0.8	1.2	18.3
	16.9	13.9	16.0		67.01	3.8	5.9	35.1

Table 3: Summary of Results of Design Calculations

Parameter	Value
Speed of motor	3500rpm
Speed of driven shaft	1400rpm
Diameter of pulley on the motor shaft	60mm
Diameter of pulley on the rotor shaft	150mm
Diameter of shaft	29.27mm
Diameter of shaft selected	30mm
Length of shaft	720mm
Major pitch of auger	0.85mm
Thickness of barrel	4.17mm
Thickness of barrel selected	4.20mm
Volume of hopper	0.93m^2
Diameter of discharge or outlet end	50mm
Bearing number used where C(Basic dynamic load rating) =19KN	210

Formed Briquettes

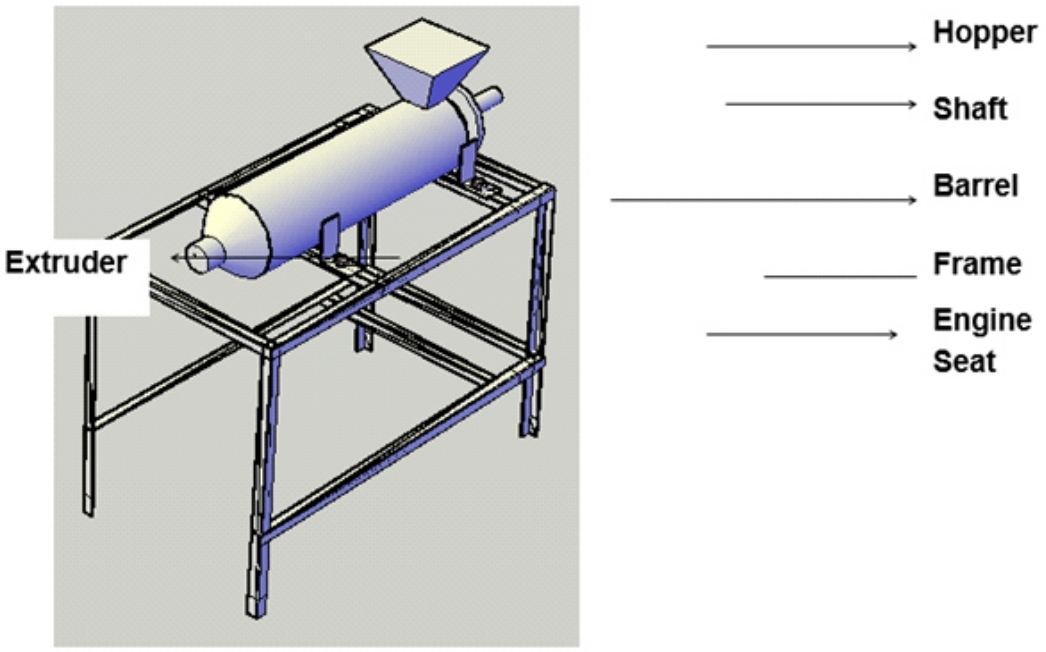


Figure 1: Isometric Drawing of the Briquetting Machine



Figure 1: Briquettes Produced

MODELING OF WATER ABSORPTION RATE OF DOUM PALM FRUIT

O.K. Fadele[1*] and A.K. Aremu[2]
[1]Department of Agricultural Engineering, Federal College of Forestry Mechanization Afaka Kaduna. Forestry Research Institute of Nigeria.
[2]Department of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Nigeria
([*]Corresponding author's email and phone no: fadeleseyi@yahoo.com, 08064487957)

ABSTRACT
The water absorption rate of doum palm fruit was found and the relationship between quantity of water absorbed by the fruit and retention period was established. The range values of water absorption rate were found to be 0.6 to 3.26 g/hr. The mean value for the water absorption rate was found to be 1.66 g/hr. Some models were established to estimate water absorption rate in doum palm fruit. The best fitted model for water absorbed by the fruit with respect to retention period was quadratic model. The coefficient of determination of this model was 0.998 and the F-value was 539.83 ($P < 0.05$). Since water enhances the extraction of some nutrients from the fruit, this model will be useful in pre-determining the moisture present in the fruit with respect to the soaking period.

Keywords: Absorption Rate, Doum Palm, Model, Retention Period And Water.

1.0 INTRODUCTION
Doum palm popularly known as gingerbread and goriba in hausa belongs to *Palmae* family which is made up of over 217 genera and 2500 species that grow to 6 or 9 m and usually has forked stems with fan shaped leaves, 6575 cm long. It grows in the Sahel, and hot Savannah, between 12-18 N from Senegal to Northern Nigeria, Chad, Zaire and North East Africa. It is listed as one of the useful plants of the world (Fletcher, 1997; Lokuruka, 2008, Nwosu et al., 2008). This fruit is widespread all over semi-arid Sahelian zone of West Africa and appears in March and persists until the following season's flowers, in Nigeria (Moussa et al., 1998; Orwal et al., 2009). It is commonly found in the northern part of Nigeria and usually consumed by children just like the almond is consumed by children in the western part of Nigeria. The husk from the fruit can be pounded to form a powder or cut in slices; the powder is often dried then added to food as a flavouring agent. Young shoots produce tasty palm cabbage; the husk is edible, and so are the immature seeds if well prepared (Orwa et al.,2009).The trunk of this type of palm commonly branches into 2 like a 'Y' and often each branch divides again in a 'Y' form, giving the tree a very distinctive appearance. The fruit is ovoid or slightly 3 lobed. It is as shown in figure 1.

2.0 MATERIALS AND METHODS
Some quantities of doum palm fruits were purchased from Mando Market Kaduna and stored in a cool place before carrying out the experiment. Ripe fruits of doum palm were used for the purpose of this experiment as shown in figure 1. All the experiments were conducted at normal room condition.

2.1 Moisture Content Adjustment

The moisture absorbing tendency of some doum palm fruits was studied by varying the retaining period of the fruit in water. A method for adjusting the fruit's moisture content without damaging its morphology was developed. The initial quantity of water present in some fruit was found by oven drying method and the mean value was also determined. This value was taken as the quantity of water present in the fruit when time't' was zero. Subsequently, another set of doum palm fruits were selected randomly and soaked in water for 3, 7, 16 and 36 hours, respectively with initial mass being measured. After soaking the fruits water the samples were stored in the cellophane bags and stored in the fridge at about 15^{o}C before taking the final mass to allow uniform distribution of water within the fruit (Aremu and Fadele, 2011; Olaniyan and Oje, 2002; Fadele, 2010). The differences in both final and initial masses indicate the quantity of water absorbed with their respective time.

2.2 Establishment of Equations for Water Absorption Prediction

Some analyses were done to determine the effects of retention period in water on water absorbance tendency of the fruit. This was based on values obtained for quantity of water absorbed by the fruit against the retention period. Some regression models were developed and evaluated to establish the equation that best fits water absorption rate in doum palm fruit.

2.3 Validation of Equation for Water Absorption Prediction

Several equations were developed to study the rate of water absorption in some doum palm fruits. The most appropriate equation for water absorption prediction would be selected based on coefficient of determination and significance level. This was further validated by subjecting the equation to F-test. All the statistical analyses were performed using the software SPSS version 15.0

3.0 RESULTS AND DISCUSSION

The relationships between quantity of water absorbed in the husk of doum palm fruit and soaking time have been studied and the following is the outcome of the research conducted on it.

3.1 Modeling Findings

The water absorption rate was found to have values ranging from 0.6 to 3.26 g/hr. The mean value for the water absorption rate was found to be 1.66 g/hr. Some regression models were developed as shown in Table 1. The best fitted model for water absorption for doum palm fruit was quadratic model. It was observed that the rate of water absorption of doum palm fruit in water increased with retention period. The water absorption rate was high initially as shown in figure 2. This could be due to high hydration rate as reported by Khazaei and Mohammadi (2009). At stage water absorption rate was constant, thus indicating the quantity of water the fruit could absorb at a point in time.

3.2 Model Validation

The validation of the model for water absorption rate in doum palm fruit was based on some statistical parameters. This includes F-value and coefficient of determination value. Table 1 shows that the quadratic equation has the highest values of coefficient of determination and F-values indicating the strength of relationship between the observed and predicted values. This is stated in equation 1. Different models were used, as done by other researchers to determine the one that best fitted for the relationship between the

parameters considered (Pompelli et al., 2012; He et al., 2005).

$$\text{F-value} = 539.825, R^2 = 0.998 \quad (1)$$

CONCLUSION

The model for soaking behavior of doum palm fruit was found and established. The soaking rate at the room temperature was also found. Since water enhances the extraction of some nutrients from the fruit, this model will be useful in pre-determining the moisture present in the fruit with respect to the soaking period. However, this study should be further investigated to determine the effect of temperature on the soaking rate of the fruit as well as hydration kinetic of the fruit.

REFERENCES

Aremu, A.K. and Fadele, O.K. (2011) Study of some properties of doum palm fruit (Hyphaene thebaica Mart.) in relation to moisture content. African Journal of agricultural Research. Vol. 6(15): 3597-3602.

Fadele, O. K. (2010). Determination of Some Engineering Properties of Doum Palm Fruit (Hyphaene thebaica). Unpublished MSc. Thesis. University of Ibadan.

Fletcher, R. (1997). Listing of useful plants of the world. Australian New Cropshttp://www.newcrops.uq.edu.au/listing/hyphaenethebaica.htm.

He, Y.; Zhang, Y.; Pereira, A.G.; Gomez, A.H. and Wang, J. (2005). Nondestructive Determination of Tomato Fruit Quality Characteristics Using Vis/NIR Spectroscopy Technique. International Journal of Information Technology. Vol.11(11): 97 108.

Khazaei, J. and Mohammadi, N. (2009). Effect of temperature on hydration kinetics of sesame seeds (Sesamum indicum L.). Journal of Food Engineering. Vol.91:542552.

Lokuruka, M.N.I. (2008). Fatty Acids in the Nut of the Turkana Doum Palm (Hyphaene coriacea). African Journal of Food Agriculture Nutrition and Development. Vol. 8(2): 118 -132.

Moussa, H.; Hank A. Margolis, H.A.; Dube´, P. and Odongo, J. (1998). Factors Affecting the Germination of Doum Palm (Hyphaene thebaica Mart.) Seeds from the Semi-Arid Zone of Niger, West Africa. Forest Ecology and Management. Elsevier Science Direct. Vol.104: 27 41.

Nwosu, F. O., Dosumu, O. O., and Okocha, J. O. C. (2008). The potential of Terminalia catappa (Almond) and Hyphaene thebaica (Doum Palm) Fruits as Raw Materials for Livestock Feed. African Journal of Biotechnology. Vol. 7 (24), pp. 4576-4580.

Olaniyan, A.M. and Oje, K. (2002). Some Aspects of the Mechanical Properties of Shea Nut Biosystem Engineering. Vol. 81(4): 413 420.

Orwa, C.; Mutua, A.; Kindt, R.; Jamnadass, R. and Anthony, S. (2009). Agro-Forest

Tree Data Base: A Tree Reference and Selection version 4.0
(http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

Pompelli, M.F.; Antunes, W.C.; Ferreira, D.T.R.G.; Cavalcante, P.G.S.; Wanderley-Filho H.C.L. and Endres, L. (2012). Allometric models for non-destructive leaf area estimation of Jatropha curcas. Biomass and Bio-energy.Vol.36: 77 85.

Table 1: Regression Models for Estimation of Absorbed Water

Model	R^2	F-Value	Significance Level	Estimator of Moisture Content (g)
Linear	0.966	86.328	0.003	ÄÄ = 9.031 + 0.366??
Quadratic	0.998	539.825	0.002	ÄÄ = 8.067 + 0.626?? - 0.007??^{2}
Growth	0.898	26.289	0.014	ÄÄ = ?????$^{(2.227+0.026??)}$
Exponential	0.898	26.289	0.014	ÄÄ = 9.269?????$^{(0.0257??)}$

Note: W is the quantity of water absorbed by the fruit with respect to time 'T'.



Figure 1: Doum Palm Fruit

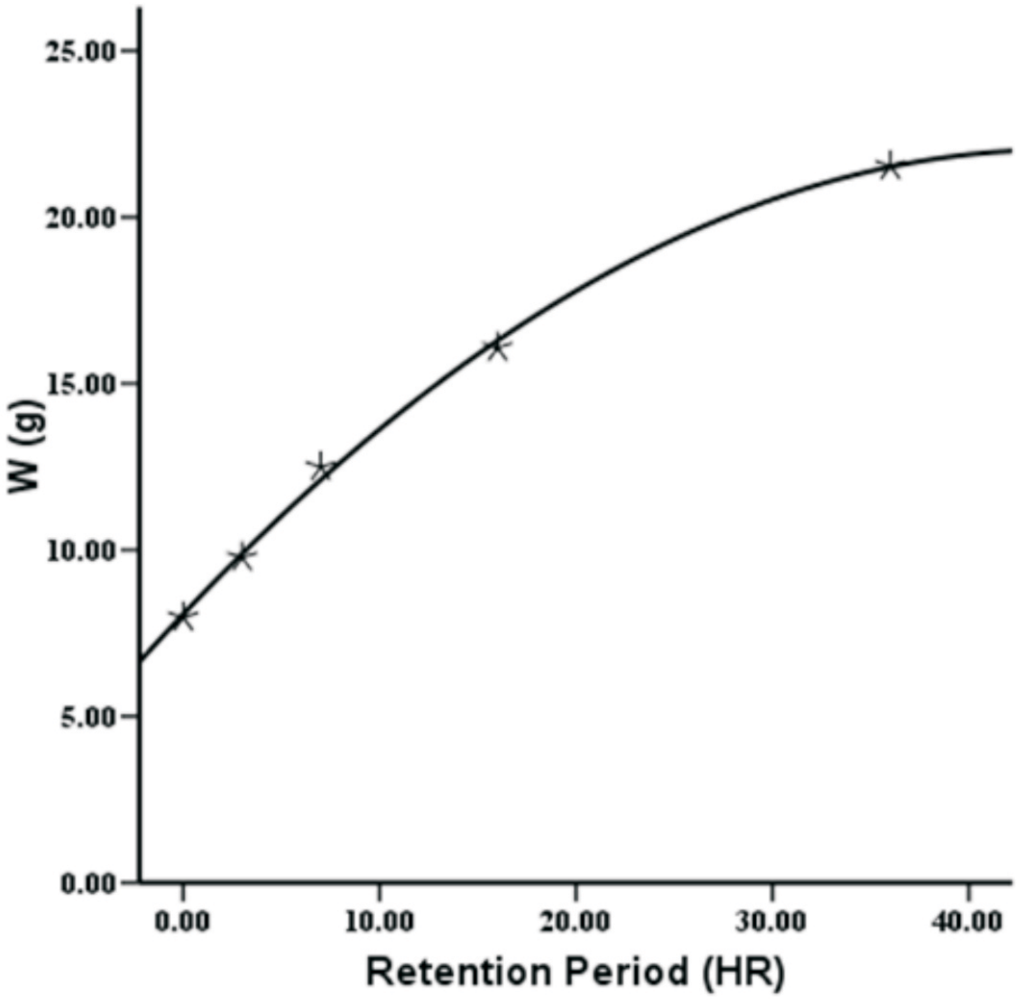


Figure 2: Variation Of Water Absorbed With Retention Period

CARROT PRESERVATION BY VACUUM PACKAGING TECHNIQUE

S. L. Ezeoha, F. U. Asoiro and A. Ikejiofor
Department of Agricultural and Bioresources Engineering
University of Nigeria, Nsukka
[+]Corresponding author. Email: felixasoiro@yahoo.com
Tel.: +2348063588320

ABSTRACT
Consumer appeal for fresh, low-calorie, healthy, nutritious and high quality foods has grown steadily in the last 10 years. Such food trends may be attributed to consummer attitudes on lifestyle, nutrition, fitness, health and food quality. Current growing demand for near-fresh quality and shelf-stable products has spurred the development of many innovative, processing and preservation techniques. Foremost among these are retortable pouches, aseptic packaging, controlled-atmosphere storage, modified atmosphere packaging and vacuum packaging. The last two being the most promising and the most extensively studied at the present time. The effect of vacuum packaging on microbial load, rate of moisture loss and the hardening of whole carrot and also'ready-to-use' carrot slices was investigated. This is needed in inorder to determine its effectiveness in prolonging the shelf life of carrot and other vegetables. The microbial development on vacuum packaged carrots was slower than that of non-vacuum packaged material. The predominant organisms present were Leuconostoc spp. in the vacuum packs as opposed to Erwinia spp. in the aerobic packs. Vacuum packaging of both whole and sliced carrots retarded the rate of moisture loss in the product when stored at 4°C. In vacuum packaging, leakage and gas permeation which affects the normal function of the components, were major problems.

Keywords : Carrot, Carrot Preservation, Vacuum Packaging, Preservation Technique

1.0 INTRODUCTION

1.1 Essentials of Food Preservation

Biological materials from which most food is derived will deteriorate or spoil, given adequate time, especially when kept under unfavourable conditions or not processed into a more stable form. The deterioration is due essentially to microbial degradation and/or chemical reactions, producing changes in the product which may lower product quality causing a potential health hazard and ultimately, a substantial economic loss. **Food preservation** is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms. Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food (e.g., cheese, wine). Maintaining or creating nutritional value (Artes et al., 1999a), texture and flavour is important in preserving its value as food. This is culturally dependent, as what qualifies as food fit for humans in one culture may not qualify in another culture. Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. It also includes processes to inhibit natural ageing and discolouration that can occur during food preparation such as the enzymatic

browning reaction in apples after they are cut (Drake and Spayd, 1983). Some preservation methods require the food to be sealed after treatment to prevent recontamination with microbes; others, such as drying, allow food to be stored without any special containment for long periods. Common methods of applying these processes include drying, spray drying, freeze drying, freezing, vacuum-packing, canning, preserving in syrup, sugar crystallisation, food irradiation, and adding preservatives or inert gases such as carbon dioxide. Other methods that not only help to preserve food, but also add flavour, include pickling, salting, smoking, preserving in syrup or alcohol, sugar crystallization and curing.

Consumer appeal for fresh, low-calorie, healthy, nutritious and high quality foods has grown steadily in the last 10 years. Such food trends may be attributed to consumer attitudes on lifestyle, nutrition, fitness, health and food quality. Current growing demand for near-fresh quality and shelf-stable products has spurred the development of many innovative, processing and preservation techniques. Foremost among these are retortable pouches, aseptic packaging, controlled-atmosphere storage, modified atmosphere packaging and vacuum packaging. The last two being the most promising and the most extensively studied at the present time. A vacuum is simply the absence of air. We can create a vacuum in a plastic bag or container by sucking out all of the air and then sealing it to prevent air from leaking back in. The single most important reason for creating a vacuum is to remove oxygen from around the product that we are going to store. This is because air is made up of about 21% oxygen. Most bacteria associated with food spoilage need oxygen to grow (Benwart et al., 2005); the less oxygen that is available, the slower bacteria will grow and the longer food will last before spoiling. Also oxygen is a highly reactive element and many of the organic compounds that give food its flavour will react with it and make the food taste stale. (Newton and Guillespie, 2010).

1.2 Importance of Carrot

The U.S. Food and Drug Administration have approved the following nutrient content descriptors for carrots: fat free, saturated fat free, low-sodium, cholesterol-free, a good source of fibre and high in vitamin A. No other vegetable or fruit contains as much carotene as carrots, which the body converts to vitamin A. This is a truly versatile vegetable and an excellent source of vitamins B and C as well as calcium pectate, an extraordinary pectin fibre that has been found to have cholesterol-lowering properties. Carrot is an herbaceous plant containing about 87% water, rich in mineral salts and vitamins (B, C, D, E).Raw carrot is an excellent source of vitamin A and potassium; it also contains vitamin C, vitamin B6, thiamine, folic acid, and magnesium. Cooked carrot is an excellent source of vitamin A, a good source of potassium, and contains vitamin B6, copper, folic acid, and magnesium. The high level of beta-carotene is very important and gives carrot its distinctive orange colour. Carrot also contains, in smaller amounts, essential oils, carbohydrates and nitrogenous composites. They are well-known for their sweetening, anti-anaemic, healing, diuretic, remineralizing and sedative properties. In order to assimilate the greatest quantity of the nutrients present in carrots, it is important to chew them well. Also most of the "goodness" is actually in, or just below the skin. Carrots are one of the best sources of carotene which is a strong antioxidant, but carrots also contain other phenolic compounds (Castamer et al., 1999) that are antioxidants. Many people do not realize that numerous phenolic compounds (Castamer et al., 1999) are located in the skin of fruit and vegetables, many of which are removed by peeling prior to processing.

The green leafy parts of a carrot plant can be eaten and are high in vitamin K, which is lacking in the carrot itself. Nutrition is the cornerstone of good health. As we go

through life, there are so many illnesses that could have been prevented with better nutrition. This has been proven beyond any shadow of doubt over the past few years. Research has proven that getting the proper level of antioxidants into our blood stream will reduce the risk of cancer. Consumption of carrots increases the level of key antioxidants in the bloodstream. Carrots have many important vitamins and minerals. They are rich in antioxidants Beta Carotene, Alpha Carotene, Phytochemicals and Glutathione, Calcium and Potassium, and vitamins A, B1, B2, C, and E, which are also considered antioxidants, protecting as well as nourishing the skin. They contain a form of calcium easily absorbed by the body. Finally they also contain Copper, Iron, Magnesium, Manganese, Phosphorous and Sulphur. (Deeley, 2006). Carrot is also helpful in the following cases: obesity, poisoning of the blood, gum disease, insomnia, inflamed kidney, liver, gall bladder, Alzheimer's disease, colitis, ulcer and painful urination. Carrots are one of the richest sources of Vitamin A. Carotene present in this vegetable gets converted into Vitamin A by our body. It is indeed amazing that a mere 100 grams of carrot supplies around 11,000 milligrams of vitamin A (Deeley, 2006).

Chlorine present in carrot is vital for the proper functioning of liver and provides a cleansing and antiseptic effect on the digestive and circulatory systems. Calcium, phosphorus and magnesium are essential for ensuring the strength of bones. Phosphorus is essential for the health of skin, hair and nerves. The vital magnesium content present in fresh carrot enables mental development, digestion of fats and the metabolism of mineral salts such as calcium, phosphorus, sodium, and potassium. Sulphur also forms a major ingredient of insulin, the hormonal function of which is to convert carbohydrates into energy. Another nutrient in carrot, which deserves mentioning, is Vitamin E, the muscle vitamin. It promotes the efficiency of the entire muscular system by the effective utilisation of oxygen. **Carrots contain elements that keep one healthy on many levels.** The 3 most important elements are Beta-carotene, Alpha Carotene, and Phytochemicals. Beta carotene usually receives most attention when examining carrots. It is one of about 500 similar compounds called carotenoids, which are present in many fruits and vegetables (Esau, 2006). The body changes beta carotene into vitamin A, which is important in strengthening the immune system, keeping the skin, lungs and intestinal track in order, and promoting healthy cell growth. Beta-carotene is found primarily in dark green, red, yellow, and orange-coloured plants, and is converted by the body into vitamin A and also works on its own. Because beta-carotene is an antioxidant, and anti-oxidants are important in the fight against heart disease, studies have found that high doses of beta carotene may lower the risk of heart disease by as much as 45% (McGee, 2001).

1.3 Merits of Vacuum Packing

Merits of vacuum packing include elimination of food oxidation, avoidance of contamination, preservation of delicate flavours and oils, prevention of freezer burns, maintenance of natural moisture, and stoppage of moisture contamination Once food is in contact with the air it begins to lose its flavour and its appearance changes, for example banana and apple (Drake and Spayd, 1983 and Martin-Belloso and Soliva-Fortuny, 2006) quickly show signs of oxidation by browning. This reaction affects all fresh foods to some extent, even if the effects are not immediately obvious. Vacuum packing eliminates contact with the air and therefore eliminates oxidation.

Food is handled several times before you buy it in the shops or supermarket. Vacuum packing prevents food products from being contaminated during handling and transportation. With increasing emphasis on increasing natural oils in our diets many people now endeavour to eat fish rich in eicosapentaenoic (EPA) oil and which helps to prevent cardiovascular disease. Fish oils deteriorate and become rancid faster than the fat

found in meat such as, beef, chicken, and pork.Well-wrapped fish kept in a fridge can last for 2-days, and 2-months if frozen. By vacuum packing, such foods can preserve all its natural goodness and taste for 4-6 days in the fridge or for 2-years when frozen. (Newton and Guillespie, 2010).

Whilst freezing foods offers greater flexibility, this is often achieved at the expense of texture and taste of the food. This is due to oxidation, dehydration, and slow bacterial growth which cause freezer burn. Vacuum packing offers the same flexibility and prevents oxidation by eliminating oxygen, thus preventing freezer burn, and making the food's taste and appearance to remain as good as when packed.

One of the reasons why we package or wrap food is to keep it from drying out; air causes moisture to evaporate. So by removing the air with vacuum packing the foods' natural moisture is maintained along with all its flavour and texture. So there is no longer need to throw away the top slices of bread to find the soft ones or have sliced meat curling up at the edges; as everything will retain its own natural moisture.

Keeping cereals, museli and crackers crisp and fresh is another problem, especially if bought in bulk to reduce costs. This is because dehydrated foods unless they are kept in an airtight container quickly spoil as moisture in the air softens and spoils them Vacuum packing such foods in useable quantities is far superior in maintaining the natural textures and flavours as it not only removes the air but the moisture it carries as well.

1.4 Demerits of Vacuum Packing

Every thing that has merits usually has demerits as well. Vacuum packing is not an exception, and therefore its demerits include: high initial cost, safety concerns, and misconceptions. Buying a vacuum packaging machine can be expensive. The initial cost of a machine can be very high, depending on the quality and size of the machine. Also, there is the ongoing cost of the packing material, which comes in rolls or bags. While it may save you money in the long run, you should think about how much you will actually use it. If you have limited freezer space and do not purchase in bulk, then a vacuum packaging machine may not be a good investment. The advantage a low-oxygen environment creates can also be a disadvantage. There are types of bacteria that cause diseases which prefer low oxygen environments and grow very well in foods that have been vacuum packed. If the biomaterial is very clean and uncontaminated, then this should not be a problem, but if there is any question about the safety, then the food should not be vacuum packed, as you would just be creating a perfect breeding ground for some very bad bacteria like botulism. Sealing food in vacuum packs does not eliminate the need to handle it properly. Frozen food needs to be stored in the freezer and thawed in an appropriate manner to minimize bacteria growth. Also, a vacuum seal is not a heat process, which kills bacteria, so if they were present during packaging, they will still be there when the package is opened. Vacuum packing does not automatically make food safe and eliminate the need to take precautions. There is therefore the need to continue to be vigilant with food safety.

1.5 Objective of the Work.

The main objective of this work was to apply vacuum packaging to carrot preservation inorder to determine its effect on microbial load, rate of moisture loss, and the hardening of whole carrot.

2 MATERIALS AND METHODS

2.1 Materials

Materials used in the execution of this work included chopped blanched carrot, washed whole carrot, thin transparent polyethelene bags which are impermeable to gas, vacuum pump and compressor for the creation of vacuum, and a sealing machine to provide instant sealing of the package and avoid re-entry of unwanted gas (oxygen).

2.1.1 Samples

The carrots (*Daucus carota*) were purchased from the local market (Ogige market). A single batch of carrots was used in the experiments, which were restricted to a period of time. To ensure optimum results, matured carrots were selected for the work . The work involved whole and sliced carrots. For the experiments carrots were washed and some sliced (4mm thickness) with sharpened knife to avoid much bruising. The sliced carrots were blanched in hot water (80°C for 1 min) to reduce undesirable enzymatic reaction.

2.1.2 Sealing machine

The sealing machine (Impulse sealer) was used to provide an air-tight closing to prevent penetration of air (oxygen). It consists of the upper and lower teflon tape with a live heating element located underneath, a knob attached to the upper lid and a sealing time adjuster .

2.1.3 Vacuum pump and compressor

This was used for creation of vacuum in the polyethylene bag before sealing. The vacuum pump consists of an inlet valve, outlet valve, and a rotating fan which connects the pump to the compressor.

2.2 Methods

Having been washed in distilled water, tests on hardness and moisture content were carried out on a sample of the fresh carrot before they were put into a polyethylene bag. The bag was then attached to the inlet valve using a band. Two rotors with identical profiles rotated in opposite directions within a casing. As they rotated, gas was drawn into the space between each rotor and the casing where it was trapped, transported and discharged by the rotation through the outlet valve. The gas evacuation made the polyethylene bag wrap itself tightly around the sample. The evacuation of gas continued till a pressure of 3kPa was achieved. The sealing machine was then used to seal the packaged carrot. The sealing time (6s) was adjusted according to the bag thickness (0.038mm). The bag was placed on the sealing work-place and the upper lid pressed down evenly. The bag which was still attached to the vacuum pump was then detached. The same procedure was used to vacuum package the sliced samples. As control, some whole samples were also packed without the removal of air. All the samples were then placed in the refrigerator for observation and storage. Analysis were carried out on the samples randomly: 0 day (i.e before storage), 3 days, 7 days, 10 days, 13 days and in 15 days from time of refrigerated storage. A mechanical hardness testing machine was used to determine hardness which can be used as a measure of 'crunchiness', a desirable quality in fresh carrot.

Slices of carrot from each of the samples were placed on the test platform as shown in the figure 3 above. As the handle located on top was turned, the gauge measured the force (kg) needed to make an indentation on the samples. The hardness was gotten by calculating the difference in the reading of the driver and the driven hand of the gauge. The moisture content can be used as a measure of food texture. Before storage, a sample

of carrot was weighed on a weighing balance, it was then dried at a temperature of 70°C using drying oven and re-weighed. The moisture content (dry basis) (%) was then gotten by using equation (1).

$$MC_{db} = \frac{(M_1 - M_2)}{M_2} \subset 100 \quad (1)$$

Where, MC_{db} is moisture content (% db), M_1 is the mass of moist carrot (g) and M_2 is the mass of dried carrot (g)

3.0 RESULTS AND DISCUSSION

3.1 Results

A cross reference of the cultural characteristics gram staining reaction and biochemical tests of the studied isolates with the Bergey's manual of determinate bacteriology showed that the predominant organisms present were Leuconostoc spp. in the vacuum packs as opposed to Erwinia spp. in the aerobic packs. This can be attributed to the fact that different micro-organisms grow better in different environment. Also, the rate of microbial degradation was found to be slower in the vacuum packs when compared with the aerobic pack. This shows that aerobic bacteria is more destructive and having been limited by the absence of air (oxygen), could no longer work at the same rate as in the aerobic pack. Fig. 4 shows the effect of vacuum packing on moisture retention in the samples, the steepest curve represents the aerobic packed whole carrot curve, the next curve represents the vacuum packed sliced carrot curve and the top most curve represents the vacuum packed whole carrot curve. Fig. 5 is a graphical representation of the rate of hardening of carrot cells in storage which can have an effect on its acceptability in the market. In Fig 5, the upper most curve represents the aerobic pack curve, followed by the vacuum packed sliced carrot curve and lastly the vacuum packed whole carrot curve.

3.2 Discussion

The negative slope of the graph indicates that dehydration (loss of moisture) occured in the stored produce . It can be seen from the graphical representation that the rate of moisture loss from the analysed carrot samples was lowest for the sample that was vacuum packaged whole , followed by the samples that were sliced before vacuum packaging with the highest rate of moisture loss occuring in the non-vacuum packaged sample. This can be explained by the fact that dry air has a dehydrating effect on fresh produce. This could lead to an unattractive appearance due to change in texture. Therefore, it can be deduced that vacuum packaging does aid in the retention of moisture in fresh produce like carrot. Here, the loss of moisture affects the structure of the carrot causing it to stiffen and become hard and this occurs more in the aerobic pack due to exposure to air. This also shows that vacuum packing helps in the preservation of carrot in structure, in chemical composition and in physical appearance.

4 .0 CONCLUSIONS AND RECOMMENDATION

4.1 Conclusion

This work applied vacuum packaging technique to carrot preservation. Vacuum-packaging of carrot resulted in less microbial load, lower rate of moisture loss, and less hardening of carrot cells. Vacuum packaging is therefore an important technique in the quest to provide consummers with fresh high quality vegetables, and to reduce wastages.

4.2 Recommendations

More research is needed in the study of the microbes which can survive in an oxygen deprived environment so that specific treatments can be undertaken before vacuum packaging is applied. Also standard food safety measures must not be disregarded while applying the vacuum packing method of preservation to crops and other biomaterials.

REFERENCES

Artés F., Gómez P.A. and Artés-Hernández F. 1999a.Modified atmosphere packaging of fruits and vegetables.*Stewart Postharvest Review* **5**(2): 113.

Benwart G. J., Allende A. and Artés A.2005. Shelf life and overall quality of Minimally processed pomegranate arils modified atmosphere packaged and treated with UV-C. *Postharvest Biology and Technology* **37**: 174185.

Castañer M., Gil M.I., Artés F. and Tomás-Barberán F.1999. Inhibition of browning of harvested head lettuce.*Journal of Food Science* **61**(2): 314316.

Deeley C. M. 2006. Carrots and Nutrition. McGraw-Hill Book Co.,Inc. New York Drake S. and Spayd S. 1983. Influence of calcium treatmenton 'Golden Delicious' apple quality. *Journal ofFood Science*

Esau H.2006.Thiol-containing compounds as controlling agents of enzymatic browning in some apple products.*Food Research International*

Martin-Belloso O. and Soliva-Fortuny R. 2006. Effect of modified atmosphere packaging on the quality of freshcut fruits. *Stewart Postharvest Review* **1**: 3.

McGee, C.T. 2001. Heart Frauds: Uncovering the Biggest Health Scam in History. Health-Wise Publications: Piccadilly Books Ltd., Colorado, USA.

Newton, P. and Guillespie, A. 2010. Practical Guide to Vacuum Packing. http// www.lava vacuum-packing.com Retrieved 18 May, 2010.



Fig. 1: Sealing Machine



Fig. 2: Vacuum Pump and Compressor



Fig. 3: Hardness (Toughness) Testing Machine

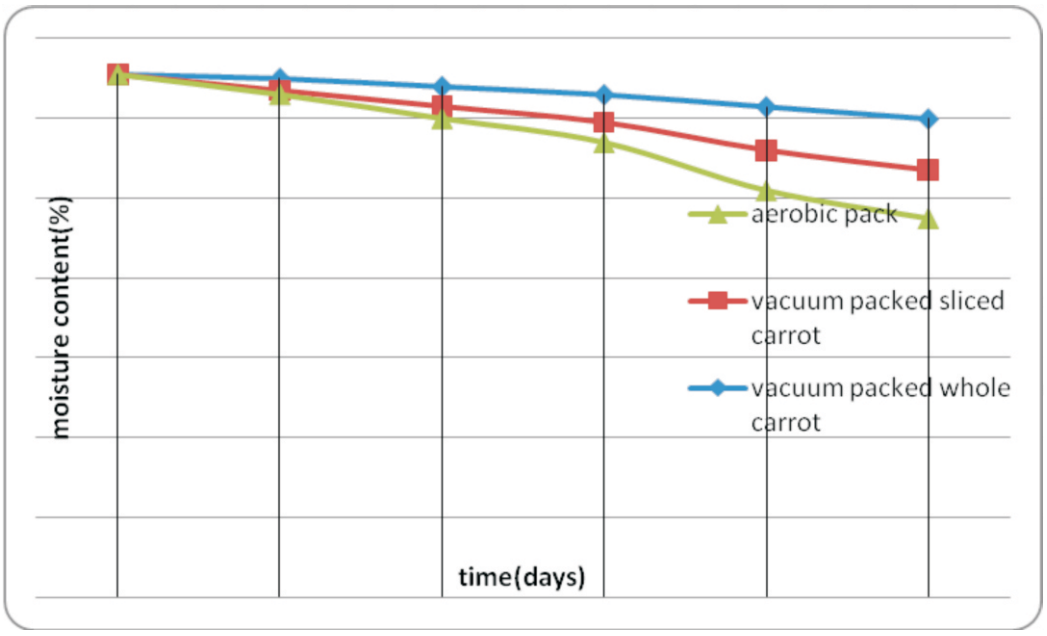


Fig.4: Rate of Dehydration in Vacuum Packaged Carrot(whole and Sliced)

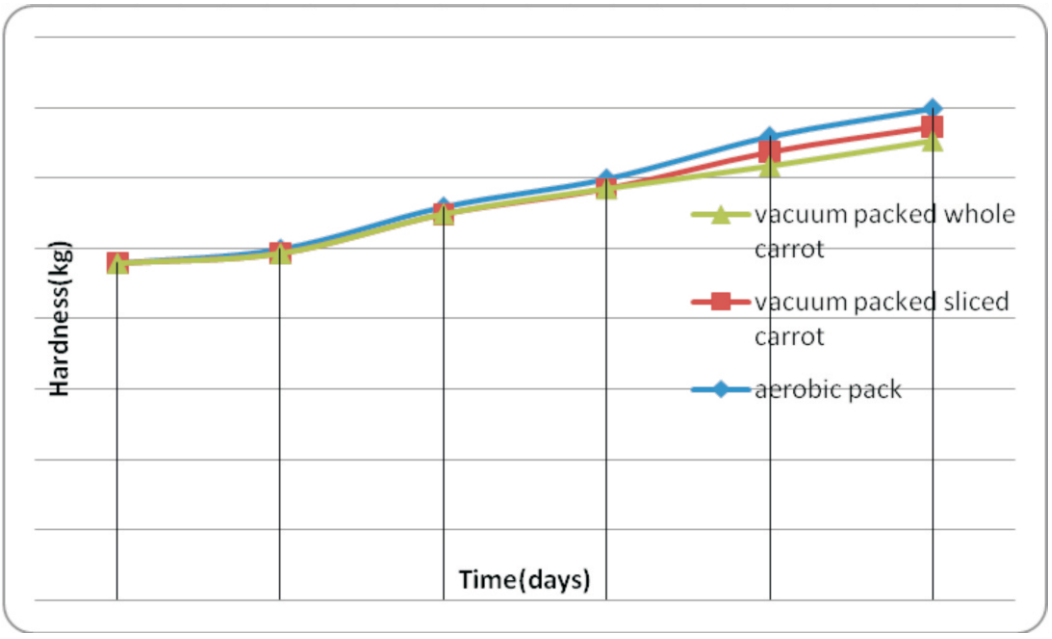


Fig.5: Rate Of Hardening in Vacuum Packaged Carrot (whole and Sliced)

ENGINEERING PROPERTIES OF AFRICAN MAHOGANY (*KHAYA SENEGALENSIS)* SEEDS RELEVANT TO PROCESSING

Usman, D. D[1], Ibrahim, M. E[2]. , Yakubu, I. T[3]. and Adanu, E. O[4].
[1,4]School of Vocational Education, Federal College of Edu. (Tech), Gombe, Gombe State
[2]Mechanical Engineering Dept, Modibbo Adama University of Technology, Yola, Adamawa State.
[3,]Agricultural and Environmental Engineering Dept, Modibbo Adama University of Technology, Yola, Adamawa State.
Correspondence: drambiusman@gmail.com , +2347036689063

ABSTRACT
Khaya Senegalensis (African mahogany) seeds have been discovered to be a rich source of oil that can be used for domestic and industrial purposes. As a first step in developing processes and machine for the extraction of oil from the seeds, some physical properties namely: size, sphericity and roundness, surface area, weight, volume and density, bulk density, porosity, angle of repose and coefficient of friction (on wood and steel) and specific heat capacity were determined . The seeds which are commonly found in Adamawa state were sampled and subjected to physical property test at a moisture content of 12.20% wet basis. Major, intermediate and minor diameter varied from 14.49 to 20.59 mm, 9.47 to 13.58 mm and 0.79 to 2.60 mm respectively, while sphericity and roundness varied from 0.34 to 0.48 and 0.43 to 0.75. Volume and density values varied from 0.20 to 0.24 cm^3 and 0.56 to 1.34 g/cm^3 while the weight varied from 0.10 to 0.259. Surface area, bulk density and porosity varied from 31.41 to 66.42 mm^2, 0.40 to 0.45 g/cm^3 and 0.42 to 0.56 respectively, while the values for coefficient of friction and angle of repose for wood and plywood varied from 0.466 to 0.601 (for plywood), 0.510 to 0.554 (steel) and 25^0 to 32^0 (plywood) and 27^0 to 29^0C steel respectively. Specific heat value varied from 20.77 to 32.85 KJ/Kg^{0}C. These results are necessary as design parameters when designing equipment for processing the seed.

Keywords: Physical Property, Specific Heat, Bulk Density, Sphericity, Coefficient Of Friction.

1.0 INTRODUCTION
The seed *Khaya senegalensis* (African mahogany) from which oil were extracted are essentially not among the popular cultivars of oil seeds like groundnut, soya bean, palm fruit and palm seed. At best they are allowed to waste away in the forest. *Khaya senegalensis* is an important multipurpose tree in its natural range in Africa and Madagascar (Roger, 2004). All species become big trees, 20 35 m tall with a trunk over 1 m in diameter, often buttressed at the base. The plant strives well in Riverine forest and scattered in high rainfall Savannah woodland with 700 1750 mm rain/year and a dry season of 4 7 months (Dorthe and Sylvia, 2003). The plant is commonly found in Nigeria around Lagos, Ogun, Edo, Osun and Oyo states in the rain forest zone, while in the middle belt it is found around Niger, Benue, Adamawa and Taraba states (Michael, 2004). The plant begins to produce seeds when they are 15 25 yrs and in most places fruiting is regular and the fruits remain on the tree for most of the dry season. Besides timber, rated as one of the best African mahogany wood, moderately hard with a density of 0.6 0.8 g/cm^3, the plant is valued for its medicinal purposes, especially the back, which is used to

treat a number of diseases. The leaves are used for fodder at the end of dry season, but the forage value is low (Dorthe and Sylvia, 2003). In West Africa and Nigeria in particular, the seed oil is used as edible and for cosmetics, with an oil content of 67%, comprising 21% palmatic acid, 10% stearic acid, 65% oleic acid, and 4% unidentified acid (Dorthe and Sylvia, 2003).

During the 20th century, the non edible use of oil seeds products decline substantially due to availability of relatively inexpensive oil derived from fossil reserves (Lea and Leegood, 1993). Though the reserves could be exhausted or becomes less in supply and are not renewable (Bodhouwer, 1983). Hence, looking into alternative oil source from various seeds remains a subject of active investigation. *Khaya senegalensis* seed is valued among the best in production of non-fossil oil used for various applications. Although, such oils are not expected to replace petrochemicals in their entirety, however, the processing of the seeds for the extraction of oil is mostly done traditionally and has great effect on the quality, efficiency and oil yield of the seeds. As such the need to optimize the post harvest production process which has not received significant engineering research like investigating the physical and mechanical properties of the seed that constitute an important and essential engineering data in the mechanization of its production, handling, processing and storage. Despite these little is known about the basic physical and mechanical properties of plants and animal materials. Maduoko and Hamman (2000), as well as Istifanus (2006) emphasized the need for the characterization of agricultural materials in terms of their physical, mechanical thermal, electrical and optical properties necessary in the design of machines for post harvest handling and processing. Alcali and Guyen (1990), as well as Olaoye (2000) observed that a rational approach to the design of agricultural machinery equipment and facilities involves a theoretical analysis of the effect of the physical properties of the agricultural product on the characteristics of the machinery, facilities and process or operation. However, this research objective is to investigate some physical properties of *Khaya senegalensis* seed which include shape and size, sphericity, roundness, volume, weight, surface area, static coefficient of friction against steel and plywood, angle of repose and specific heat capacity.

2.0 MATERIALS AND METHODS

All the seeds were collected from crop science department, Federal University of Technology Yola, north and Yola south local government area, and Michika local government area respectively during their annual season availability in 2010. The good quality seed were handpicked to separate them from bad ones. Since the seed is an oil seed, moisture content was determined by oven drying the seeds at a temperature of 105^0C and a time of 4 hours (Istifanus, 2006). Moisture content was found to be 12.20% wb.

One hundred seeds were randomly selected from the sample. Measurements of dimensions on three naturally perpendicular axes were made, namely: major, intermediate and minor diameters. These dimensions were measured with electrical digital Vernier Calipers with a resolution, reliability and maximum error of 0.01 mm, 0.01 mm and 0.02 mm respectively.

Sphericity and roundness were determined for the seeds. Each seed was placed in its natural resting position on a sheet of graph paper. A sharp pencil was used to carefully trace the edge of seed. Projected area and the diameters of circles inscribing and circumscribing the projected areas were measured (Oje and Ugbor 1991), and sphericity and roundness were determined using these equations:

$$\text{Ë ÑÕÑÍ ÑĮ ÓÓ} = \frac{A_p}{A_c} \quad . \quad . \quad . \quad . \quad . \quad 1$$

$$S(\Phi) = (LWT)^{1/3}/L \quad . \quad . \quad . \quad . \quad . \quad 2$$

A_p = Largest projected area of seed in rest position
A_c = Area of smallest circumscribed circle
S = Sphericity
L = Length of seed
W = Width of seed
T = Thickness of seed

The volume and hence density of 50 seeds each was determined by the water displacement method as described by Ojo and Ugbor (1991). Individual seed were immersed in water inside a measuring cylinder sharing a notably rise in water level. The difference in the final and initial reading was recorded as the volume of the seed. Density was determined by dividing weight by volume.

The surface area of 100 seeds each was determined using:

$$S = (D_p)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 3$$

D_p = Geometric mean diameter of seed
As described by Fraser et al, (1978).

Bulk density was obtained using

$$D_b = \frac{M_2 - M_1}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 4$$

Where M_1 = Mass of empty cylinder
M_2 = Mass of cylinder plus seed
V = Volume
D_b = Bulk density of seed

Empty 132 cm^3 cylinder was weighed, then filled with the *Khaya* seeds and reweighed. Computation was done using equation 4.

The porosity (P_f) was obtained from the relationship as stated by Mohsenin (1988)

$$P_f = 1 - \frac{D_b}{D_s} \quad . \quad . \quad . \quad . \quad . \quad 5$$

Where D_b = Bulk density of seed and D_s = Density of seed.

The angle of repose and coefficient of friction were determined with respect to two structural materials namely: plywood and galvanized steel. An inclined plane apparatus was used to obtain the angle of repose by placing some amount of seeds on an adjustable tilting surface. It was gradually raised with a crew device until it just start to slide down the angle

of the incline was read from a graduated scale. The coefficient of friction was obtained from the relationship as described by Mohsenin (1988).

$$\mu = \tan^{\alpha} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 6$$

Specific heat capacity was determined by the method of mixture (Ojo and Ugbor, 1991) using an adiabatic drop calorimeter. Water of known weight and temperature was poured into a calorimeter containing the seeds. At equilibrium, the final temperature was noted. Specific heat capacity Cs, was calculated by the expression

$$C_s = \frac{[(M_f C_f + M_c C_c)(T_f - T_m)]}{M_{s(T_s - T_m)}} \quad . \quad . \quad 7$$

Where M_f = Mass of water
T_f = Initial temperature of water
C_f = Specific heat capacity of water
Mc = Mass of calorimeter
T_m = Initial temperature of mixture
C_c = Specific heat capacity of calorimeter
T_s = Initial temperature of seed

3. RESULTS AND DISCUSSION

3.1 Results

Table 1: Measured Parameters

Parameters	Replica	Max	Min	Mean
Major dia mm	100	20.59	14.49	17.52
Inter. dia mm	100	13.58	4.49	11.79
Minor dia mm	100	2.60	0.79	1.52
Weight g	100	0.27	0.11	0.18
Angle of Repose				
Steel surface (°)	50	29	27	27.85
Wood surface (°)	50	32	25	29.60

Table 2: Calculated Parameters

Parameters	Replica	Max	Min	Mean
Surface area (mm^2)	100	66.42	31.14	48.85
Roundness	100	0.75	0.43	0.58
Sphericity (mm)	100	0.48	0.34	0.54
Volume (cm^3)	100	0.25	0.18	0.21
Density (g/cm^3)	100	1.34	0.56	0.88
Bulk density	50	0.45	0.40	0.42
Porosity	50	0.56	0.42	0.51
Coeff of friction				
a. Steel surface (°)	50	0.55	0.51	0.53
b. Wood surface (°)	50	0.60	0.47	0.57
c. Specific heat (KJ/KgS	50	37.22	20.80	27.94

4. DISCUSSION

The sizes were determined along the major, minor and intermediate axes. The mean values and ranges (table 1) of the seeds along major axis were 17.52 mm and 20.54 to 14.49 mm, along the major axis, 1.5 mm and 2.60 to 0.79 mm along minor axis, and 11.70 mm and 13.58 to 9.47 mm along the intermediate axis respectively. A positive correlation was established between the seed length, width and thickness with other parameters of the seeds at 0.01 significant level (Appendix 1). The sizing of the seed dimension is important in aperture design of machine. The seeds dimension was observed to differ with those reported for pea seeds (Poksay and Aydin, 2006), and sunflower seeds (Gupta and Das 1997).

The weights were determined at 12.20% mc (wb) with a mean value of 0.18 and ranges from 0.10 to 0.259. The values were higher than those of sufflower seeds at 9.2% mc (wb) (Turkan et al, 2006). Positive correlation was established between weight of Khaya seeds and its density and volume at 0.01 significant level. Similar trend was reported for pea seed between its weight and moisture content (Poksay and Aydin, 2006).

The angle of repose for the seed was observed to vary from 32^{o} to 25^{o} with a mean value of 29.6^{o} for plywood, while the mean value and ranges for galvanised steel were 26.85 and 29^{o} to 27^{o} respectively. The angle of repose for the seeds was less than those of sunflower (Gupta and Das, 1997). A positive correlation was also established between the seed angle of repose and coefficient of friction at 0.01 level of significance.

The surface area of the seed was evaluated and the mean value was found to be 48.85 mm^2, and varies from 31.14 to 66.42 mm^2. The surface area will aid in the study of heat transfer in the heating and cooling processes and in machine design especially for the mechanical expression of oil from the seeds as reported by Mohsenin (1980). A positive correlation was observed between surface area of the seed with its length, width, thickness and sphericity at 0.01 significant levels.

The mean values of sphericity and roundness of the seeds were evaluated as 0.54 and 0.58 while they range from 0.34 to 0.48 and 0.43 to 0.75 respectively. The values of sphericity was similar to those reported for sunflower seeds but lower for pigeon pea and soya bean seeds (Gupta and Das, 1997). The results indicated the seed would rather slide than role which will aid in design of hopper, loading and unloading devices. Sphericity correlates positively with seed thickness and surface area while roundness correlates positively with seed thickness at 0.01 significant levels.

The mean value and density of Khaya seeds were obtained as 0.21 cm^3 and 0.8891 cm^3 while they vary from 0.20 to 0.24 cm^3 and 0.56 to 1.34 g/cm^3 respectively. The value was found to be similar to those sunflower seed at 4.47% mc (Turka et al, 2006). Also positive correlation exists between volume and density with the seed weight.

Bulk density of khaya seed have a mean value of 0.42 g/cm^3 and varies from 0.40 to 0.45 g/cm^3, there was no relationship between bulk density and other parameters obtained for the khaya seeds. However, porosity varies from 0.42 to 0.56 with a mean of 0.51. The porosity of Khaya seed was higher than those of sunflower, sufflower, and pumpkin seed (Joshi et al, 1993; Desphade et al, 1993 and Gupta and Prakash, 1992). Correlation was not established between porosity and other parameters determined.

Static coefficient of friction for the Khaya seed was determined and ranges from 0.601 to 0.466 for wooden surface with a mean value of 0.567, while for galvanized steel,

it varies from 0.554 to 0.510 with a mean value of 0.528 respectively. Values were higher for wooden surface than for steel surfaces. The static coefficient of friction of the seeds on steel surface is similar to those of sunflower seeds on galvanized iron surface while it is higher for sufflower, grains, and oil bean seed (Gupta and Das, 1997). A positive correlation exists between coefficient of friction for steel surface and angle for repose for steel surface at 0.01 significant levels.

The specific heat capacity of Khaya seed were evaluated and found to vary from 20.77 to 32.85 KJ/Kg^{o}C. These results are higher than those reported for palm kernel seeds (Gbadamosi, 2006).

5. CONCLUSIONS

The average value of the seeds hardness was 3.02 Kg/mm^2. This result can aid in determining the method of size reduction and milling process of the seeds.

The seeds were found to be stronger along its intermediate axes with a mean force of 620.06 N, at break point, compared to 20.13 N and 12.29 N along major and minor axes respectively. Alternatively, more energy is required to rupture the seed along intermediate axis with a mean energy of 759 x 10^{-3} J, as compared to 429 x 10^{-3} and 239 x 10^{-3} J, along the major and minor axes respectively.

From the experimental results obtained, it was observed that compressive force and rupture energy were not obtained along the intermediate axis (at yield point) while the behavior of the seeds under loading along the principal axes (major, minor and intermediate) differs. Statistically, the mechanical properties tend to have positive correlation at 0.01 and 0.05 significant level.

REFERENCES

Alcali, I.D. and Guyen, O. (1990), Physical properties of peanut in Turkey, Agricultural Mechanization in Asian, African and Latin American, 2(3) 5559.

Beolhouwer, C. (1983). Trends in Chemistry and technology of Lipids. J. Am. Oil chemists Soc. 60:457 462.

Dorthe, J. and Sylvie, G (2003). *Khaya senegalensis* (Desr)-Taxonomy and nomenclature. Seed leaflet, No 66

http://74.125.45.132/search?q=cache:t2k8gDE7YAJ.

Food Security:info/food-security.inf.

Fraser, B.M., Verma, S.S. and Muir, W.E. (1978) Sources Physical Properties of Fababeans. J. Agric Eng. Res., 23:53 57.

Istifanus, A. B. (2006). A study of source mechanical properties of bambara nut [*Vigna subterranean (L) verde*] M.Sc. Thesis, Department of Agric Eng. FUT-Yola. Pp 6-21

Lea, P.J. and Leegood, R.C. (1993). Plant Biochemistry and Molecular Biology (Chister

John Willey). P. 269.

Maduako, J.N. and Hamman, M. (2000). Physical Properties of some groundnut varieties for the mechanization of shelling operation. A paper presented at the National Conference on the Revitalization of Agriculture in the Nigeria Economy FUT-Yola, Pp. 74 79.

Michael, A. (2004). Trees, shrubs and lianas of West Africa dry zones. CIRAD Muggraf Publishers GMBH. MNHN.Pp 355

Mohsenin, N.N. (1980). Physical Properties of plant and animal materials. New York. Garden and Breach Science Publishers Inc. One Park Avenue.

Mohsenin, N.N. (1988). Physical Properties of plant and animal materials. New York. Garden and Breach Science Publishers Inc. N.Y. Pp. 5 12, 89 106.

Oje, K. and Ugbor, E.C. (1991). Some physical properties oil bean seed. Journal of Agric Eng. Res. 50:305 313.

Olaoye, J.O. (2000). Some physical Properties of Castor Nut relevant to the design of processing equipment. Journal of Agricultural Engineering research. 77 (1): 113 118.

Roger, A. (2004). *Khaya senegalensis* current use from it's natural range and it's potential in Sri-Lanka and elsewhere in Asia. CSIRO and Forest Research, Kingston. ACT 2604.

DEVELOPMENT OF A REFLECTIVE SOLAR COOKER

S. L. Ezeoha, F. U. Asoiro And I. G. Tobias
Department of Agricultural and Bioresources Engineering
University of Nigeria, Nsukka
[+]Corresponding author. Email: felixasoiro@yahoo.com
Tel.: +2348063588320

ABSTRACT
The rising cost of non-renewable sources of energy has led people to look for alternative forms of energy for their cooking. Solar cookers have been able to meet this demand. In this work, a reflective solar cooker was developed using low cost and readily-available materials. It comprises a parabolic satellite dish which enables the reflector to reflect sun rays incident on it to the focus, a reflective material, a supporting mechanism for the dish, a cooking pot, and the tracking mechanism which tracks the sun's motion across the sky. Performance evaluation of the solar cooker was carried out. This solar cooker cooks faster and cleaner compared with other conventional/traditional cooking systems. One hundred and sixty grams (160g) of Indomie and three (3) eggs were boiled. It took 30mins to cook the noodles and 23mins to boil the eggs. It also took 38mins to boil 1.4 kg of water at a temperature of 100^{o}C. This performance evaluation was carried out when temperature range was between 25-50^{o}C. The highest temperature obtained at the focal zone was 101^{o}C when the ambient temperature was 50^{o}C at a solar radiation intensity of 910.72 W/m^{2}. The thermal efficiency of the solar cooker at this time was 9%. The purchasing cost was about seventy three thousand naira (N73, 000.) which is within the reach of the average rural farmer.

Keyword: Solar Cooker, Thermal Efficiency, Solar Radiation, Pyranometer, Thermal Conduction.

1.0 INTRODUCTION
Energy plays a vital role in human development and welfare. Indeed, a direct relationship exists between the level of economic development and the consumption of energy. The standard of living is found to rise with the increase in per capita consumption of energy. The rising costs of non-renewable sources of energy because of its dwindling stocks coupled with global warming and greenhouse effect have led people to look for alternative sources of energy for electricity, fuelling and cooking needs. One of the most preferred and convenient form of alternative energy is solar energy, which can be harnessed for use both at homes and in commercial establishments. Because of economic and financial meltdown all over the world, it is expected that in the near future, food production will no longer meet the needs of the world's rapidly increasing population. The lack of appropriate preservation, storage and processing techniques is therefore a big concern as vital nutrients could be lost during these processes. Increase in crop yield, improvement of production quality and reduction of losses are all directly related to the availability of energy. Providing energy from an alternative source like sunlight is therefore an urgent necessity (Okonkwo, 2011). The importance of solar energy cannot be over-emphasized. It is an ultra-clean and natural energy resource which has been proven to have an immense amount of constructive and helpful impact on the environment. Contrasting to the fossil fuels that we consume and use on a daily basis,

solar energy does not contribute to the excessive injurious pollutants that are liable for the greenhouse effect which lead to global warming as well as acid rain which affect crop production, hence, reduces food availability. Solar energy use reduces the quantity of contamination and toxic waste, not to forget pollution that the endangering plants have to produce. With solar energy, the sun's rays are used to create electricity, heat water or other fluids, charge a battery, heat homes through glass windows and cook food. In recent years, many solar gadgets have been developed for variety of applications. Different solar concentrators can provide excellent boiling, steaming, blanching and roasting capabilities. Technology has certainly changed the aspect of cooking to a great extent.

Formally, humans were used to the traditional method of cooking, but these days, the invention of new technologies has helped ease the hassles associated with cooking. The development of different solar cookers for example, is a relief. New technologies for cooking speed up kitchen processes as well as shorten cooking time (Gibbs and Myhrvold, 2005). Cooking can be done with the use of solar cookers. Solar cookers use sunlight for cooking, drying and pasteurization. They can be grouped into three broad categories: Box cookers, Panel cookers and Reflector cookers (Anderson and Palkovic, 1994).

Box cooker: The simplest Solar Cooker is the Box Cooker first built by Horace de Saussure in 1967. A basic solar box cooker which consists of an insulated container with a transparent lid can be used effectively with partially overcast skies and will typically reach temperature of 90-150^{o}C (Anderson and Palkovic, 1994).

Panel cooker: Panel Cookers use a reflective panel to direct sunlight onto an insulated container and reach temperatures comparable to Box Cookers (Anderson and Palkovic, 1994).

Reflector cooker: Reflector Cookers use various concentrating geometrics (dish, trough, Fresnel mirrors) to focus light on a cooking container. These Cookers reach temperatures of 315^{o}C and above but require direct light to function properly and must be repositioned to track the Sun (Anderson and Palkovic, 1994).

In general, solar cookers work best on bright, sunny days and when the sun is high. But they can still do useful cooking even if the sky is hazy or partly cloudy but this will take longer time. Because solar cookers use the sun, they save natural resources, provide better quality of produce in terms of colour, aroma and taste. Also, low capital investment in this technology makes it financially viable (Beth and Halacy, 1992). Therefore, this work seeks to design, construct and evaluate the performance of a reflective solar cooker.

2. MATERIALS AND METHODS

2.1. Design Considerations

The following points were considered:

1. Higher cooking efficiency compared to the conventional/primitive systems for cooking
2. Reduction in cooking time associated with conventional/ primitive cooking systems
3. Preservation of desirable food qualities after cooking

2.2. Design Requirements

The choice of materials was based on functionality, strength, toughness, durability and cost.

The following materials were selected in the design and construction of a reflective solar cooker:

(i) **Parabola:** A fairly-used and discarded satellite dish made of steel was used. The dish has a diameter of 1.81m; area of 2.57m^2; depth of 0.325m and thickness of 1mm.

(ii) **Reflective material:** A 500mm x 3000mm aluminium foil of 0.5mm thickness and reflectivity of 0.7 was used because the desired aluminium plate that suits this purpose was not readily available.

(iii) **Cooking vessel:** A matt black aluminium pot was used for this work. The specification for the vessel are as stated: Inner diameter, 0.153m; Outer diameter, 0.156m; Area, 0.018m^2; Thickness, 1.5mm; Thermal conductivity, K, 237Wm^{-1}. K^{-1} and Depth: 83mm.

(iv) **Supporting and tracking mechanisms:** The supporting mechanism for the dish consists of a galvanized pipe of length, 87cm; inner diameter, 8cm and outer diameter, 9cm on which the dish directly rests and a U-channel mild steel metal of lenght107cm and thickness of 10cm which offers stability to the whole system The whole assembly (Figure 1) are coupled together by a 4pc M10 x 1.5P bolt and nut.

The supporting mechanism for the pot consists of three iron rods of length 93cm each, 2pcs of galvanized pipe of length 103cm and 4 mild steel flat bars of length 15cm. The tracking mechanism is made of mild steel metal. Other materials include a thermometer which was used to measure ambient temperature as well as the temperature of water during testing, a measuring tape, and thick gloves which offer protection against burn.

2.3. System Component Selection and Design Calculations (Analysis)

2.3.1 Determination of parabola dimensions

Considering a parabolic satellite dish of 1.81m in diameter (D) and a depth of 0.325m:

The aperture area, A of the dish can be calculated using equation 1 below

$$A = \frac{\pi D^2}{4} \qquad (1)$$

$$A = \frac{3.142 \subset (1.81)^2}{4}$$

Therefore,

$$= 2.57\text{m}^2$$

2.3.2 Determination of focal length and focal point

Focal length is the distance from the centre of the parabolic dish to the focus. Focal point is the point where all the reflected rays focus. The focal length and focal point can be determined from the following procedures: The diameter and depth of the dish were measured. The diameter was divided by 2 to obtain the radius. The radius was squared and the parabola depth was multiplied by 4. Equation 2 was used to calculate the distance above the vertex where the focal point is located.

$$D_f = \frac{R^2}{4d} \qquad (2)$$

Where, D_f is the distance above the vertex where the focal point is located (m), R is the radius of the parabola (m) and d is the depth of the parabola (m). Measuring the diameter, D and depth, d of the dish as 1.81m and 0.325m respectively, the radius, R was calculated as 0.905m while the distance above the vertex where the focal point is located, D_f was computed as 0.63m. Therefore the focal length is from 0-0.63m. Hence, the focal point is 0.63m above the vertex.

2.3.3 Determination of efficiency and thermal requirement.

A solar cooker utilizes only direct solar radiation. Thus, the diffused radiation is unimportant. The direct radiation was determined at 12:00 noon solar time using August 15 as the mean day for Nsukka, which is at the latitude of 7°N. Direct solar radiation at normal incidence, I_{DN} was computed using equation 3

$$I_{DN} = \frac{Ae^{-B}}{Sin\beta} \quad . \quad . \quad . \quad . \quad . \quad . \quad 3$$

The values of apparent solar irradiance just outside the atmosphere, A, and atmosphere extinction coefficients, B were obtained from Table 1 as A = 351Btu/hrft^2. Multiplying with 3.1525 to convert to W/m^2:
A = 351 ◈ 3.1525 = 1106.53W/m^2; B = 0.201

Declination, δ is determined from Table 2. Declination for the month of August is given by: δ = 13.4°

Hour Angle, H is determined from equation 4

$$H = \frac{360}{24}(12 - T) \quad 4$$

T = solar time = 12noon

$$H = \frac{360}{24}(12 - 0) = 0$$

At noon, hour angle is zero.
Altitude Angle, βis determined from equation 5.

$$\beta = \sin^{-1}(\sin\theta\sin\delta + \cos\theta\cos\delta\cos H) \quad 5$$
$$= \sin^{-1}(\sin 7^{o}\sin 13.4 + \cos 7^{o}\cos 13.4\cos 0) = 83.60^{o}$$

Direct Radiation was gotten as 910.72W/m^2 by using equation 3 stated above
Therefore, $H_B = I_{DN} \, x \, Sin\beta = 910.72 \, x \, Sin 83.2 = 905.04 W/m^2$
The value obtained above varies with day of year and solar intensity. As a result, an allowance of 12% is given to account for these variations as well as losses due to convection and radiation. The value of H_B will therefore become

Allowance = 905.04 *x* 0.12 = 108.6048
Therefore, H_B = 905.04 – 108.6048=796.44W/m^2
Given mass of water = 1.4kg, specific heat capacity of water = 4200J/kg, temperature difference, ΔT = 96°C – 25°C = 71°C, solar cooker area, A = 2.57m^2 and time taken for water to boil, t =38mins = 38 ◈ 60 = 2280sec. Therefore, efficiency, η calculated using eqn. (6) gives 9%.

$$\eta = \frac{M_W C_W \Delta T \; x \; 100\%}{A_C H_B t} \quad \text{(Murty } et\ al.\text{, 2007)} \quad (6)$$

Where,

? = average sensible efficiency of the cooker, %

A = solar cooker area, m^2,

H_B = beam radiation on the solar cooker;

t= time of cooking, secs.

The sensible cooking power can be calculated using equation 7

$$P = A \, x \, \eta \, x \, H_B \qquad (7)$$

Where,

P = sensible cooking power, J/s;

A= solar cooker area, m^2;

? = average sensible efficiency of the cooker, %;

H_B= beam radiation on the solar cooker, W/m^2.

From literature, the thermal efficiency of a parabolic solar cooker cannot exceed 15%. The low efficiency of the cooker is attributed to the following factors.

1. Very low solar radiation.
2. Wrinkles formed by the reflector during pasting which will reflect some rays incident on it away from the focus.
3. Distance of heat from the reflector to the pot, caused by the architectural structure of the dish.
4. Losses due to convection.

The second factor can be controlled by using a better reflector like aluminium plate but this was not available. The other factors cannot be controlled.

2.3.4 Selection of altitude angle.

For the purpose of selecting the altitude angle of the solar cooker, a time interval was taken to select the minimum altitude angle at which the cooker tracks the sun. Practically, on bright sunny days, solar radiation intensifies at about 9:00am solar time and starts fading at about 4:30pm solar time. Hence, 9.00am- 4.30pm solar times were taken as the time required in carrying out effective cooking.

For 9:00am solar time

$H = (360/24)(12-T) = (360/24)(12-9) = 45^o$

Hour angle is positive in the morning.

From previous calculations, $\delta = 13.4^o$, $\Theta = 7^o N$

$\beta = \sin^{-1}(\sin 7 \sin 13.4 + \cos 7 \cos 13.4 \cos 45) = 45.23^o$

For 4:30am solar time

$H = -67.5^o$ Hour angle is negative in the afternoon.

$\beta = \sin^{-1}(\sin 7 \sin 13.4 + \cos 7 \cos 13.4 \cos(-67.5)) = 23.40^o$

Total altitude angle = $45.23 + 23.40 = 68.63^o$

Let the horizontal surface of the earth be 180^o

$180 - 68.63 = 111.37^o$

Hence, the cooker will track the sun through an angle of 111.37^o across the sky. The above calculations show that the minimum altitude angle for the tracking mechanism is 23.40^o

2.4 Performance Evaluation of the Solar Cooker

The cooker needs clear sunlight to work. Under the cooker is a clear shadow picture of the whole mirror. There was no shadow of trees, buildings or persons in the mirror area while cooking as this will affect rate of cooking. Also, the pot itself makes shadow on the mirror, which can of cause not be avoided. But smaller pots make less shadow and therefore slightly collect more energy. The cooker was placed on level

2.3.4 Selection of altitude angle.

For the purpose of selecting the altitude angle of the solar cooker, a time interval was taken to select the minimum altitude angle at which the cooker tracks the sun. Practically, on bright sunny days, solar radiation intensifies at about 9:00am solar time and starts fading at about 4:30pm solar time. Hence, 9.00am- 4.30pm solar times were taken as the time required in carrying out effective cooking.

For 9:00am solar time

$H = (360/24)(12-T) = (360/24)(12-9) = 45^{o}$

Hour angle is positive in the morning.

From previous calculations, $\delta = 13.4^{o}$, ? = 7°N

$\beta = \sin^{-1}(\sin 7 \sin 13.4 + \cos 7 \cos 13.4 \cos 45) = 45.23^{o}$

For 4:30am solar time

$H = -67.5^{o}$ Hour angle is negative in the afternoon.

$\beta = \sin^{-1}(\sin 7 \sin 13.4 + \cos 7 \cos 13.4 \cos(-67.5)) = 23.40^{o}$

Total altitude angle = $45.23 + 23.40 = 68.63^{o}$

Let the horizontal surface of the earth be 180^{o}

$180 - 68.63 = 111.37^{o}$

Hence, the cooker will track the sun through an angle of 111.37^{o} across the sky. The above calculations show that the minimum altitude angle for the tracking mechanism is 23.40^{o}

2.4 Performance Evaluation of the Solar Cooker

The cooker needs clear sunlight to work. Under the cooker is a clear shadow picture of the whole mirror. There was no shadow of trees, buildings or persons in the mirror area while cooking as this will affect rate of cooking. Also, the pot itself makes shadow on the mirror, which can of cause not be avoided. But smaller pots make less shadow and therefore slightly collect more energy. The cooker was placed on level ground. In about 2 meter distance around the cooker, there was no dry grass on the ground, which may inflame in a very unlucky combination of conditions. For convenience, a shade was provided for the cook next to the cooking place, was in the full sunlight. An umbrella was used for this purpose while cooking. The Solar Cooker was turned towards the Sun and left until the food was cooked. The solar cooker was always checked to turn the cooker to face the Sun more precisely and to ensure that shadows from nearby buildings or plants have not blocked the sunlight. Food items namely, indomie and 3 eggs were boiled on the cooker. 1.4 kg of water was also boiled. The overall performance of the solar cooker during test days was quite satisfactory. However, it was greatly affected by very low solar intensity which could not be controlled.

3. RESULTS AND DISCUSSION

Tables A-1 to A-3(in Appendix) and Figures 2 to 6 show fluctuations in ambient temperature as well as temperature at the focus. Some data could not be obtained for focal point temperature because there was no sunlight to be tracked to the focus. Generally, the highest temperature obtained at the focus was 101°C at ambient temperature of 50°C. In essence, the solar cooker will perform efficiently during the dry season when solar intensity is higher.

Weather conditions on test days and results:

On test day 1, ambient temperature varies as shown on Table A-1 and Fig.2. The temperature was so low that sunlight could not be tracked. So the temperature at the focal zone could not be measured. Hence, no cooking was done. On test day 2, ambient

temperature was fair. Temperature variations at the focal zone were measured and recorded as shown on Table A-2 and Figures 3 & 4. The temperature was able to boil 1.4kg of water in 38mins, 160g of Indomie in 30 mins, and 3 eggs in 23mins. The time taken to cook was longer than usual because of fluctuations in temperature. On test day 3, ambient temperature was not fair. However, temperature variations at the focal zone were measured and recorded as shown on Table A-3 and Figures 5 & 6. One hundred and sixty gram (160g) of indomie noodles were cooked but took a very long time.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Solar energy may be able to replace the use of fossil fuels in the long run and save the reserves of fossil fuels. It would reduce air pollution from methane and carbon dioxide contained in fuels and also reduce climate change. Its use would combat the cutting down of trees which lead to deforestation, desert encroachment and soil erosion. Solar energy would improve health, nutrition and also serve as a good alternative during this period of fuel scarcity. Solar energy is universal, abundant, free and inexhaustible. The reflective solar cooker developed is easy to operate. Testing and performance evaluation of the system showed that the system can be recommended for use by small or large households as well as farmers and cooperatives in both rural and urban communities, considering the fact that the total cost of about N73, 000. (Seventy Three Thousand Naira) required to realize the system is within the means of an individual peasant farmer. Therefore manufacturers should take up this innovation and implement it for both domestic and industrial mass use.

4.2 Recommendation

The following recommendations are suggested. An automated device that can track the sun's motion across the sky should be incorporated into the system. The use of more durable and reflective material like aluminium plate is also recommended. A means should be devised for storing energy for usage at night, cloudy or rainy periods, as this will not only increase cooking efficiency but also make cooking possible any time of the day.

REFERENCES

Anderson and Palkovic (1994): Cooking with Sunshine (The complete Guide to Solar Cuisine with 150 Easy Sun-cooked Recipes). Marlone and Company. ISBN 1-56924-300X.

ASHRAE, *Handbook of Fundamental*: (1981): American Society of Heating, Refrigeration and Air- Conditioning Engineers Inc. New York.

Beth and Halacy D. (1992): *Cooking With the Sun*: *How to Build and use Solar Cookers.* Morning Sun Press.

Gibbs, W. W. and Myhrvold N. (2005): *A new spin on cooking.* Retrieved from www.scientificamerican.com/article.cfm?id=a-new-spin-on-cooking

Murty V. V. S. (2007): *Evaluation of Thermal Performance of Heat Exchanger.* Indian Journal of Pure and Applied Physics, Vol.45, p. 745 – 748.

Okonkwo W. I (2010): Course Note on *ABE 535* (*Solar Energy Applications in Bioprocess Engineering*). Department of Agricultural and Bio resources Engineering, University of Nigeria, Nsukka.

APPENDIX

Table A-1: Data of Solar Time and Ambient Temperature for Test Day One

Solar Time, hrs	Ambient Temperature, ^oC
9:00am	24
10:00am	26
11:00am	27
12:00pm	29
1:00pm	30
2:00pm	27
3:00pm	30
4:00pm	30

Table A-2: Data of Solar Time, Ambient Temperature and Temperature at the Focal Zone For Test Day Two

Solar Time (Hour)	Ambient Temperature (^oC)	Temperature at Focal Zone (^oC)
9am	Drizzles	Drizzles
10am	25	25
11am	29	29
12pm	41	63
1pm	47	76
2pm	50	101
3pm	42	46
4pm	32	40

Table A-3: Data of Solar Time, Ambient Temperature and Temperature at the Focal Zone for test day three.

Solar Time (Hour)	Ambient Temperature (^oC)	Temperature at Focal Zone (^oC)
9am	24	0
10am	27	0
11am	32	0
12pm	30	0
1pm	41	62
2pm	27	0
3pm	33	42
4pm	34	43



Figure 1: The Reflective Solar Cooker

Table 1: Constants for ASHRAE Equations For 21st Day of Each Month

Month	*A (Btu/hr ft²)*	*B*
January	390	0.142
February	385	0.144
March	376	0.156
April	360	0.180
May	350	0.196
June	345	0.205
July	344	0.207
August	351	0.201
September	365	0.177
October	378	0.160
November	387	0.149
December	391	0.142

Table 2: Recommended Average Day For Each Month and Values of n by Month.

Month	n of ith Day of Month	For Average Date	Day of the Month n, Day of Year	Declination(δ)
January	I	17	17	-20.9
February	31 + i	16	47	-13.0
March	59 + i	16	75	-2.4
April	90 + i	15	105	9.4
May	120 + i	15	135	18.8
June	151 + i	11	162	23.0
July	181 + i	17	198	21.2
August	212 + i	16	228	13.4
September	243 + i	15	258	2.2
October	273 + i	15	288	-9.6
November	304 + i	14	318	-18.9
December	334 + i	10	344	-23.1

(Okonkwo, 2011)

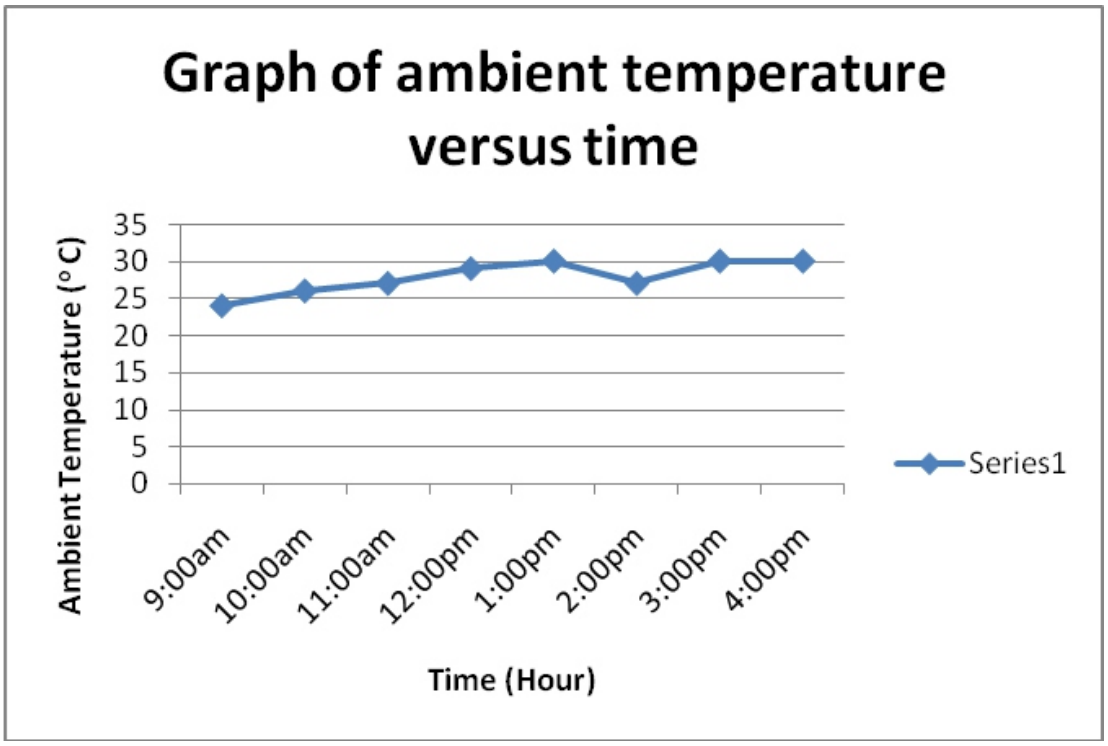


Fig. 2: Graph of Ambient Temperature Versus Time For Test Day One

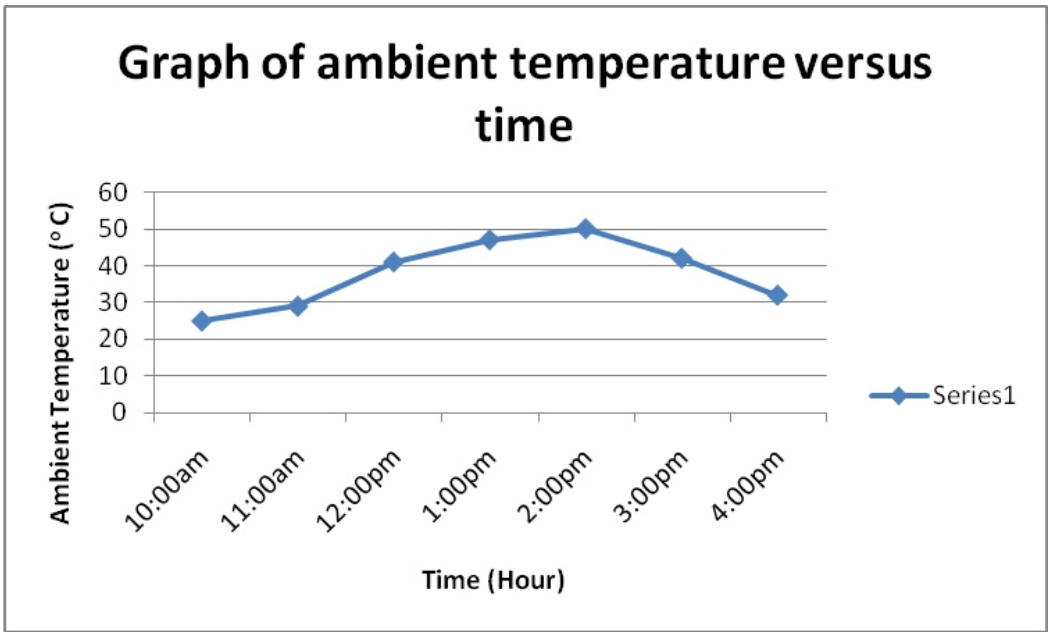


Fig. 3: Graph of Ambient Temperature Versus Time For Test Day Two

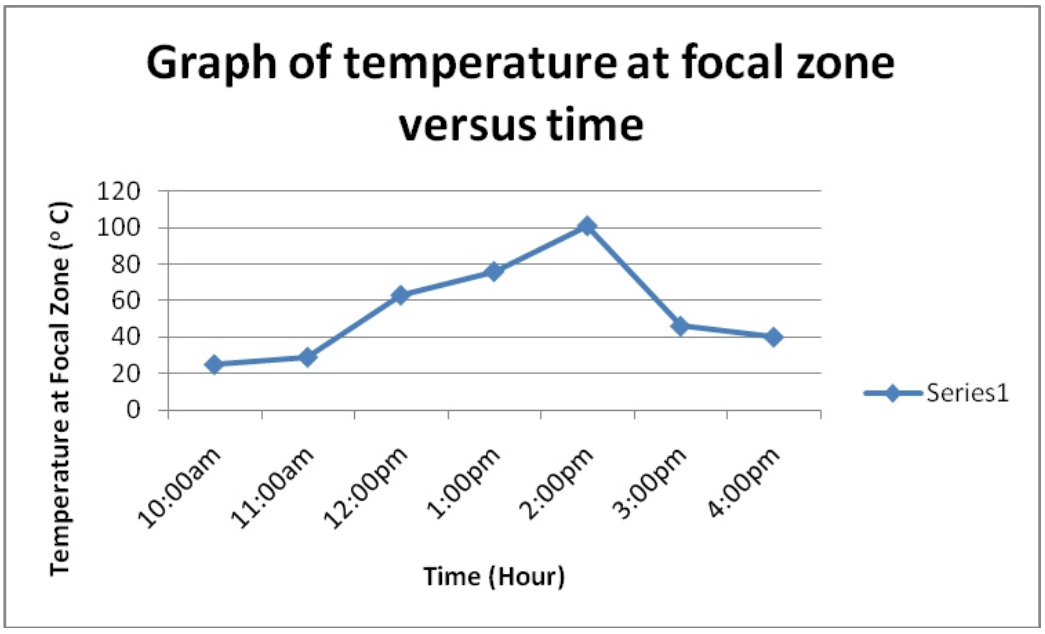


Fig. 4: Graph of Temperature At Focal Zone Versus Time For Test Day Two

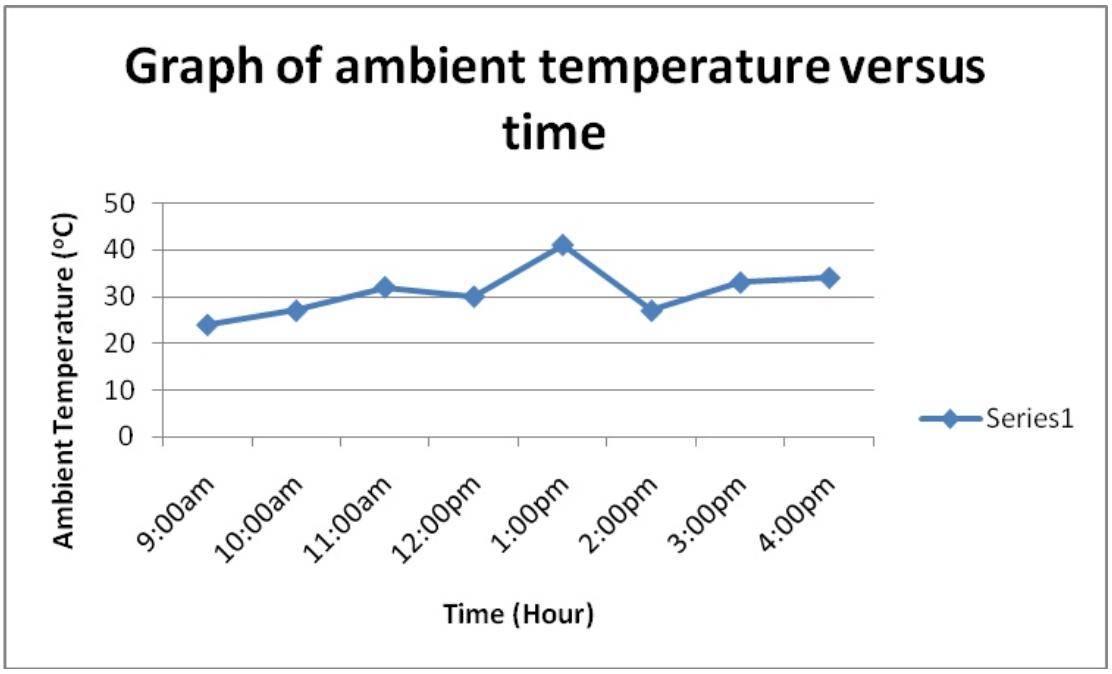


Fig. 5: Graph of Ambient Temperature Versus Time For Test Day Three.

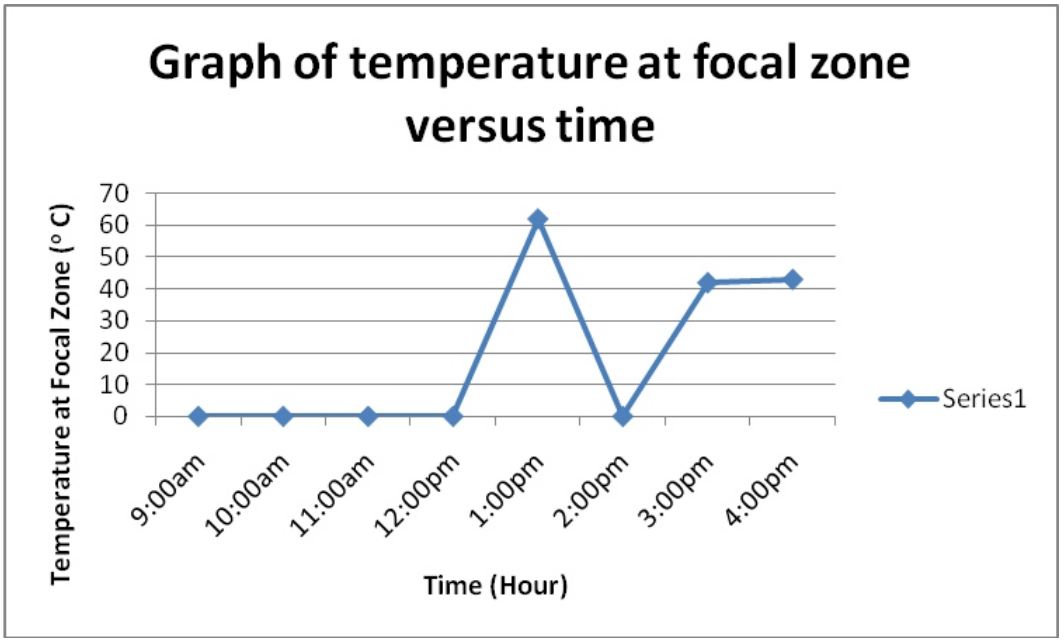


Fig. 6: Graph of Temperature At Focal Zone Versus Time For Test Day Three.

DESIGN OF A ROASTER/FRYER FOR HIGHER EFFICIENCY AND ENERGY SAVING IN TRADITIONAL GROUNDNUT OIL PROCESSING

M. A. Ali[1] and A. Shitu
Department of Agricultural Engineering, Faculty of Engineering,
Bayero University, Kano.
[1]Telephone: 080-33153491 and
[1]E-mail: dralimohd@yahoo.co.uk

ABSTRACT
The traditional groundnut oil processing is a popular commercial value addition activity, especially amongst women in Northern Nigeria. The process comprises of seven sub-processes, which include roasting, de-skinning, winnowing, milling, kneading, frying and forming of groundnut cake. To improve the efficiency of the traditional process, a roaster/fryer was designed and constructed. Comparative evaluation of the roasting process using same quantity of groundnut revealed that average roasting efficiency was 95.8 % with the roaster/fryer whilst it was 93.4% by the traditional process; and fuel consumption during roasting was 2.3kg/hr by the roaster/ fryer and 5.4kg/hr by the traditional process (an energy saving of 57.4%). Similarly results of frying of 2.4kg of groundnut meal with the roaster/fryer gave average frying efficiency of 89.3% and average fuel consumption of 2.6kg/hr; whilst same process in the traditional way gave average frying efficiency of 69.3% and average fuel consumption of 5.1kg/hr (an energy saving of 49.0%). In effect, the roaster/fryer enhances the quality of products from the two sub-processes; whilst also increasing profit margin of this commercial value addition activity, by reducing cost of fuel consumption.

Keywords: Groundnut Oil, Value Addition, Roaster/fryer, Efficiency And Fuel Consumption.

1.0 INTRODUCTION
Groundnut is an important crop grown in different parts of the world because of its seed. It is directly consumed as food or processed to remove oil. After the oil extraction it remains a meal which is very rich in high protein and it's a consumable derivative. Smart (1994) as cited by Ola (2000) found the percentage oil content as 42-53.8%, 45 – 58.6%, and 41 – 53.6% respectively for the three main varieties of groundnut, namely Spanish, Virgina and Runner. The oil is the important product of the crop, with about 40% of the world production crushed for oil (Ola, 2000).

Groundnut oil extraction is carried out in the Northern states of Nigeria by women in rural areas using the traditional process. It was found that amongst 436 processors of groundnut oil in three Northern states, (Niger, Kaduna and Kano), 74% claimed that they were processing for income generation (Nalumansi and Kaul 1992). Thus, the processing represents an important economic activity for the women.

The traditional processing comprises seven sub-processes, which include roasting, de-skinning, winnowing, milling, kneading, frying and forming of groundnut cake. A detailed study of the entire traditional process revealed that there is scope for improvement of each sub-process that could result in better efficiency, time saving and higher economic returns (Ali et al., 2012). Thus this work is aimed at improvement of the roasting and frying sub-processes.

2.0 MATERIALS AND METHODS

2.1 Materials

Materials used to carry out the study included: **Stop clock** - for noting the time taken to carry out a given process**; Weighing balance** - for measuring the weight of the groundnut and products derived from the roasting and frying sub-processes; **Roasting/frying pan -** for roasting or frying groundnut meal (known commonly as 'kulikuli') on an open fire; **Shelled groundnut** - the main raw material for roasting; **Fire wood -** as a source of energy used to roast groundnut and fry the groundnut meal. **Packing Strainer Spoon** – for packing roasted groundnut or fried groundnut meal.

2.2 Methods

2.2.1 Study of the traditional process of roasting and frying

The traditional methods of roasting and frying were studied in detail by observing a processor, whilst processing different quantities of groundnut. This study was a detailed observation of the process in order to properly understand the traditional process and to identify area(s) of improvement of the process. Therefore, information collected was the detailed step by step procedure, types of tools used and areas that need modification.

2.2.2 Development of a roaster and fryer

i. D**esign aims**

The improvements intended on the traditional system of roasting groundnut and frying were:

- To enhance the stirring action so as to achieve efficient roasting of the nuts.
  This could be achieved through development of an improved roasting chamber. The chamber should have paddles inside so as to evenly stir the nuts; thus reducing burning due to uneven stirring and increasing the efficiency of roasting.
- To reduce over roasting and over frying so as to improve the quality of the resulting products.
  Lack of proper heat regulation is the main cause of over roasting and over frying. This problem could be solved by designing a stove with heat regulation device to enable the processor control the frying or roasting temperature.
- To reduce fuel consumption and save more fuel; and to eliminate the constant contact of the processor with the heat and smoke from the open fire.

A stove with the following characteristics would be developed:

i. A good draft into the fire.
ii. Insulation around the fire to help it burn hotter to increase efficiency and release less smoke.
iii. An adjustable grate to regulate the heating process.

ii. **Establishment of design parameters**

The roaster comprises of a chamber and a stirrer with paddles. Hence the parameters established in this section included roasting chamber capacity, stirrer and paddle dimensions.

Roasting chamber capacity:

The roasting chamber was designed for capacity. The capacity of the roasting chamber is a function of the bulk density and mass of the groundnut to be roasted. Equation below can be used to calculate the capacity.

For cylindrical roasting chamber, the capacity should be at most four (4) times the calculated capacity. Thus

$\rho_b = \underline{M_b}$ ..... (Firouzi et al., 2009)

V_b

Where:

ρ_b = bulk density (kg/m^3)

M_b = Mass of seeds (kg),

V_b = volume of container (m^3)

M_b = 6.6*kg (minimum weight of groundnut used in the study)*

$\rho_b = \frac{479.28kg}{m^3}$ ..... (Davies, 2009)

$V_b = 6.6/479.28 = 0.0138m^3$

For cylindrical roasting chamber, the capacity should be at most four (4) times the calculated capacity. Thus

$$V = 0.0138 \times 4 = 0.055m^3$$

Hence the equivalent diameter and height of the roasting chamber for a capacity of 0.055m^3 is 0.4m for both dimensions.

- Paddle Dimensions

The dimensions of the vertical members of the paddle were obtained using the equation below:

$\sigma = \frac{6M_b}{bd^2}$ ..... (Ryder, 2002)

Where: M_b = bending moment on each vertical bar = $\frac{6.6\,x\,9.81\,x\,0.18}{2} = 5.83Nm$

$\boldsymbol{\sigma}$ = permissible stress for the bar material, 160Mpa for mild steel (Ryder, 2002)

b and d = width and thickness of the bar

$bd^2 = \frac{6x5.83}{160x10^6} = 2.2\text{x}10^{-5}m^2$

For b = 25mm

- Stirrer shaft Diameter

The stirrer shaft is subjected to a static load of 5.96N at 2cm from both end bearings due the weight of the attached paddles. For a shaft subjected to a combine and twisting, the size can be obtained by using the equation below:

$$d = \sqrt{\left(\frac{2.2x10^{-5}}{25x10^{-3}}\right)} = 0.0029m = 3mm$$

$$\sigma = \left(\frac{16}{\pi d_o^3(1-k^4)}\right)\left(M + \sqrt{(M^2) + T^2}\right)$$ ..... (Ryder, 2002)

Where

ρ = permissible stress of the shaft material, 160Mpa for mild steel.

M= maximum bending moment due to static loading, 0.119Nm from the bending moment diagram.

$T = \frac{60xP}{2\pi N}$ ..... (Ryder, 2002)

T = torque applied through the lever arm, Nm
P = average power developed by normal healthy human being, 0.075kW.
N = rpm of the lever arm. This can take any value depending on the operator, assuming 30 rpm.

$T = \frac{60xP}{2\pi N}$ = 23.87Nm

d_0 = Outside diameter of hollow pipe, m
K = shaft factor, 0.75

$$160x10^6 = \left(\frac{16}{\pi d_o^{\,3}(1-0.75^4)}\right)\left(0.119 + \sqrt{(0.119^2 + 23.87^2)}\right)$$

Further simplification gives $d_0 = 0.0103m = 10.3mm$ say 15mm.

- Stove Dimensions

The stove will provide the heat to the roaster (when roasting) or to the frying pan (when frying). The design of typical firewood stove, as described by Aprovecho and depicted in Fig. 1, was adopted in this work. The sizes of gaps shown in the figure 1 were obtained using the Winiarki table. For a square combustion chamber 16cm x 16cm and pot diameter 40cm, the sizes of the gaps are: GAP A=4cm, GAP B=3.7cm, GAP C=2cm and GAP D=1.9cm.

iii. **Construction materials**

The materials used for the construction of the roaster/fryer were mild steel sheet, flat bar, hollow pipe and steel bearings. These materials were selected based on their suitable engineering properties, cost effectiveness, availability locally, and machinability.

2.2.3 Comparative evaluation

This comprised of two different evaluations, described as follows:

I. Comparative performance evaluation of the improved and the traditional roasting processes

The parameters used in the comparative performance evaluation of the improved and the traditional roasting process were the roasting efficiency (E_r) %, percentage seed loss (E_l) and throughput capacity Q_t (kg/hr).

A processor, conversant for many years with the process, was asked to roast 8.7kg using the improved devices (stove and roasting chamber) and then repeating same using the traditional process. For each method, the time taken to roast the groundnut was recorded using stop watch; the quantity of fuel used was recorded using weighing balance. Mathematical expressions used in evaluating the performances of the methods were:

Where,

E_r = Roasting efficiency, %

E_t = percentage seed loss, %

Q_t = throughput capacity, kg/hr

W_d = Weight of over roasted seed (damaged seed), kg

W_t = Total weight of seed roasted, kg

W_r = Weight of roasted seed not damaged, kg

T = Effective roasting time, mins

ii. Comparative performance evaluation of the improved and the traditional frying processes

The same processor used in comparative evaluation of the roasting process was asked to fry the same weight of groundnut meal (i.e. 2.4kg) using the two processes. The time taken to fry kuli-kuli, the quantity of fuel used as well as weight of kuli-kuli over roasted were all recorded using stop watch and weighing balance respectively. The following equations were used to evaluate the performance of the two processes evaluated.

$$E_r = \left(\frac{W_r}{W_t}\right) \times 100 \quad \text{.....(1)}$$

$$E_i = \left(\frac{W_d}{W_t}\right) \times 100 \quad \text{.....(2)}$$

$$Q_t = \frac{W_t}{T} \quad \text{.....(3)}$$

Where,

E_f = Frying efficiency, %

F_{cr} = Fuel consumption rate, kg/hr

W_d = weight of kuli-kuli damaged or over fried (kg).

W_n = weight of kuli-kuli not damaged, kg.

W_t – total weight of fried kuli-kuli,kg

F_c – fuel consumed during the process, kg.

T_f – frying time, hrs.

$$E_f = \left(\frac{W_n}{W_t}\right) \times 100 \quad \text{..... (4)}$$

$$F_{cr} = \frac{F_c(kg)}{T_f(hr)} \quad \text{.....(5)}$$

3.0 RESULTS AND DISCUSSION

3.1 Study of the Traditional Process of Roasting and Frying

3.1.1 Description of the traditional roasting and frying processes

The sub-processes of roasting and frying in the traditional method of groundnut oil extraction could be described as follows:

i. Roasting: The processor performed the roasting of the groundnut over an open wood fire in an iron pan (plate 1). Upon commencement of the roasting, the turning of the nuts began almost immediately, using a flat calabash plate, and was observed to be about three times in the first five minutes thereafter becoming more frequent. On an average the groundnut were observed to be turned once every second throughout the entire roasting, with interruption in between to adjust the fire and to check (visually and by feeling) for completion of the operation. This operation, it was observed, needed the constant attention of the processor.

Nine minutes after the onset of the roasting for each batch, a handful of coarse ground sorghum was added to the nuts in the roasting pan. This was a precautionary measure taken to prevent the nuts from burning. The processor explained that if the heat was too much the sorghum would burn first before the nuts, thus allowing the processor time to remove the pan from the fire.

To check whether the nuts were ready, the processor picks out a handful from the pan and tightly squeezes them in her palm. When the temperature is unbearable, it is then time to remove the pan from the fire. Checking by sight for a change in color is another way of determining the completion of the roasting process.

When the groundnut was properly roasted, the processor completely winnowed out the sorghum before the roasted nuts are spread out on a flat surface to cool.

ii. Frying of the formed meal: The same tools used by the processor for roasting (shown in plate 1) were used for frying of groundnut meal. The processor first starts the fire, then places the pan with oil inside on the fire. About ten minutes was allowed for the oil to heat up before the processor introduces pieces of the groundnut meal into the oil. The processor intermittently turns the meal pieces. After about ten minutes, the processor confirms the meal is well fried and uses a straining spoon (perforated spoon) to bring out the meal pieces (*kulikuli)* onto a bowl, where it cools and solidifies further.

3.1.2 Tools used for the traditional roasting and frying

The tools used by the processors in the traditional roasting and frying are same for the two sub-processes. They include a pan and an open fire place erected with three stones or a local stove (see plate 1). Others are flat calabash plate and a straining spoon.

3.1.3 Areas identified for improvement

From the detailed observation of the traditional roasting and frying, the following were identified as areas of improvement:

i. Method of stirring of the groundnut during roasting.
ii. Regulation of heat intensity during roasting and frying.
iii. Reduction of heat and smoke contact with the processor.
iv. Reduction of fuel requirement for the roasting and frying processes.

3.2 Development of a Roaster/Fryer

3.2.1 Description and operation of the roaster/fryer

Plate 2 depicts the roaster, which comprises of the roasting chamber and the stove. The roasting chamber consists of a cylindrical trough with two end covers and with an opening along its length through which groundnut for roasting is poured into the trough. The cylinder houses a shaft on which are two paddles 180 degrees apart. The shaft, which could be rotated through a handle, is centrally positioned within the cylinder by two bearings mounted in the middle of the two cylinder end covers.

The stove is made up of pot skirt, combustion chamber, an adjustable grate and an entrance (for firewood and air). The pot skirt provides support for the roasting chamber and frying pan during roasting and frying operations respectively. It is square in shape with its surface slanting from the outer edge towards the fire opening. The fire wood burns inside the combustion chamber which is lined with ceramic floor tiles so as to conserve heat. The grate fits inside the combustion chamber and it can be raised or

lowered to regulate the fire. On the front side of the stove is an opening through which air can enter into the combustion chamber and more firewood can also be added through the same opening.

Plate 3 shows the fryer. It is essentially same with the roaster, except that a pan replaces the roasting chamber. The pan is an open vessel, similar to the type used by the traditional processors.

For roasting operation, groundnut is poured into the chamber through the opening. The chamber is then placed on the stove. Firewood placed through the stove opening is lighted. After few minutes, when the chamber has heated up sufficiently, stirring of the groundnut begins by rotating the paddle carrying shaft through the rotating handle. The stirring action continues intermittently until the groundnut is properly roasted. In between, depending on heat requirement, the processor regulates the heat source via the adjustable grate.

For frying, the pan, instead of the roasting chamber, is placed on the stove. The stove is then lighted. Oil is first poured into the pan, and allowed to heat-up before groundnut meals (formed into small pieces) are introduced into the oil. With time, the meal pieces or "kulikuli" are stirred, using a parking strainer spoon, to avoid over frying and burning. The stove is occasionally adjusted, as described previously in the case of roasting.

3.2.2 Cost of materials

Table 1 shows the various materials used and their cost.

3.3 Comparative Evaluation

3.3.1 Roasting process

The results of the comparative evaluation of the two different roasting processes are given in table 2 below. For same quantity of groundnut (i.e. 8.7kg), the table shows that all the performance indexes were better while roasting with the developed roaster/fryer. Note that for the roaster/fryer, there was 57.4% saving in energy.

3.3.1 Frying process

The results from the comparison of the two frying processes are given in table 3 below. Frying of 2.4 kg of groundnut meal using the two processes in turn resulted in energy saving of 49.0% while using the developed fryer. The developed fryer has the additional advantage of protecting the user from heat and smoke.

4.0 CONCLUSION

The roaster/fryer was developed and evaluated by roasting 8.7kg of groundnut and by frying 2.4kg of groundnut meal. For comparison, same quantities of groundnut and groundnut meal were also processed using the traditional processes. Comparative analysis of the results obtained revealed an energy saving of 57.4% and 49.0% for roasting and frying with the developed roaster/fryer. These improved efficiencies and energy savings, achievable with the developed roaster/fryer, would definitely enhance profit margins of the processors, thereby further empowering them economically.

REFERENCES

Ali M. A., I. I. Ibrahim, I. W. Muhammad, I. Lawan and M. M. Bello (2012): Technological Intervention in the Traditional Groundnut Oil Extraction. Proceedings of the 46th Annual Conference of the Agricultural Society of Nigeria "Kano 2012". ISBN: 0300368X.

Aprovecho Research Center Shell Foundation (2002). Design Principle for Wood Burning Cook Stoves. Launched by the U.S. Environmental Protection Agency (EPA) at the World Summit for Sustainable Development in Johannesberg.

Davies R. M. (2009). Some Physical Properties of Groundnut Grain. Research Journal of Applied Science, Engineering and Technology. 1(2).

FirouziS., M. N. S. Vishgaei and B. Kaviani (2009). Some Physical Properties of Groundnut (Arachis Hypogaea L.) Kernel Cv. NC2 as a Function of Moisture Content. American-Eurasian Journal of Agric. And Environmental Science 6(6): 675-679.

Nalumansi S.R. and R.N.Kaul (1992) "studies on the tradition sysyem of groundnut oil extraction and possible improvement" (Nigerian agricultural Mechanisation research programmed, IAR/ABU-Zaria).

Ola, F.A (2000). "Development of a motorized groundnut oil extractor". A master thesis submitted to Department of Agricultural Engineering, ABU, Zaria.

Ryder, G. H. (2002). Strength of Materials. 3rd Edition. Macmillan Publishers India Limited, ISBN: 0333144430. 352 pages.

Smart, J. (1994): The Groundnut Crop: a Scientific Basis or Improvement Pub. By Chapman and Hall, London, pp 482-542 Samuel son and Nordhaus (2002). Economics (second edition).

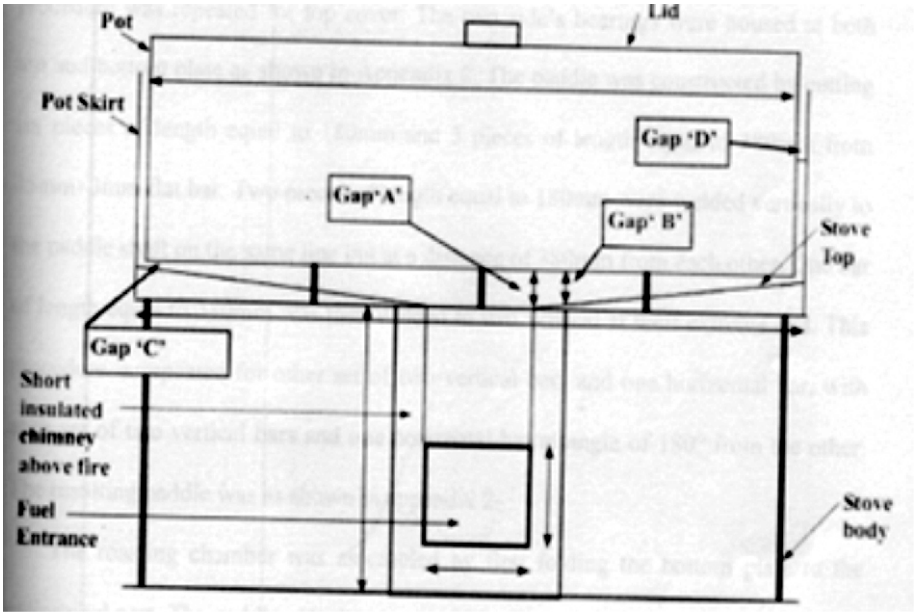


Fig. 1: Fire Wood Stove



Plate 1: Traditional Method of Roasting Groundnut

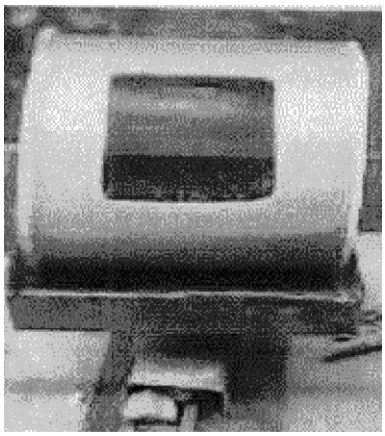


Plate 2: Developed Roaster

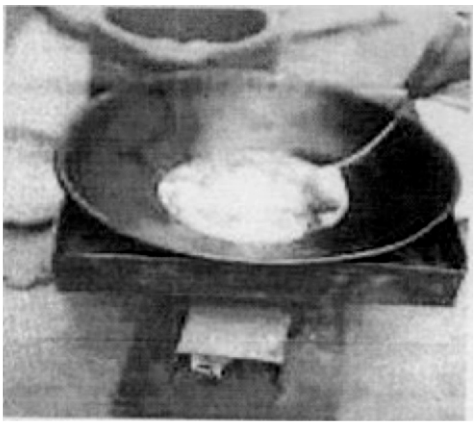


Plate 3: The Fryer

Table 1: Cost of Materials

Description	Quantity	Size	Unit Cost (N)	Total Cost (N)
0.5mm sheet	1	50x200cm	1,000.00	1,000.00
1mm mild steel sheet	1	64x160cm	1,500.00	1,500.00
Flat bar (3mmx25mm)	1	300cm	400.00	400.00
Hollow pipe (15cm diameter)	1	50cm	200.00	200.00
6304 Ball bearings	2	15mm dia.	100.00	200.00
Plywood	1	35x35cm	200.00	200.00
Labour Cost				2,000.00
Indirect Costs (power, machine depreciation, etc.)				1,650.00
Total				7,150.00

Table 2: Comparative Performance Evaluation of the Two Roasting Processes

S/N	Traditional roasting method				Improved roasting method			
	E_r (%)	E_L (%)	Q_t (kg/hr)	F_{cr} (kg/hr)	E_r (%)	E_L (%)	Q_t (kg/hr)	F_{cr} (kg/hr)
1	92.9	5.5	13.8	5.6	98.9	1.1	32.7	2.3
2	92.6	6.7	13.8	5.8	95.2	4.8	25.0	2.1
3	94.8	8.3	13.8	4.9	93.4	6.1	30.0	2.5
Ave.	93.4	6.8	13.8	5.4	95.8	4.0	29.2	2.3

Table 3: Comparative Performance Evaluation of the Two Frying Processes

S/No.	Improved frying method							Traditional frying method						
	W_t	W_d	W_n	T_f	E_f	F_c	F_{cr}	W_t	W_d	W_n	T_f	E_f	F_c	F_{cr}
1	2.47	0.2	2.3	11.3	93	0.47	2.5	2.47	0.7	1.8	20.0	73	1.6	4.7
2	2.89	0.5	2.4	14.5	83	0.60	2.7	2.89	0.8	2.1	17.0	73	1.7	5.9
3	1.95	0.2	1.8	10.2	92	0.42	2.5	1.95	0.7	1.2	16.7	62	1.3	4.6
Ave.	2.40				89.3		2.6	2.40				69.3		5.1

DEVELOPMENT OF INDIGENOUS PSYCHROMETER FOR ESTIMATING PSYCHROMETRIC PROPERTIES DURING PRESERVATION OF VEGETABLES IN EVAPORATIVE COOLER IN AKURE, NIGERIA

Simon O. Odey[1], Seth I. Manuwa[2] and Raphael S. Bello[3]
[1] Department of Agronomy, Cross River University of Technology, Obubra Campus, Nigeria
[2] Department of Agricultural Engineering, The Federal University of Technology, Akure, Nigeria
[3] Department of Agricultural Engineering, Federal College of Agriculture, Ishiagu, Nigeria
Correspondence: Simon O. Odey, simonogbecheodey@yahoo.com, 07034575615

ABSTRACT
Locally developed psychrometer was used to measure the environmental condition of a medium during preservation of vegetables using evaporative cooler. The vegetables preserved were Okra (*Hybiscus esculentus*), Water leaf (*Talinium triangulare*), Fluted pumpkin (*Telferia Occidentalis*) leaves , and Amaranthus (*Amaranthus spp.*). Two of the constructed psychrometers (same type) were placed in the storage medium while one was place outside the medium, in ambient condition in order to measure their dry bulb and wet bulb temperatures. From these measured data, temperature drop, relative humidity, and evaporative efficiency of the medium were determined using the psychrometric tables and calculations. Results got from the use of locally developed psychrometers were compared with that from orthodox psychrometer ("Raj" Psychrometer, model: RT 078, New Delhi, India) using correlation and x/y line plots. Thus maximum temperature drops of 7.9 ^{o}C and 8.0 ^{o}C were realized from the use of orthodox and indigenously developed types respectively. The mean relative humidity values were 88.74 ^{o}C and 88.68 ^{o}C for locally developed and orthodox psychrometers accordingly. While the mean evaporative efficiencies determined from locally developed and orthodox psychrometers were 74.51 ^{o}C and 74.91 ^{o}C. Relative humidity and evaporative efficiency determined using both types of hygrometers revealed that both worked effectively well. Hence it is suggested that local development of tools and equipment for scientific and engineering application should be highly encouraged as this will at the long run lead to technological breakthrough.

Keywords: Psychrometer, Psychrometric Properties, Preservation, Evaporative Cooler

1. INTRODUCTION
Measurement and control of psychrometric properties is very vital to the efficient storage of agricultural produce. Relative humidity, temperature, equilibrium moisture content, dew point, vapour pressure are very useful in adequately designing storage systems for preservation of agricultural products. Biological activity occurs only when moisture is present. Therefore the moisture content of the product itself, as well as the moisture content of the surrounding air, is important for safe storage. Each product has its own characteristic balance (or equilibrium) between the moisture it contains and the water vapour in the air surrounding it. This equilibrium is known as the moisture content/relative humidity pattern (Wadia, 1986; Kittas et al., 2001; Xuan et al., 2012).

Psychrometer is an easy to use tool for measuring the amount of humidity in the atmosphere. There are two main types of Psychrometers – a dry and wet bulb psychrometer and a mechanical hygrometer. Measurement of these properties is made simple by installing psychrometers strategically inside (to measure storage medium or cooler condition) and outside (to measure ambient condition) the storage medium.

Nigeria is one of the developing nations in tropical Africa with more than 70% of its population engaging in agriculture. Most of the people in rural communities depend mainly on subsistence farming. Hayman (2003) revealed that between 25 and 40% of stored agricultural products is lost each year because of inadequate farm and village-level storage. In the field and during storage the products are threatened by insects, rodents, birds and other pests. Moreover, the product could be spoiled by infection from fungi, yeasts or bacteria. In addition, for sowing seed it is important that the viability (its capacity to germinate) is maintained (Acedo, 1997). The loss of food is not only wasteful; it poses food security problems and loss of potential income for farmers who are forced to sell immediately after harvest (Mohammed, 1995). In order to minimize the losses during storage it is important to identify and measure the optimum environmental conditions for storage of the product, as well as the conditions under which its attackers flourish (Olosunde et al, 2009).

Dowdy (1982), Manuwa (1989), Roca et al. (1991), Ndukwu (2011), and Manuwa and Odey (2012) reported that the performance of evaporative cooler is measured by the following parameters:

- Evaporative efficiency
- Total cooling capacity
- Relative humidity
- Dry bulb temperature of air
- Wet bulb temperature of air

Evaporative efficiency is defined by: $\eta ef = \frac{Tdb - To}{Tdb - Twb} \; X \; 100\,\%$

Where,

$?_{ef}$	=	Evaporative efficiency
T_{db}	=	Dry bulb temperature of air
T_o	=	Output temperature of the cooler (dry bulb)
T_{wb}	=	Wet bulb temperate of air
$T_{db} - T_o$	=	Temperature drop
$T_{db} - T_{wb}$	=	Wet bulb depression

Thus having the above parameters make it quite easy for knowing the psychrometric properties of any medium.

In line with the above Otterbein (1996) illustrated the use of psychrometer in measuring the efficiency of a storage medium such as evaporative cooler. According to him if a cooler has 21.1°C air leaving the pad during a 37.8°C day, and has a wet bulb temperature of 15.6°C.

Evaporative efficiency,

$$\eta ef = \frac{Tdb - To}{Tdb - Twb} \; X \; 100\,\%$$

$$= \frac{37.8 - 21.1}{37.8 - 15.6} \; X\,100$$

$$= \frac{16.7 \times 100}{22.2}$$

$$= \underline{75\%}$$

Thus, the efficiency of a storage medium, relative humidity, equilibrium moisture content, dewpoint and other properties can be easily measured provided the psychrometer is available. In most research institutions and Nigerian universities, most of the simple equipment for measuring similar properties are lacking; this is why Nigerian Universities are poorly rated (Olatunji, 2012). There is need therefore for concerted effort by Nigerian Scientists and Engineers to design and produce such equipment using locally sourced and cost effective materials; rather than continuously depending on imported laboratory tools.

1.2 Objectives of the Research Work

The objectives of this research work are to:

(a) design, construct and test psychrometer, using locally available materials;

(b) Compare its performance with an orthodox psychrometer ("Raj" Psychrometer, model: RT 078, New Delhi, India).

2. MATERIALS AND METHODS

2.1 Design Considerations of Psychrometer

The following conditions were taken for the design of the psychrometer:

- The height, width and thickness of the components were such that the equipment would easily sense the temperature of the system where it could be used.
- The drilled holes on the wood were such that common laboratory thermometers could fit into them without slipping.
- One side of the psychrometer is exposed so as to make it sensitive to the system temperature.

2.2 Main Components of the Psychrometer

Three psychrometers were constructed and adapted for recording temperatures. As shown in figure 1, each of the three constructed psychrometers was made up of wood, two thermometers, a wick and rubber can or bottle. The constructed wood was made up of two number 6 cm by 33 cm in dimension. These were joint together by three number 2.5 cm by 4 cm wood; all having a thickness of 1 cm. this was covered on one side by a plywood having a dimension 6 cm by 33 cm. Two holes having diameter 5 mm located 2.5 cm apart were drilled on the two upper 2.5 cm by 4 cm woods. Two thermometers were inserted into these holes as shown in figure 2. A wick was fixed into the bulb of one of the thermometers. The wick was then connected into a rubber can or bottle containing distilled water. The estimated cost of the constructed psychrometer was N 570.00 ($ 3.6).

2.3. Calibration and Testing of the Psychrometers

The psychrometers were calibrated by comparing their readings at different conditions with orthodox psychrometer ("Raj" Psychrometer, model: RT 078, New Delhi, India). The dry and wet bulb temperatures were taken hourly from 7.00 hours to 18.00 hours. Readings were not taken between the hours of 19.00 and 6.00 due to the cumbersome nature of the experiment. From the dry-bulb and wet-bulb temperatures that were observed, wet-bulb depressions were determined and the corresponding relative humilities were read from standard psychrometric tables. The relative humidity values determined were those of the ambient environment, the coolers' inner space at

hourly intervals.

The performance of the cooling system was based on the saturation or cooling efficiency. The evaporative efficiency was calculated using the model reported by Otterbein (1996) and Haris (1997)

$$\eta ef = \frac{Tab - Tcool}{Tab - Twb} \; X \; 100\,\%$$

Where,

$T_{ab} - T_{cool}$ = temperature drop
$T_{ab} - T_{wb}$ = wet bulb depression
$?_{ef}$ = evaporative efficiency
T_{cool} = dry bulb temperature of air within cooler
T_{ab} = dry bulb temperature of air entering pad (ambient temperature)
T_{wb} = wet bulb temperature of air entering pad

3. RESULTS AND DISCUSSION

3.1 Temperature Drop, Relative Humidity and Evaporative Efficiency of Cooler

In other to know the performance of the fabricated psychrometer, temperature drop, relative humidity and evaporative efficiency as determined were compared with those of the orthodox psychrometer.

Figure 3 shows the temperature drop (TD) of cooler with time as determined using orthodox and locally constructed psychrometer. The mean maximum temperature drop as determined using locally constructed hygrometer was 8.0°C while that determined using the orthodox type was 7.9 °C. Thus the temperature drop as determined using both hydrometers increased uniformly from the early hours of the day towards the afternoon hours and started dropping uniformly. This results compare favourably with the result recorded by Ndukwu (2011) where temperature reduction of 10.0°C was realized using orthodox hygrometers.

Figure 4 depicts the variation in mean saturation efficiency ($\mathbf{N}_f$) as determined from readings of the Locally constructed and Orthodox psychrometers. While in Figure 5 the variation in mean Relative Humidity (R_h) determined from readings of the locally constructed and orthodox psychrometers were plotted. In both graphs, the $?_{ef}$ and R_h for orthodox and locally developed psychromers were comparably related. Showing that either of the measuring devices can be used during experiment and determination of psychrometric properties of an environment. These observations agree with the works of Turner (1986), Karpiscak and Marion (1994), Harner et al. (2007 and 2009), Ndukwu (2011); and Manuwa and Odey (2012) where psychrometic equipment were used in the determination of relative humidity, temperature drop and evaporative efficiency during use of evaporative coolers.

Thus correlated results for temperature drop, relative humidity as determined using orthodox and locally developed hygrometers revealed 2.9 (lower) and 6.2 (upper) at 95% confidence interval of the difference for both hygrometers respectively. While the mean difference was 4.57 and 4.60 for orthodox and locally constructed psychrometers respectively.

4. CONCLUSION

Indigenous psychrometers were developed. These were used in measuring dry bulb and wet bulb temperatures. Psychrometeric properties such as relative humidity, temperature drop and evaporative efficiency were determined during preservation of vegetables using evaporative cooler. The results obtained were compared to that when orthodox type was used. This shows a favourable comparism as the results were not significantly different from each other. Thus maximum temperature drops of 7.9^{o}C and 8.0^{o}C were realized from the use of orthodox and indigenously developed types respectively. Relative humidity and evaporative efficiency determined using both types of hygrometers revealed that both worked effectively.

REFERENCES

Acedo, A.L. (1997). Storage life of vegetables in simple evaporative coolers. Tropical Science 37:169175.

Dowdy, J. A. (1982) Comparative performance test of 4 evaporative coolers, Canutilo, Tx, 79835.

Karpiscak, M. and Marion, M. H. (1994). Evaporative Cooler Water Use. Arizona Cooperative Extension, The University of Arizona College of Agriculture Tucson, Arizona 85721. http://ag.arizona.edu/pubs/consumer/az9145.pdf

Haris, J. A. (1997); Environmental factors affecting evaporative coolers. Agro-building, Campinas. Sp. Brazil Federal University of Vicos, Brazil.

Harner, J. P., Schmidt, C., Smith, J. F., and Brouk, M. J. (2007). Consumptive Water Use of Evaporative Pads. ASABE Publication Number 701P0507e, Sixth International Dairy Housing Conference Proceeding (Minneapolis, Minnesota, USA)

Harner, J. P., Smith, J. F., Zimmerman, R. and Vanbaale, M. (2009). Water Consumption of Evaporative Pads. ASABE Paper Number: 096728, 2950 Niles Road, St. Joseph, MI 49085-9659 USA.

Hayman, J. (2003). The Storage of Tropical Agricultural Products. Agrodok 31. Printed by: STOAS Digigrafi, Wageningen, the Netherlands. ISBN: 90-77073-60-4

Kittas, C., Bartzanas, T. and Jaffrin, A. (2001). Greenhouse evaporative cooling: Measurement and data analysis. A Transaction of ASAE. Vol. 44(3): 683–689.

Manuwa, S. I. (1989). A Comparison of Different Structural Materials and Shapes for Constructing Evaporative Coolers. Unpublished M.Sc. Thesis, Department of Agric Engineering, University of Ibadan, Nigeria.

Manuwa, S. I. and Odey, S. O. (2012). Evaluation of Pads and Geometrical Shapes for Constructing Evaporative Cooling System. Modern Applied Science; Vol. 6, No. 6; 2012. ISSN 1913-1844, E-ISSN 1913-1852. Pp. 45 – 53. Published by Canadian Center of Science and Education.

Mohammed, B. A. (1995); Development of a Low-Cost cooler to preserve perishable foods in countries with arid climates. www.rolexawards.com 2002.

Ndukwu, M. C. (2011). Development of Clay Evaporative Cooler for Fruits and Vegetables Preservation. Agricultural Engineering International: CIGR Journal, 13(1), 1-8.

Olosunde, W. A., Igbeka, J. C., & Olurin, T. O. (2009). Performance Evaluation of Absorbent Materials in Evaporative Cooling System for the Storage of Fruits and Vegetables. International Journal of Food Engineering, 5(3), 1-15. http:// dx.doi.org/ 10.2202/1556-3758.1376.

Olatunji, S. (2012). Why Nigeria Versities are Poorly Rated. The PUNCH News Paper, January 15, 2012.

Otterbein, R. (1996); Installing and Maintaining Evaporative coolers. Home Energy Magazine Online Vol. 13, No. 3. pp. 5 –11.

Roca, R. W., Hughes, W. C., & Christianson, L. L. (1991). Evaporative cooling pads: test procedure and evaluation. Applied Engineering in Agriculture, 7(4), 485-490.

Turner, R. H. (1986). Water Consumption of Evaporative Cooling Systems. Advancing Toward Technology Breakout in Energy Conversion. 21st Intersociety Energy Conversion 'Engineering Conference, San Diego, California. Vol. 2(3).

Xuan, Y. M., Xiao, F., Niu, X. F., Huang, X., & Wang, S. W. (2012). Research and application of evaporative cooling in China: a review (I)-Research (In Press). Renewable and Sustainable Energy Reviews.

Wadia, R. A. (1986); Effect of temperature and relative humidity on post harvest disease of certain fruits and vegetables. Horticultural Abstract. 39 (4) 568 – 573.

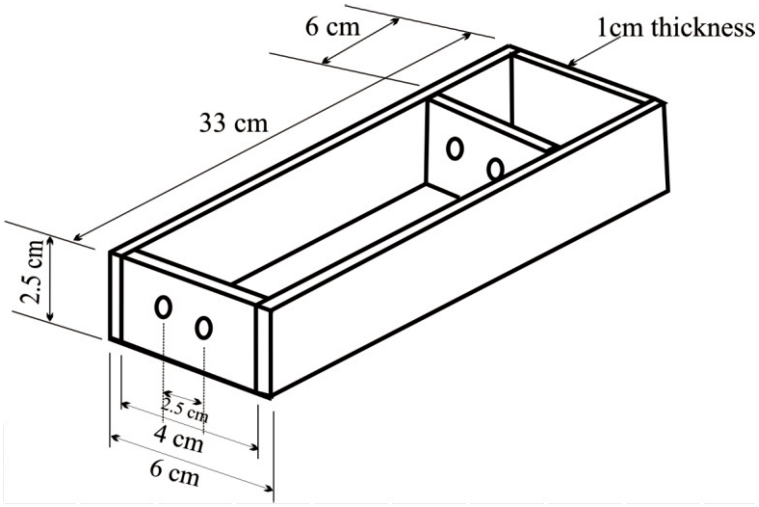


Fig. 1: Sketch Showing the Main Dimensions of the Psychrometer Casing

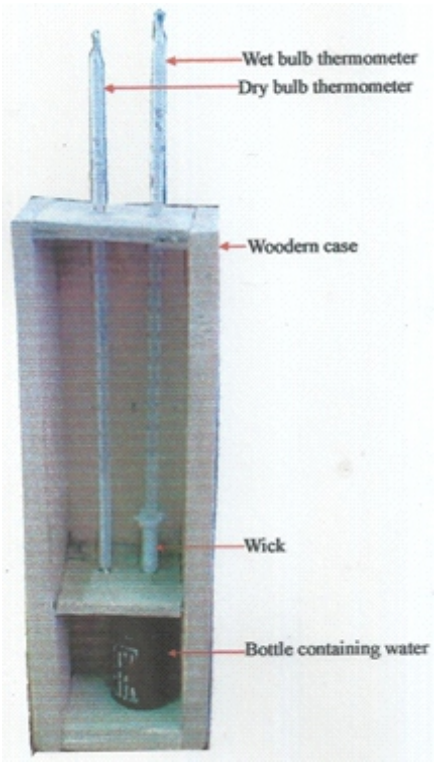


Fig. 2: Locally Fabricated Psychrometer

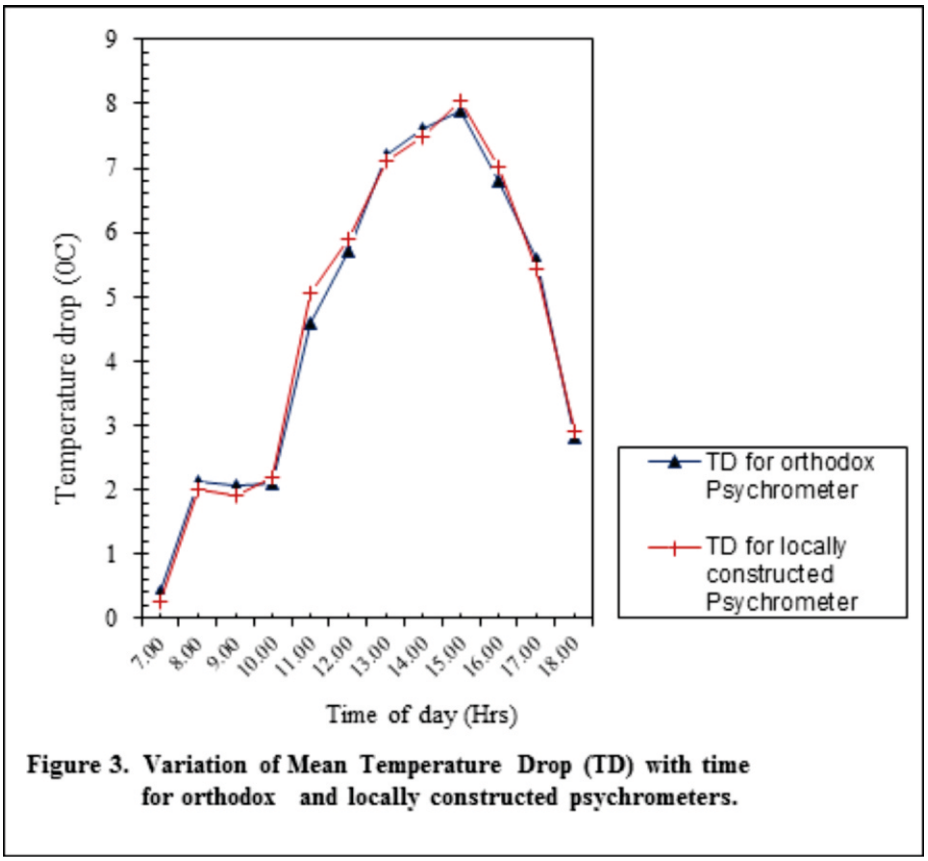


Figure 3. Variation of Mean Temperature Drop (TD) with time for orthodox and locally constructed psychrometers.

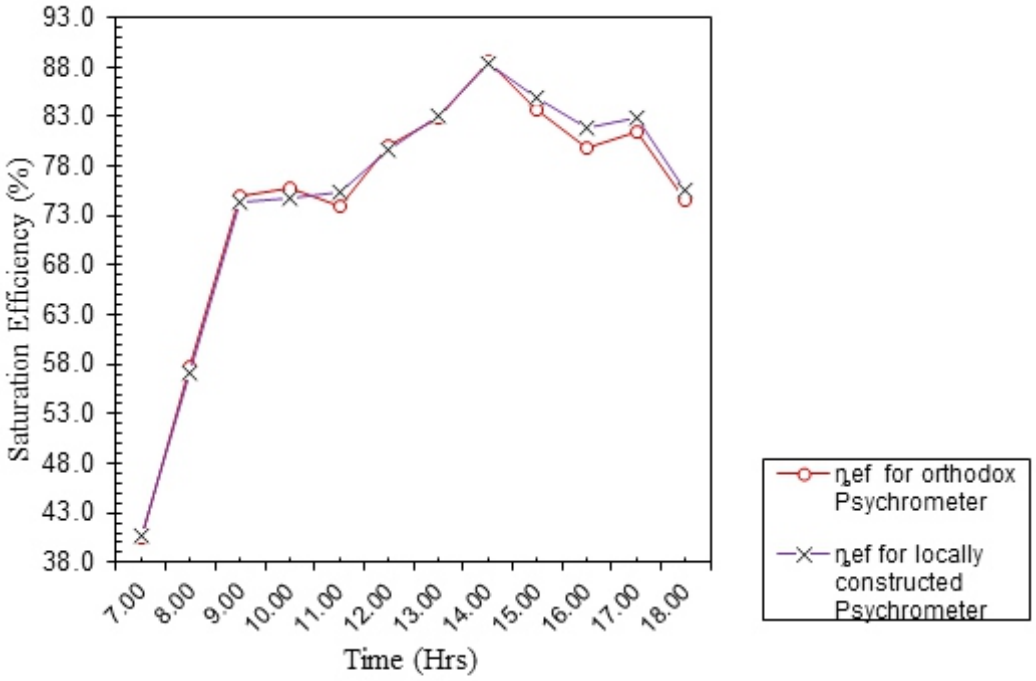


Figure 2: Variation of Mean Saturation Efficiencies of cooler using Orthodox and Fabricated Psychrometer

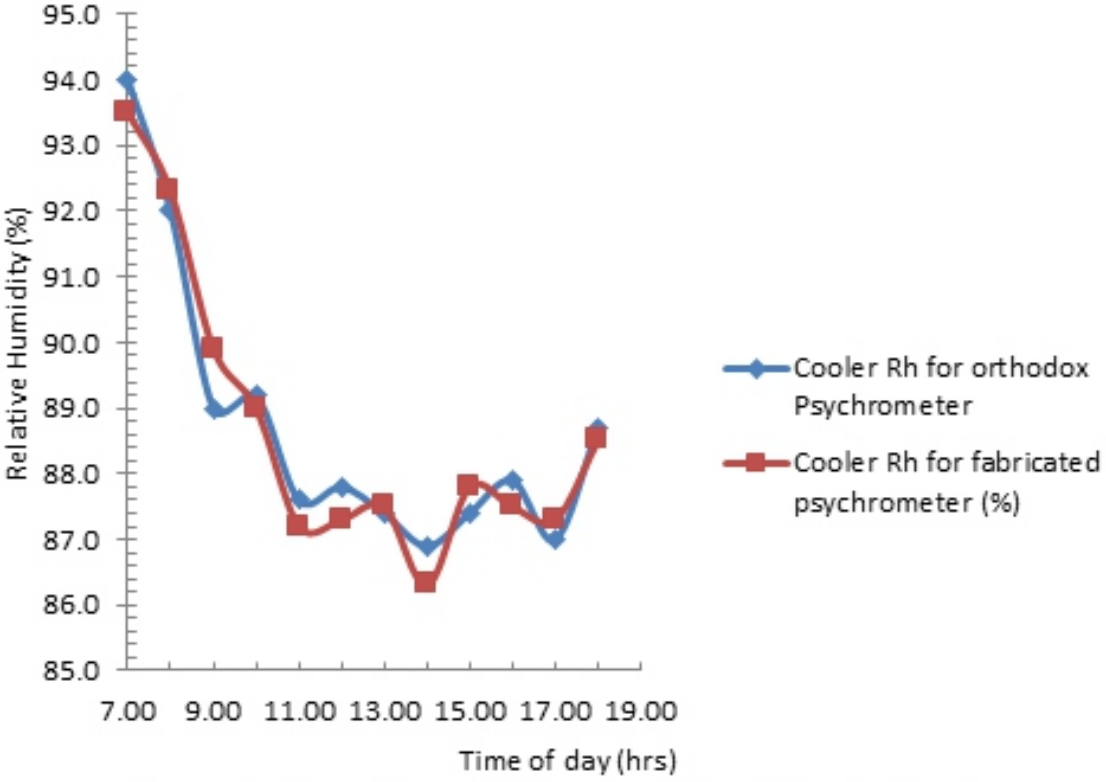


Figure 5. Comparism of Relative humidities Determined using Orthodox and Fabricated Psychrometer

CONSUMPTIVE WATER USE OF EVAPORATIVE COOLING PAD DURING PRESERVATION OF VEGETABLES

Simon O. Odey[1], Seth I. Manuwa[2] and Raphael S. Bello[3]
[1] Department of Agronomy, Cross River University of Technology, Obubra Campus, Nigeria
[2] Department of Agricultural Engineering, The Federal University of Technology, Akure, Nigeria
[3] Department of Agricultural Engineering, Federal College of Agriculture, Ishiagu, Nigeria
Correspondence: Simon O. Odey, simonogbecheodey@yahoo.com, 07034575615

ABSTRACT
Water flow through the inlet and outlet channels of a locally constructed evaporative cooler during preservation of vegetables was monitored. The total height of the cooler was 153 cm, with a main frame height of 133 cm. The net surface area of the cooler was 19,959 cm^2, with a total capacity of 2.21 x 10^5 cm^3. The capacities of the top and base water tanks were 52.8 and 75.3 litres respectively. Two plastic rulers were mounted on the top and base water tanks of the cooler to record the decrease and increase in water levels respectively. The top water tank was filled with water and the valves were opened wide to get the pad properly saturated within a short time. Subsequently, the-valves were opened slightly to maintain the pad in a saturated state by water drips. Freshly harvested vegetables were weighed and loaded in the cooler. The consumptive water use of the pad material (jute) was determined. Results showed that the average rate of water flow in and out of the cooler were 31.67 and 31.15 l/hr respectively. The average consumptive water use of the cooler was 0.52 l/hr, with temperature drop of cooler up to 8 ^oC, and with 93.5% relative humidity and 88.3% evaporative efficiency. The use of this type of evaporative cooler by farmers should be encouraged since its advantages cannot be overemphasised, as it does not require electricity to operate, it does not require a blower, re-circulating water pump, electric motor, and refrigerants. An alternative type of cooling, which does not expel Chlorofluorocarbons (CFCs) is highly desirable as one important step in the correction of the current problems of global warming.

Keywords: Evaporative Cooler, Pad Materials, Water Flow, Consumptive Water Use

1.0 INTRODUCTION
The application of evaporative cooling in Sub-Saharan African countries with climatic conditions quite different from that of the temperate regions is gaining momentum. Most of the research publications on evaporative cooling are from the temperate regions of the world whose climatic conditions are quite different from those of tropical countries. Harris (1987) recorded that the wet-bulb temperature prevailing in an area is one of the important limitations in evaporative cooler performance. He further stressed that it is only in localities where reasonable low wet-bulb temperature (21°C and below) occurs intermittently with high dry-bulb temperature (32°C and above) for extended period of time that evaporative cooling was successful.
Water usage by evaporative pads depends on weather conditions, heat abatement system, and operational characteristics. Evaporative cooling systems cool the air within the storage system to help reduce heat stress and maintain optimally low temperature and high relative humidity of the system for vegetable crops preservation. Distributors of evaporative pads assume a pad efficiency of 75 percent regardless of air properties or air

speed. Generally, the recommended maximum air speed through a pad is 2 m/s (4.5 mph) (Turner, 1986; Karpiscak and Marion, 1994; Harner et al., 2007 and 2009).

Different pad materials have been experimented on by researchers but there is little information on the water demand and water usage of evaporative pads. Some of the pad materials are: successive layers of corrugated paper (Roca et al., 1991), jute and rice husk (Acedo, 1997), Clay pot (Anyanwu, 2004), natural fibers- jute, palm, luffa (Al-Sulaiman, 2002), corrugated cellulose (Lertsatitthanakorn et al., 2006), pumice stones-coarse and fine (Gunhan et al., 2007), jute, hessian and cotton waste (Olosunde et al., 2009), rice straw and palm leaf fibers (Darwesh et al., 2009), Celdek R7060-15, Munters AB, Kista, Sweden (Dagtekina et al., 2009), clay (Ndukwu, 2011), straw, CELdek, sliced wood (Ahmed et al., 2011), metal pad, cellulose pad, organic pad (CELdek), inorganic pad (GLASdek), PVC pad, porous ceramic pad, wood wool pad (Xuan et al., 2012), latex foam, jute, charcoal and wood shavings (Manuwa and Odey, 2012) .

Harner et al (2007) reported average daily water usage rate of 0.1 l/min (1.65 gph) per cow during a period from July 18th to August 10th for an evaporative cooled tunnel ventilated tie stall dairy in Kansas in the summer of 2006. Pad water usage equalled 0.20 l/min/m2 (0.30 gph/ft2) of pad. Average temperature humidity index was 82.7 ± 1.6 during the 7 monitoring periods. They reported consumptive water use rates at the ND dairy equalled 7.5 l/min (2 gpm), 22.9 l/min (6.1 gpm) and 28.9 l/min (7.7 gpm) for the low, medium, and high airflow rate studies, respectively.

Harner et al., (2009) further stated that when cellulose pad of dimension 3 m by 107 m and 15 cm (6 in) thick was used the water usage per unit surface area of the evaporative pad equalled 0.19 l/min/ m2 (0.286 gph/ft2) of evaporative pad surface area. The total daily water usage per stall averaged 49 l (13 gal) with a maximum of 85.8 l (22.7 gal).

The objective of this study was to determine consumptive water usage and water flow through locally constructed evaporative cooling system using jute pad material during vegetable preservation in the tropical climate of Akure, Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted behind the Agricultural Engineering Laboratory Building, Federal University of Technology, Akure, Ondo State (with geographical coordinate of $7^{o}10$ North and $5^{o}05$ East), between 5^{th} – 10^{th} December, 2003.

2.2 Materials

2.2.1 Pad material and pad-holders

The pad used in this study was Jute material, prepared from jute bags. It had a total area of 20,615 cm^2. Pad-holders were constructed for the coolers so that they were not limited to cloth-like pads that would only wrap round the cooler. Each pad holder has a dimension of 32.7cm x 100.1cm. This was covered on both sides with 2 mm-mesh wire netting and designed to have a pad thickness of 2.5 cm. The pad-holders which were constructed with wood make the cooler more versatile and effective.

2.2.2 Evaporative cooler

The total height of the cooler was 153 cm, with a main frame height of 133 cm. The net surface area of the cooler was 19,959 cm^2, with a total capacity of $2.21 \times 10^5 cm^3$. It comprised of 3 compartments: upper compartment had a capacity of 0.423×10^5 cm^3 while the middle compartment had 0.642×10^5 cm^3 and the lower compartment with the largest volume had a capacity of 1.14×10^5 cm^3.

The cooler comprised of two tanks. The top tank was used in storing inlet water for flow through the cooler pad while the bottom (base) tank stored water outlet from the pads. The base tank is connected with a 2.5 cm diameter rubber pipe of length 100 cm to conduct excess water into a rubber bowl for onward recycling into the inlet tank manually, on timely basis.

The upper tank has a capacity of 52.8 litres. This was connected to 6 number 32.5cm perforated galvanized steel pipe via 2 number water taps/gates located on the opposite sides of the tank. The perforated galvanized steel pipes were connected together with 6 number 2.5 cm in length rubber hose with 1.88 cm diameter. The rubber pipes were tightly held to the steel pipes with the aid of 12 number metal clips. The bottom (base) water tank had a capacity of 75.3 litres. Six number 5 cm x 5 cm x 17.5 cm square steel pipes were welded to the base of the lower tank such that the 6 legs of the cooler main frame can easily fit in for the purpose of stability; and to prevent water from soaking the legs of the frame (see figures 1 and 2).

2.2.3 Cooler shed

The cooler shed was constructed mainly using bamboo poles and palm fronds. The flat roofed shed had a dimension 3.0 m x 3.0 m x 1.8 m. The cooler was installed in this shed for experimentation. The main purpose of the shed was to reduce the effect of sensible heat that could be gained from the solar radiation and to reduce direct effect of rainfall.

2.3 Methods

2.3.1 Test procedure

The cooler components were assembled and set up under the shed to determine the consumptive water use, effectiveness and evaporative efficiency of the system (see figures 1 and 2). The top water tank was filled with water and the valves were opened wide to get the pads properly saturated within a short time. Subsequently, the-valves were opened slightly to maintain the pads in a saturated state by water drips. Fresh vegetables such as fluted pumpkin leaves (*Telfairia occidentalis*), amaranthus (*Amranthus spp.)*, water leaves (*Talinum triangulare*), and okra (*Hibiscus esculentus*) were harvested from the farm. Samples of 100gm each of these vegetables were stored in the three different chambers of the cooler; we have the upper compartment, middle compartment and the lower compartment. In the control experiment, 100gm each of the vegetables were kept on a raised platform outside the cooler, in ambient condition.

2.3.2 Determination of water flow rate in-and-out, and consumptive water use of the cooler

A plastic rule was installed on the top water tank to gauge the reduction in water level (height) as a result of the water flow through the perforated galvanized steel pipe across the cooler pad. The cumulative volume of water was determined per unit time (hourly). A stop clock was used to note the time of reduction in water level from the top tank every hour.

The flow of water out of the system was also recorded by using an installed plastic rule to note the increase in level (height) of water in the bottom water tank on hourly basis. The cumulative volume of water was determined per unit time (hourly). The consumptive water use of the system was the difference in the volume of water entering the cooler from the top water tank and the volume increase in the base water tank.

2.3.3 Temperature and relative humidity evaporative efficiency measurement

Three locally constructed and calibrated hygrometers were used in taking wet-bulb and dry-bulb temperatures within and outside the cooler. Temperature changes in and around

the cooler including that of the re-circulated water were measured and recorded hourly using three sensitive mercury-in-glass thermometers. From the dry-bulb and wet-bulb temperatures that were observed, wet-bulb depressions were determined and the corresponding relative humidity values were read from standard hygrometric tables. The experiment was carried out for six consecutive days. Then the evaporative efficiency of the system was calculated using the model reported by Otterbein (1996) given as,

$$\eta ef = \frac{Tdb - To}{Tdb - Twb} \; X \; 100\,\%$$

Where,

$T_{ab} - T_{cool}$ = temperature drop
$T_{ab} - T_{wb}$ = wet bulb depression
$?_{ef}$ = evaporative efficiency
T_{cool} = dry bulb temperature of air within cooler
T_{ab} = dry bulb temperature of air entering pad (ambient temperature)
T_{wb} = wet bulb temperature of air entering pad

3. RESULTS AND DISCUSSION

3.1 Water Flow in-and-out and Consumptive Water Use of the Cooler

Results show that the average rate of water flow in and out of the cooler were 31.67 l/hr and 31.15 l/hr respectively. The average consumptive water use of the cooler was 0.52 l/hr. This depends on environmental conditions such as temperature, relative humidity and wind velocity. High water use by the evaporative cooler implies high ambient temperature, low humidity, high wind velocity and operational characteristics. This agreed with the findings of Harner et al. (2007 and 2009) where water usage equalled 0.2l/min/m^2 of pad when evaporative cooling system was employed in dairy farms.

Figure 3 shows the relationship between cumulative and average consumptive water use of cooler, and time of day in hours during storage of vegetables. From the figure, the consumptive water use by cooler was low in the morning and increased gradually as time of the day increased. For example at 8.00 hours in the morning water use was 0.15 l/hr while at 16.00 hours water usage increased to 0.54 l/hr. It could be stated here that the consumptive water use of the cooler at any time is equal to the sum of water retained by cooler pad and that evaporated for induced cooling (evaporative cooling) in the system. The average cumulative water use of cooler at 8.00 am and 6.00 pm (18.00 hours) were 0.15 and 5.72 litres (l) respectively. Generally, the water use continued to increase from the early hours to late hours of the day. The highest average cumulative water use was between 13.00 to 18.00 hours of the day.

3.2 Evaporative Efficiency, and Relative Humidity of Cooler and Ambient Conditions

Figure 4 and 5 show the relationship between Evaporative Efficiency, Ambient Relative Humidity and Cooler Relative Humidity; and consumptive water use, and time of day in hours respectively, during Vegetables storage. While the ambient relative humidity reduced sharply from 86.5% to 42.5% at 7.00 to 13.00 hours respectively, the cooler relative humidity was maintained between 93.5% and 87.2% throughout the hours of the day. This shows the effectiveness of the cooler in conserving moisture for effective preservation of fruit and vegetable crops. The evaporative efficiency increased from 40.7% at 7.00 hours to 88.3% at 14.00 hours before declining to 75.6% at 18.00 hours. These results agree with the findings of Harner (2007 and 2009), Ndukwu (2011); and Manuwa and Odey (2012), where the evaporative efficiency and relative humidity of cooler were maintained above 70%.

3.3 Cooler Temperature Drop and Consumptive Water Use of the Cooler

Figure 6 shows the relationship between temperature drop per hour and average consumptive water use (l/hr). Thus the temperature drop and consumptive water use both increased from early hours of the day to 15.00 hours before declining gradually. This revealed that the more water is used by the cooler, the more the temperature drop and the more its efficiency.

4.0 CONCLUSIONS

Results show that the average rate of water flow in and out of the cooler were 31.67 l/hr and 31.15 lit/hr respectively. The average consumptive water use of the cooler was 0.52 l/hr, with temperature drop of cooler up to 8 ^{o}C, 93.5% relative humidity and 88.3% evaporative efficiency. The use of this type of evaporative cooler should be encouraged since its advantages cannot be overemphasised as it does not require electricity to operate; it does not require a blower, re-circulating water pump, electric motor, and refrigerants. An alternative type of cooling, which does not expel chlorofluorocarbons (CFCs) is highly desirable as one important step in the correction of the current problems of global warming.

REFERENCES

Acedo, A.L. (1997). Storage life of vegetables in simple evaporative coolers. Tropical Science 37:169175.

Ahmed, E. M., Abaas, O., Ahmed, M., & Ismail, M., R. (2011). Performance evaluation of three different types of local evaporative cooling pads in greenhouses in Sudan. Saudi Journal of Biological Sciences, 18, 45-51. http:// dx.doi.org/ 10.1016/ j.sjbs. 2010.09.005.

Al-Sulaiman, F. (2002). Evaluation of the Performance of local Fibers in Evaporative Cooling. Energy Conversion and Management, 43, 2267-2273. http://dx.doi.org/10.1016/S0196-8904(01)00121-2.

Anyanwu E. E. (2004). Design and measured performance of a porous evaporative cooler for preservation of fruits and vegetables, Energy Conversion and Management (45) 2187–2195.

Dagtekina, M., Karacab, C., & Yıldızb, Y. (2009). Performance characteristics of a pad evaporative cooling system in a broiler house in a Mediterranean climate. Biosystems Engineering, 103, 100-104. http://dx.doi.org/10.1016/j.biosystemseng.2009.02.011

Darwesh, M, Abouzaher, S., Fouda, T., & Helmy, M. (2009). Effect of Using Pad Manufactured from Agricultural Residues on the Performance of Evaporative Cooling System. Jordan Journal of Agricultural Sciences, 5(2), 111-125.

Gunhan, T., Demir, V., & Yagcioglu, A. K. (2007). Evaluation of the Suitability of Some Local Materials as Cooling Pads. Biosystems Engineering, 96(3), 369-377. 10.1016/ j.biosystemseng.2006.12.001

Harner, J. P., Schmidt, C., Smith, J. F., and Brouk, M. J. (2007). Consumptive Water Use of Evaporative Pads. ASABE Publication Number 701P0507e, Sixth International Dairy

Housing Conference Proceeding (Minneapolis, Minnesota, USA)

Harner, J. P., Smith, J. F., Zimmerman, R. and Vanbaale, M. (2009). Water Consumption of Evaporative Pads. ASABE Paper Number: 096728, 2950 Niles Road, St. Joseph, MI 49085-9659 USA.

Harris, N. C. (1987). Modern Air conditioning Practice (3rd ed.). Publ. N.Y.: Mc Graw-Hill Book Co.

Karpiscak, M. and Marion, M. H. (1994). Evaporative Cooler Water Use. Arizona Cooperative Extension, The University of Arizona College of Agriculture Tucson, Arizona 85721. http://ag.arizona.edu/pubs/consumer/az9145.pdf

Lertsatitthanakorn, C., Rerngwongwitaya, S., & Soponronnarit, S. (2006). Field experiment and economic evaluation of an evaporative cooling system in a silkworm rearing house. Biosystems Engineering, 93(2), 213-219. http:// dx.doi.org/ 10.1016/ j.biosystemseng.2005.12.003.

Manuwa, S. I. and Odey, S. O. (2012). Evaluation of Pads and Geometrical Shapes for Constructing Evaporative Cooling System. Modern Applied Science; Vol. 6, No. 6; 2012. ISSN 1913-1844, E-ISSN 1913-1852. Pp. 45 – 53. Published by Canadian Center of Science and Education.

Ndukwu, M. C. (2011). Development of Clay Evaporative Cooler for Fruits and Vegetables Preservation. Agricultural Engineering International: CIGR Journal, 13(1), 1-8.

Olosunde, W. A., Igbeka, J. C., & Olurin, T. O. (2009). Performance Evaluation of Absorbent Materials in Evaporative Cooling System for the Storage of Fruits and Vegetables. International Journal of Food Engineering, 5(3), 1-15. http:// dx.doi.org/ 10.2202/1556-3758.1376.

Otterbein, R. (1996); Installing and Maintaining Evaporative coolers. Home Energy Magazine Online Vol. 13, No. 3. pp. 5 –11.

Roca, R. W., Hughes, W. C., & Christianson, L. L. (1991). Evaporative cooling pads: test procedure and evaluation. Applied Engineering in Agriculture, 7(4), 485-490.

Turner, R. H. (1986). Water Consumption of Evaporative Cooling Systems. Advancing Toward Technology Breakout in Energy Conversion. 21st Intersociety Energy Conversion 'Engineering Conference, San Diego, California. Vol. 2(3).

Xuan, Y. M., Xiao, F., Niu, X. F., Huang, X., & Wang, S. W. (2012). Research and application of evaporative cooling in China: a review (I)-Research (In Press). Renewable and Sustainable Energy Reviews.

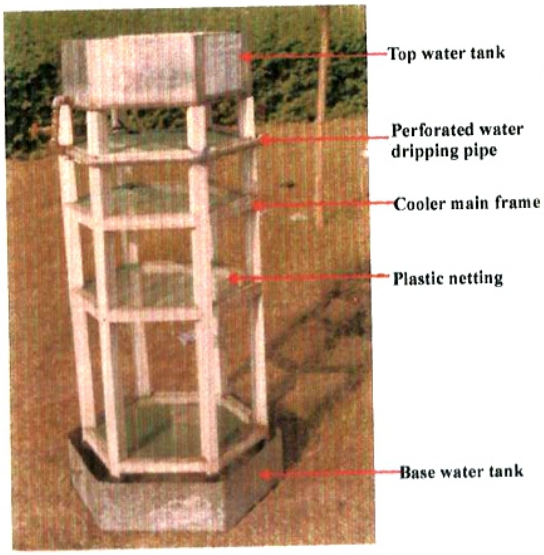


Figure 1: The main parts of the cooler frame

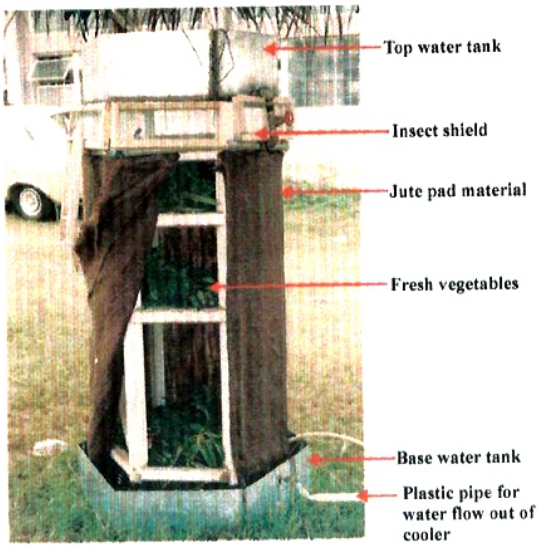


Figure 2: The main parts of the cooler during storage of vegetables

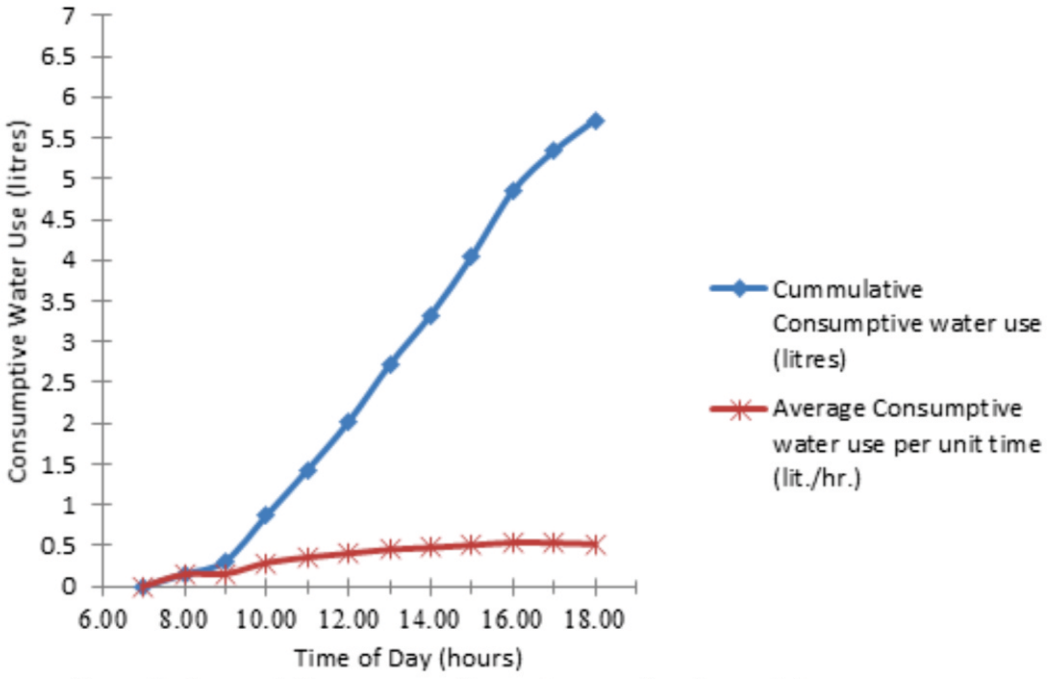


Figure 3: Cummulative consumptive water use of cooler and Average Consumptive Water use per unit time (lit/hr) versus time of day (hr).

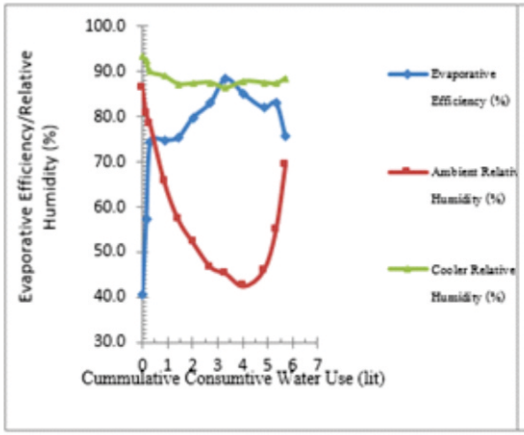


Figure 4: Relationship Between Consumptive Water Use, Evaporative Efficiency, Ambient Relative Humidity and Cooler Relative Humidity During Vegetable Storage.

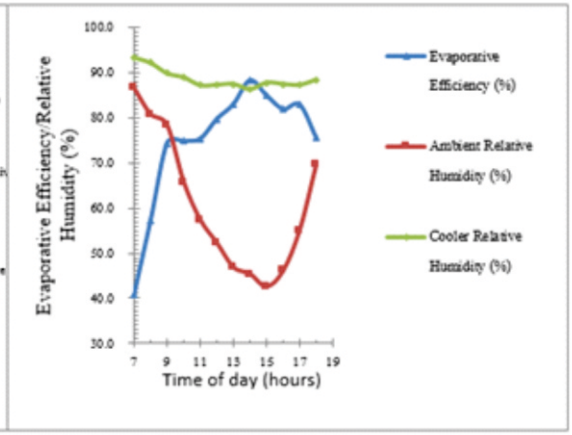


Figure 5: The Relationship Between Evaporative Efficiency, Cooler Relative Humidity and Ambient Relative Humidity With Time of Day.

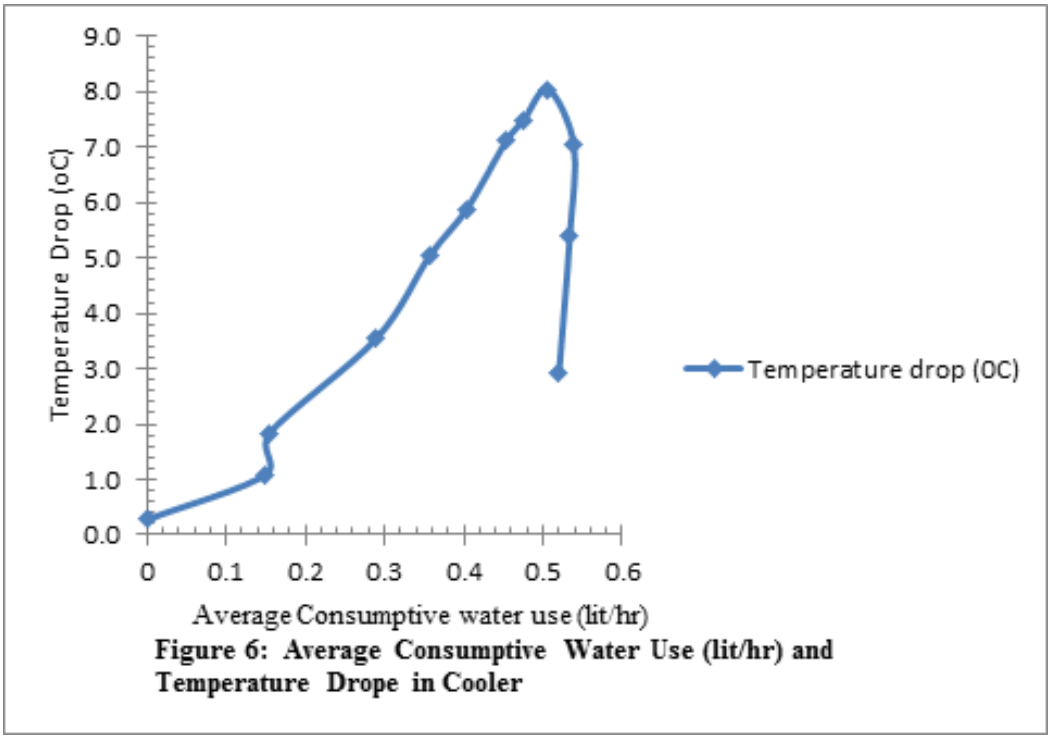


Figure 6: Average Consumptive Water Use (lit/hr) and Temperature Drope in Cooler

MECHANIZATION OF VEGETABLE PRODUCTION FOR SUSTAINABLE AGRICULTURAL PRODUCTION IN JABA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

Makarau, Shehu Bako[1], Shebi, GojeJoshua[2], Garba, Ogilvie Anna[3]. Paul[4], Wamagi Ishaku Thomas[5] and Ayuba Damina
*Faculty of Agriculture, Kaduna State University, Kafanchan Campus, PMB 1010 Kafanchan
makaraubako@gmail.com, joshuashebi@gmail.com, aann.garba@ymail.com
** School of Agricultural Technology, Nuhu Bamalli Polytechnic, Samaru Kataf Campus, P.O. Box 56, Zonkwa
adauagworok@rocketmail.com, wamagi1498@gmail.com, daminaayba@yahoo.com

ABSTRACT
The study examined the mechanization of vegetable production for sustainable Agricultural and food production in Jaba Local Local Government Area of Kaduna State. Dry-season vegetable farming constitutes a source of income and employment to rural farmers in Jaba Local Government Area of Kaduna State. A total of 125 farmers was purposefully selected at random and data were collected through structured questionnaire and scheduled interviews with farmers. The data were analyzed using percentages, frequencies, means and ranking. The findings revealed that the mean age of respondents was 34.5years, well experienced vegetable farmers with 10-14years having a mean family size of 12 people and a mean farm size of 2.45ha. A large proportion of the respondents (78.40%) were males who are married and attended one form of education or the other (88.00%). Majority of the vegetable farmers were non-indigenes (87.00%)while the main types of vegetables produced were leafy ,roots and fruit vegetables (84.0%1st 68.00% 2nd and63.20% 3rd respectively) The major constraints to mechanization of vegetable production were farm size(96.00% 1st), land tenure problems(68.00% 2nd), inadequate tractor hiring services(34.40 % 3rd) amongst others. It was concluded that vegetable production is dominated by the male folk who are experienced and educated but production is constrained by farm size as a result of land tenure system hence the small scale of production in the study area. It was recommended that the area of vegetable production should be encouraged by sensitizing farmers to explore this area of agriculture given its economic viability and government to address land ownership issues with the view of increasing land sizes to enhance sustainable agricultural and food production in the Local Government Area and the State in general.

Keywords: Mechanization, Vegetables, Sustainable, Agriculture, Food, Production

INTRODUCTION
In Sub-Sahara African (SSA) countries like Nigeria, anecdotal evidence indicates that the cost of manual farming activities has been rising, with potential causes including the growing urban sector, as well as rural non-farm economies (Oseni and Winters 2009) which often raises rural farming wages (Reardon et al. 2000). While rising rural wages may help some farmers benefit through increased off-farm income earning activities, farmers getting higher returns from farming than non-farm activities may lose from higher labor costs. However, when high labor costs have negative effects on agricultural productivity and the welfare of smallholder farm households, effective support for

(vegetables) is known as a vegan. However, vegetables often also contain toxins and anti-nutrients such as a-solanine, a-chaconine, enzyme inhibitors of cholinesterase, protease, amylase, etc.), cyanide and cynideprecusors, oxalic acid and more (Finotti, et'al, 2006). Depending on the concentration, such compounds may reduce the edibility, nutritional value, and health benefits of dietary vegetables. Cooking and/or other processing may be necessary to eliminate or reduce them.

Finotti, et'al (2006) added that diets containing recommended amounts of fruits and vegetables may help lower the risk of heart disease and type 2 diabetes. These diets may also protect against some cancers and decrease bone loss. The potassium provided by both fruits and vegetables may help prevent the formation of kidney stones.

In spite of the enormous dietary importance of vegetables to human beings, its contribution in the rural economy and the need to address food insecurity in Nigeria, most farmers in the study area are skeptical in exploring this area of agricultural production. The trend has been that only hausa settlers (popularly known and called "Kanawa") who come mostly during the off seasons and engaged in this economically viable aspect of agriculture and leave with the onset of the rainy seasons. It is certain that this activity goes with some economic gains that the study seeks to unravel, which attract migrants yearly from other parts of the country. The people involved, economic gains and the associated problems are not ascertained. It is against this background that the study seeks to achieve the following Research objectives:-

- To analyze the respondents socio-economic characteristics in the study area
- To identify the vegetable farmers in the study area
- To identify the of types vegetable produced in the study area
- To identify the vegetable consumers in the study area.
- To determine the constraints to Mechanization of vegetables in the Study area

MATERIALS AND METHODS

Population and Sampling

A total of 125 vegetable farmers were purposefully selected at random from five selected districts out of fifteen districts of the Local Government Areas. Twenty-five (25) respondents were purposively selected from each of the five selected districts due to their dominance in vegetable production with the help of trained field extension workers of the Kaduna State Agricultural Development Project (KADP) Samaru Zone which brought the total sample size to one hundred and twenty-five (125).

Primary and secondary data were used for the study. The primary data were collected from the selected farmers with the aid of structured questionnaires while the secondary data were gotten from published and unpublished literatures such as journals, magazines, textbooks, bulletins and other documentations. The questionnaires were designed to capture variables such as age, gender, marital status, occupation, household size, educational attainment, farm size and farming experience. The questionnaire was administered face to face on identified farmers at their residence or at the farm sites for easy retrieval.

Analysis and Presentation

Data analysis was purely computer aided using descriptive statistics such as frequencies, percentages, means and ranking while data were presented through tables.

RESULTS AND DISCUSSION

Socio-Economic Variables

Table 1 presents data on the socio-economic variables examined thus; age, gender, marital status, level of education, occupation, family size, farm size and farming experience.

Result on age groupings shows that the mean age of the respondent was 34.5 years. About 48.00% 0f the respondents were within the age bracket of between 30 and 39 years with vegetable production years of experience (10-19 years) constituting 56.80%. These categories of farmers could be considered to be the economically active population as the age and experience of a farmer dictates and affects the type of farming he/she could positively engaged as reported by Food and Agricultural Organization (FAO,1992). This implies that farmers within this age bracket and years of experience were less cautious of undertaking new risk, thus implore and adopt new methods to boost productivity and income.

The result also indicates that a large proportion (78.40%) of the respondents were males. This suggest that most of the vegetables, farming is undertaken by men in the study area, as vegetable production is labour intensive more so that most of the operations were manually done. This agrees with the claims of Makarau (2011) that leadership roles visa- vise decision making are dominated by the men folk.

On marital status, 65.60% of the respondents were married The result supported the findings of Ojo and Jibowo (2008) who reported that married people are responsible individual whose views are highly respected within rural communities in Africa.

Farmer's educational attainments revealed that a large proportion (88.00% of the respondents acquired one form of education or the other. This findings share a common view with Abdullahi and Abdullahi (2011) who reported that western education facilitates the acceptance of modern technologies and improved farm practices.. The implication of the result is that the more educated a farmer is, the greater his/her chances of taken risk hence agriculture is more of risk taking.

The occupation shows that 42.40% of the respondents were fully engaged in farming as their primary occupation while 44.00% of the respondents had family size ranging from 10-14 people with a mean household size of 12persons. The result find relevance with Orojobi and Damisa (2007), who in their study asserted that household size is crucial to traditional agriculture where the main source of labour is the family in developing countries particularly Nigeria.

In addition, results further revealed that a large proportion (80%) of the respondents had farm size ranging from les than 1.0-1.9ha, a mean farm size of 2.45ha and mean years of farming experience of 12.

Vegetable Farmers State of Origin

Table 2 presents data on the vegetable farmer's origin.

Result on the indigineship of respondents shows that majority of the vegetable farmers are not indigenes of the study area (85.60%) with only 14.40% of the sampled population are indigenes. This implicates that the indigenes are either not aware of the economic viability of this area of Agriculture or are avoiding the high labour demand of dry season farming hence the need for mechanized labour. The study agrees with Abdulrahman and Yahaya, (2009) who in their study revealed that vegetable production is constrained by high cost of labour, labour intensive operations.

Types of Vegetables Produced

Table 3 shows that the types of vegetables produced in the study area.

The result on table 3 indicates that the most common vegetables produced in the study area are leafy Vegetables (84.00% 1^{st}), Root Vegetables (68.00% 2^{nd}), Fruit Vegetables

mechanization may be critical. It has been observed that the major constraint to the expansion and modernization of agricultural production is the low level of engineering technology inputs into the agricultural sector of the economy. This is obvious because Farm power in African agriculture, especially sub-Saharan African (SSA) countries and Nigeria in particular, relies on human muscle power and is based on operations that depend on the hoe and other hand tools. It has been estimated that using only hand hoes, a farmer can only prepare about 0.5 ha for planting per season and for farmers to earn a living from agriculture, they cannot rely only on hand-tool technologies.

Dry-season vegetable farming constitutes a source of income and employment to rural farmers in Jaba Local Government Area of Kaduna State. This aspect of agriculture is mostly practiced during the dry-season in the form of small-scale and low cost irrigation system.

However, it is true that in Nigeria, farmers' yields fall below global yields. These low yields according to Abdulrahman and Yahaya, (2009) are due to a decline in the unit output from the various agricultural inputs such as capital, land, labor and management. Other constraints according to them include; soil fertility decline, soil borne diseases and pests, inadequate planting materials, high cost of labour, labour intensive operations and marketing of the product. There has been a rise in the production of vegetables in general , stimulated by high public demand, driven in large part by enhanced consumer awareness of the dietary and health benefits of fresh vegetable consumption (Iheke, 2009). Vegetables are the most affordable and accessible sources of micronutrient and its production is increasingly recognized as a catalyst for rural development and as a means of increasing and generating foreign exchange in Africa (AVRDC, 2004). Vegetables, according to Iheke (2009), supply components of a balance diet at a comparatively low price.

A balance diet should contain 250-325g of vegetables and the average human requirement for vegetable is 285g per person per day (Attavar, 2000). Hart,*etal*, (2005); Iheke, (2009), observed that in Nigeria, the consumption of vegetables range from 59-130g per person per day during the months of May –July the peak-season of vegetable production. This range is far below the recommended average. However, vegetable production could be viable economic alternative for raising the farm income of resource poor farmers. Sahu (2004) in support of this assertion maintained that a much better return can be obtained through vegetable cultivation than from the cultivation of other crops on land with less water usage. In Nigeria, between 1970-2003, vegetable production contributed about 4.6 percent of the total staple food production (CBN, 2004). Vegetables according to Kochhar (1986) are plants or plant parts that are usually eaten with the main meal and are commonly salted, boiled, or used for deserts and salad and have been a major component for human diets all over the world. Even though they are not the major source of energy, they serve as major as the much-needed minerals and vitamins providing flavor and taste to diets, thus increasing the appetite of the consumer. Barley (2010), maintained that vegetables are products of herbaceous plants and usually of annuals, where the fruits are products of woody plants.

Vegetables are eaten in a variety of ways, as part of meals, minerals and as snacks. The nutritional content of vegetables varies considerably, though generally they contain little protein or fat and varying proportions of vitamins such as Vitamin A, Vitamin K and Vitamin B6, pro-vitamins, dietary minerals and carbohydrates (Woodruff, 1995 and Whitaker, (2001). According to SteinmezKA, (1996) and Gruda, (2005) vegetables contain a great variety of other phytochemicals, some of which have been claimed to have antioxidant, antibacterial, antifungal, antiviral and anti-carcinogenic properties. The same authorities added that some vegetables also contain fiber, important for gastrointestinal function and important nutrients necessary for healthy hair and skin as well. A person who refrains from dairy and meat products, and eats only plants

(63.00% *3rd*), Pod Vegetables (52.00% *4th*), Seed Vegetables (16.00% 5th) and other vegetables constitutes 7.20% .

Vegetable Consumption

Table 4 presents and analyzed the result on the consumption of vegetables in the study area.

Result on table 4 indicate that most of the vegetables are consumed by retailers who buy from farm gates and transport to nearby villages within and outside the study area(70.00%), 55.00% by consumers who buy direct from the farmers for home consumption, 40.00% by government agencies while 28.00% and 18.00% are bought by wholesalers and other sources respectively. It means that the bulk of vegetables produced is bought by retailers.

Constraints to Mechanization of Vegetable Production

Table 5 presents the constraints to mechanization of vegetables in the study area.

The major respondents constraints to mechanization of vegetable production included farm size (96.00% *1st*), land tenure problems (68.00% *2n*), inadequate tractor hiring services (34.40% *3rd*) and un even ripening of fruits(32.80%). This finding is consistent with the work of Makarau (2011) that land tenure is the bane of agriculture in rural Kaduna State This implies, that lands are fragmented traditionally on ownership basis, which resultantly deny large production and income.

CONCLUSION AND RECOMMENDATION

The findings on the socio-economic factors revealed that the males dominated vegetable production, mostly educated, well experience in vegetable farming and at the productive age bracket of 30-39years. The farmers operate small farm holdings mostly <1.0-1.9 ha and are constrained by land ownership and small scale. Despite the importance of the vegetable production as fast income generating venture, the scale of production is still low.

It was recommended that:

- Farmers should be sensitized to explore this area of agriculture given its economic viability.
- Land ownership should be addressed by government with the view to increasing land sizes to enhance production

REFERENCES

Abdullahi, A. N. and Abdullahi, I. 2011. Cowpea Marketing in Isa Local Government Area of Sokoto State, Nigeria. *Nigerian Journal of Farm Management (Formerly FAMAN Journal)*. Vol.13(1) ISBN-9782607-002. pp80

Abdulrahman A. and Yahaya, A. 2009. Resource Use Efficiency of Vegetable Production in Kaduna State, Nigeria. Agricultural Society of Nigeria Proceeding of the 43rd Annual Conference held in Abuja, October, 20th – 23rd 2009. Pp270.

AVRDC, 2004. Asian Vegetable Research Development Centre for Africa, 11th Regional Training Course on Vegetable Crop Production and Research. Tanzania July,4th – November, 4th 2004.

Barley, L. H. 2010. Principles of Vegetable cultivation: Discovery publishing House, New Delhi – 1100 02, P2. ISBN81-7141-489-3

Beck-Chenoweth, Ha. 2010. Practical Research for Shrewd Farmers Resilience Research Farm. Hartshorne Missionary, 654471 . Herman Beck-Chenoweth Directors(573) 858-3559

Bonet, P. N. 2010. Chiefdom or Emirate in Southern Kaduna. A historical Perspective (Revised and edited). Images Point Graphics. No.6 Cameroon Road Opposite Primary School Gate Kaduna.

Central Bank of Nigeria, CBN. 2004. *Annual Report and Statistical Bulletin*, Vol. 6 (12)

Finotti, Enrico; Bertone, Aldo; Vivanti, Vittorio 2006. "Balance between nutrients and anti-nutrients in nine Italian potato cultivars". *Food Chemistry* 99 (4): 698. doi:10.1016/j.foodchem.2005.08.046

Food and Agricultural Organization, FAO, 1992. Farm Management Research for Small Farmers Development. Food and Agricultural Organization of United Nations, Rome, pp10-18.

Gruda, N, 2005. "Impact of Environmental Factors on Product Quality of Greenhouse Vegetables for Fresh Consumption". Crit. Rev. Plant Sci. 24(3): Taylor & Francis Group. pp. 227–247.

Iheke, O .R.2009. Economics of Homestead Vegetable Production in Abia State, Nigeria. Agricultural Society of Nigeria Proceeding of the 43rd Annual Conference held in Abuja, October, 20th – 23rd 2009. pp305

Kochhar, S.L.1986. Tropical Crop (2nd edition). The Interstate Printers and Publishers. Inc. USA.

Makarau, S. B. 2011. Socio-economic Factors Affecting the Adoption of Ginger Farming Innovations in Kaduna State Agricultural Development Project (KADP) Zone II , Samaru-Kataf. Unpublished M.Sc. Thesis, Abubakar Tafawa Balewa University, Bauchi. pp 45-68

Ojo, M.A. and Jibowa, A. A. 2008 Socio-economic Characteristics Influencing Role Performance of Rural Community Power Actors in Agricultural Extension Delivery System in Osun State, Nigeria: *Journal of Agriculture and Rural Development*.IssN1990-3375 Vol. 2 pp27-40. Swaziland Printing and Publishing Company Limited Mbabane, H100 Swaziland.

Orojobi, J. O. and Damisa, M. A. 2007 Assessment of Agrochemical Input Application on Smallholder Farms in Kaduna State Nigeria. *Nigerian Journal of Rural Economy and Society*.Vol.4 Pp 56-61.

Oseni, G. and Winters, P. 2009. Rural Non-Farm Activities and Agricultural Crop Production in Nigeria. *Journal of Agricultural Economics. 40:189-201*

Reardon, T., Taylor, J. E., Stamoulis, K. Lanjoun, P. and Balisacan, A. 2000. Effects of Non-Farm Employment on Rural Income Inequality in Developing Countries: An Investment Perspective. *Journal of Agricultural Economics*: 51(2) 266-288.

Sahu, P. K. 2004. "Analysis of Vegetable Production in India, China and World". *Journal of Vegetable Production,* Vol.10(1) Food Product Press.

Steinmetz KA, Potter JD 1996. "Vegetables, fruit, and cancer prevention: a review". *J Am Diet Assoc* 96 (10): 1027–39. doi: 10.1016/S0002-8223(96)00273-8 PMID-8841165

Whitaker, Julian M. 2001. *Reversing Diabetes*. New York: Warner Books. ISBN 0-446-67658-6-OCLC 45058465

Woodruff, Sandra L. 1995. *Secrets of Fat-Free Cooking: Over 150 Fat-Free and Low-Fat Recipes from Breakfast to Dinner-Appetizers to Desserts*. Garden City Park, N.Y: Avery Publishing Group.ISBN-0-89539-668-3. OCLC 33142867.

Table 1: Distribution of Respondents According to their Socio-Economic Characteristics (N=125)

Variables	Frequency	Percentage	Mean ($\overline{X}$)
Age (years)			
< 20	12	9.60	
20-29	28	22.40	
30-39	60	48.00	34.5
40-49	17	13.60	
50 and above	8	6.40	
Gender (male/female)			
Male	98	78.40	
Female	27	21.60	
Marital Status			
Married	82	65.60	
Single	15	12.00	
Widowed	18	14.40	
Divorced	0	0.00	
Educational Level			
Never been to school	15	12.00	
Qurrannic/Adult Education	35	28.00	
Primary Education	48	38.40	
Secondary Education	20	16.00	
Tertiary Education	7	5.60	
Occupation			
Farming	53	42.40	
Civil Servant	42	33.60	
Others	30	24.00	
Family Size			
<5	14	11.20	
5-9	30	24.00	
10-14	60	48.00	12
15-19	11	8.80	
20 and above	10	8.00	
Farm Size (Ha)			
< 1.0	75	60.00	
1.0-1.9	25	20.00	
2.0-2.9	12	9.60	2.45
3.0-3.9	10	8.00	
4.0 and above	3	2.40	
Farming Exp (years)			
<5	28	22.40	
5-9	71	56.80	
10-14	15	12.00	12
15-19	10	8.00	
20 and above	1	0.80	
Total	**125**	**100.00**	

Source: Field Survey (2012)

Table 2: Distribution of Respondents According to State of Origin

State	Frequency	Percentage	Rank
Kano	50	40.00	1st
Katsina	32	25.60	2nd
Bauchi	20	16.00	3rd
Kaduna	18	14.40	4th
Others	5	4.00	5th
Total	125	100.00	

Source: Field Survey, 2012

Table 4: Distribution of Respondents According to Consumption of vegetable

Consumers	**Frequency**	**Percentage**	**Rank**
Direct consumers	68	55.00	2nd
Wholesalers	35	28.00	4th
Retailers	87	70.00	1st
Government Agencies	49	40.00	3rd
Others	22	18.00	5th

Source: Field Survey, 2012. Multiple Responses

Table 5: Constraints to Mechanization of Vegetable Production (N=125)

Constraints	**Frequency**	**Percentage (%)**	**Rank**
Farm size	120	96.00	1st
Land tenure problems	85	68.00	2nd
Inadequate tractor hiring services	43	34.40	3rd
Un even ripening of fruits	41	32.80	4th
Inadequate capital	35	28.00	5th
High cost of labour	33	26.40	6th
Inadequate farm inputs	21	16.80	7th
Others	18	14.40	8th

Source: Field Survey (2012). Multiple responses

DETERMINATION OF SOME PHYSICAL PROPERTIES OF PHASEOLA SPECIES

A.O. Ojomo[1] and A. T. B. Aderibigbe[2]
[1]Dept. of Agricultural and Bio- environmental Engineering
ojomooluyemisi@yahoo.co.uk
[2] Dept. of Agricultural Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria
atbbenjamin@yahoo.com

ABSTRACT
In order to develop a processing and handling equipment for the varieties of phaseola species, namely: phaseolus lunatus, phaseolus angularis, phaseolus acutifolius and phaseolus mungo, some physical properties such as weight, diameter, sphericity, volume, density, porosity and angle of repose on some material surfaces were determined..
The mean values of major, minor and intermediate diameters of the four varieties of phaseola lunatus, angularis, acutifoluus and mungo were found to be: major diameter: 19.5, 12.5 11.25, 10.25, minor diameter: 12.5, 6.3, 5.5, 5.75 and intermediate diameter:18.5, 9.3, 8.6,9.0. The mean bulk density, porosity, volume and angle of repose for the four varieties of phaseola are: bulk density: 0.225, 0.0446, 0.382, 0.052, porosity: 0.0085, 0.22, 0.225, 0.382, volume: 0.64, 0.42, 0.45, 0.42 and angle of repose: 46, 17.5, 17.5, 17.5 respectively.
The result obtained from the study showed that, the same machine parameters could be used for shelling, separating and handling of phaseolus mungo, phaseolus acutifolius and phaseolus angularis according to their dimensions while, machine adjustment could be necessary for phaseolus lunatus due to its larger shape and size.

Keywords: Physical Properties, Phaseola Species, Sphericity, Angle of Repose, Diameter

1.0 INTRODUCTION

Phaseolus species (Pakala or Papala) is a tropical leguminous crop that is underutilized partly because of inadequate information on their processing techniques. It is one of the ancients crops of the New world (Freyland and Debouck, 2002; Broughton et al., 2002). Its origin is traced to Andean and Meso-america and is extremely diverse in terms of cultivation and uses (Papa, 2010).

Phaseolus is a dominant staple food of the people living in Ondo and Edo states of South Western part of Nigeria. Production in some parts take place in small farm holdings ranging from 0.2 – 2ha in sizes, usually in disperse, fertile land. The restriction of the crop to some few parts of Nigerian agricultural zones hinder the collection of scientific data on their physical properties and these cause low mechanization of technological process as regards to harvest and processing (Gana, 2000; Anna and Julitta, 2003).

Phaseolar beans are good source of dietary fibre, a virtually fat free source of high quality protein. They contain both soluble fibre which helps regulate blood sugar level and lower cholesterol. Also, insoluble fibre present aids in the prevention of constipation, digestive disorder and prevention of heart disease (Broughton et al., 2002).

Processing of agricultural products entail harvesting, separation, cleaning, handling and storing. Information on physical and aerodynamic properties of agricultural

vital tool for the design of processing and handling equipments. The properties which are useful during design must be known and these properties must be determined at laboratory conditions (Gursory and Guzel, 2010; Kashaninejad et. Al, 2002).

Alonge and Adegbulugbe, (2005); Adigun and Alonge, (2000); Oje et al., (2001); Koya and Adekoya, (1994); Manuwa and Muhammad, (2010) and Davies, (2010) all carried out studies on the physical and mechanical properties of some agricultural products. Little is known of the physical properties of Phaseola specie. The purpose of the study was to determine the physical properties such as dimension, weight, angle of response, spherecity, co-efficient of friction, bulk density, porosity of Sphaseola spp. relevant to its handling and shelling for the purpose of designing appropriate equipment.

2.0 MATERIALS AND METHODS

The materials used for the study was sourced at local market (Ikoko Market) in Owo, Ondo State Nigeria. Four varieties of Phaseola specie, namely phaseolus lunatus, phaseolus angaularis, phaseolus mungo and phaseolus acutifolius were purchased. The seeds were processed to remove all foreign matters such as dust, dirt, stones, chaff and broken seeds. A 10kg sample of seeds for each variety was prepared for the physical property analyses; such as weight, major diameter, minor diameter, intermediate diameter, roundness, sphericty, volume, density, bulk density, porosity and repose angle on some material surfaces.

The experimental methods for the study were given below:

2.1 Weight

The weight was determined using an electronic weighing machine.

2.2 Sizes and Shapes

One hundred seeds of each variety of phaseolas species were randomly selected for measurement of the major, minor and intermediate diameters using micrometer screw gauge. A vernier calliper with 0.001mm accuracy was used for the measurement of the length, width and thickness in three directions. The geometric mean diameter was determined using the method suggested by Song and Litchfield, (1991), by using equation 1.

$d_g = (abc)^{1/3}$ ---------- 1

where:

a=length of seed
b=width of seed
c=thickness of seed

2.3 Volume and Density

The volume of each seed was determined by water displacement method. Certain amount of seeds was wrapped with cellophane paper and was immersed in water inside a measuring cylinder. The difference in the final and initial reading on the measuring cylinder is taken as the volume of the seed. The density is the ratio of the mass of the seed to the volume of water displaced.

2.4 Bulk Density

The bulk density was determined by weighing an empty $100cm^3$ cylinder. The cylinder was then filled with seeds and reweighed. The experiment was repeated three times for each variety of seeds.

$$D_b = \frac{M_f - M_e}{V} \quad \ldots\ldots 2$$

Where:

Db = bulk density

M_e = mass of empty cylinder

M_f = mass of empty cylinder with seeds

2.5 Porosity

The porosity of the phaseolas species were determined by equation suggested by Mohsenin (1980).

$$P_r = \frac{1 - D_b}{D_s} \quad \ldots\ldots 3$$

Where:

P_r = Porosity

D_b=bulk density ofseed

d_s = Solid density of seed

2.6 Coefficient of Friction and Angle of Reponse

The static coefficient of phaseolas species was determined on three materials, plywood, glass and mild steel respectively. The method followed the procedure for the determination of static coefficient of friction of groundnut outlined by Alonge and Adegbulugbe, 2005. A box of 150mm × 150mm × 40mm with the top and the bottom opened was filled with the seeds and placed on adjustable tilting table onto which the material to be tested has previously been fastened.

The box was placed in one end of the surface and raised slightly so it was not touching the material. A screw device slowly tilted the table until the friction force between the seeds and the material was overcome by gravity and movement down the slope began. The angle of inclination was read from a graduated protractor attached to the tilting table. The tangent of the angle of inclination is the static coefficient of friction of the seed in the material.

2.7 Spherecity

Spherecity used for determining the similarity of seed to sphere was calculated by equation suggested by Gursory and Guzel, 2010; Mohsenin, 1980.

$$\text{Sphericity} = \frac{(abc)^{1/3}}{a} \quad \ldots\ldots 4$$

Where:

= sphericity index in %

3.0 RESULTS AND DISCUSSION

The mean values of major, intermediate, minor diameter, geometric mean diameter, roundness, sphericity, weight, volume, solid density, bulk density, porosity and repose angle of the varieties used are shown in the table below.

mild steel and glass of the 4 varieties of phaseola sp.

The results showed that, the phaseolus lunatus beans had the highest mean values of major, intermediate and minor diameter to be 19.5mm, 18.5mm and 12.5mm respectively. The major, intermediate and minor diameter of the phaseolus angularis, phaseolus acutifolius and phaseolus mungo had almost the same mean values and they were fouind to be 12.5mm, 11mm, 8.5mm for phaseolus angularis and 11.25mm, 8.5mm and 5.5mm for phaseolus acutifolius, 10.5mm, 9mm and 5.75mm for phaseolus mungo respectively. This indicated that there are no significant difference among phaseolus angularis, phaseolus acutifolius and phaseolus mungo according to their dimension, but,

there is significance difference between the phaseolus lunatus and the 3 phaseolus varieties interms of their mean values of major, intermediate and minor diameter. The average mean volume of phaseolus lunatus and phaseolus acutifolius were almost the same and they were found to be 0.64cm^3 for phaseolus lunatus and 0.75cm^3 for phaseolus acutifolius, while there were no significance difference between phaseolus angularis and phaseolus mungo in terms of their volume and they were found to be 0.42cm^3 for angularis and 0.42cm^3 for phaseolus mungo respectively. The phaseolus lunatus had the highest mean value of geometric mean to be 7.07, while the phaseolus angularis, phaseolus acutifolius and phaseolus mungo were almost the same in there geometric mean values and they were found to be 2.03, 1.10 and 1.6 respectively.

The average mean porosity of phaseolus angularis, phaseolus acutifolius and phaseolus mungo were almost the same and there are no significance difference among the 3 varieties and they were found to be 0.22, 0.24 and 0.22 respectively. The bulk density which is very important in separating and grading of phaseolus beans according to density and aerodynamic properties (Hauhonot and Brusewitz, 2000). The sphericity values were found to be in range of 58.67% - 84% for phaseolus lunatus, 24%- 39% for phaseolus angularis, 27%- 31% for phaseolus acutifolius and 14.69% - 20% for phaseolus mungo. This shows there shape approach that of sphere (Tabil et al, 1999). This implies that the same machine could be used for the processing of phaseolus angularis, phaseolus acutifolius and phaseolus mungo according to there shapes, sizes and length, while the same machine could also be used for processing of phaseolus lunatus in terms of adjusting the shelling unit of the machine due to its shapes, size and its length. With regards to the static coefficient of friction for phaseolus mungo determined on the three structural surface. It was found tthat glass had the highest mean value to be 0.32, while the lowest was on mild steel to be 0.21. phaseolus lunatus had the highest mean value on glass and it was found to be 0.1 and 0.02 for the lowest value on mild steel. Phaseolus acutifolius had the same values with phaseolus lunatus on glass and it was found to be 0.1. This property is needed in the design of agricultural machine hopper and other conveying equipements. It determined how a pack of phaseolus beans will flow in these systems. The angle of repose for phaseolus lunatus bean was found to be 46^0, 40.5^0 for phaseolus angularis and 17.5^0 for phaseolus mungo, while phaseolus lunatus had the highest sphericity to be 71.34% phaseolus acutifolius and phaseolus mungo had almost the same mean values to be 15.75% and 17.34%. 31.5% for phaseolus angularis. This property also determined the minimum slope of flow in self emptying bin of phaseolus species during processing. While the roundness and the sphericty determined the tendency to roll in the machine

4.0 CONCLUSION AND RECOMMENDATION

According to the study results, the phaseolus lunatus seeds were longer and wider than the phaseolus angularis, phaseolus acutifolius and phaseolus mungo seeds. Among the phaseolus varieties, phaseolus lunatus beans had the highest values for major, intermediate and minor diameter. Phaseolus Acutifolius, phaseolus angularis and phaseolus mungo varieties according to dimension were not very different.

The average seeds weight varied from each varieties of 0.52g for phaseolus lunatus, 0.022 g for phaseolus angularis, 0.025g for phaseolus acutifolus and 0.025g for phaseolus mungo beans.

The result obtained from the study showed that, the same machine parameters could be used for shelling, separating and handling of phaseolus mungo, phaseolus acutifolus and phaseolus angularis according to their dimension, while machine adjustment could be necessary for phaseolus lunatus due to its width and length in shapes and size.

REFERENCES

Alonge, A.F. and Adegbulugbe, T.A., (2005). Some physical properties of groundnuts. Journal of Agricultural Engineering Technology (AET), volume 13.

Angioi, S., Rau, D., Attene, G. Nanni, L., Bellucci, E., Logozzo, G., Negri, V., Spagnoletti Zeuli, P., and Papa, R. 2010. Beans in Europe: Origin and Structure of the European Landraces of Phaseolus VulgarisL. TAG – Theoretical and applied Genetics 121 (5): 829 – 843.

Broughton, W.J., Hernandez, G., Blair, M., Beebe, S., Gepts, P and Vanderleyden, J. 2003. Bean (Phaseolus Spp.) – Model food legumes. Plant soil. 252: 55 – 128.

Freytag, G.F., and Debouck, D.G. 2002. Taxonomy, distribution and ecology of the genus Phaseolus (Leguminosae – Papilionoideae) in North America, Mexico and Central America. Botanical Research Institute of Texas, Forth Worth.

Gursory, S and Guzel, E. (2010). Determination of Physical properties of some Agricultural Grains. Research Journal of Applied Sciences, Engineering and Technology 2(5): 492 – 498, 2010.

Koya, O.A and Adekoya, I.O., (1994). Some Physical and Aerodynamic properties of grain crops relevant to destoising. Ife Journal of Technology, 4(2): 35 – 40.

Mohseini, N.N; (1970). Physical properties of plants and animal materials. Gordon and Breach science publications, New York.

Oje, K., Alonge, A.F. and Adigun, Y. J., (2001). Some Engineering properties of shea Nut relevant to mechanical processing. Ife Journal of Technology (IJT). 10(2): 17 – 26.

Purseglove, J.W. 1974. Phaseolas lunatus In "Tropical Crops Dicotyledons". London : Longman. Pp 296 – 301.

Song, H. and Litchfield, J.B; (1991). Predatory methods of terminal velocity for grains. Trans. ASAE, 34(1): 225 – 231

Anna G. Julitta B (2003)- Physical Properties of Selected Legumes Seeds as Indicators of Technological Suitability of Small-Seed Broad Bean. *Polish Journal of Food and Nutrition Science Pol. J. Food Nutri. Sci* 2003, Vol. 12/53 No 2. Pp. 9-13.

Davies, R. M., (2010). Some Physical Properties of Arigo Seeds. *Int. agro Phys*, 24:89-92
Gana I. M. (2001). Determination of Some Physical and Mechanical Properties of Selected Nigerian Grains Federal University of Technology Minna, Niger State, Nigeria Unpublished Undergraduate Project.

Kasharineja M., A Mortazavi, A Safekordi and L.g. Tabil. (2005). Some Physical Properties of Pistachio (*Pistachia vera L.*) Nut and its kernel. *J. Food Eng*., 72:30-38.

Manuwa S.I and H A. Muhammad (2010). Moisture Content and Compression Axial Effects on Mechanical properties of Shea kernel. *Journal of Food Technology* Volume: 8/Issue: 3/94-99.

Table 5: The Mean Values of the 4 Varieties of Phaseola Spieces

	Lunatus	Angularis	Acutifolius	Mungo	LSD
Major diameter(mm)	19.5	12.5	11.25	10.25	1.42
Inter diameter(mm)	18.5	9.8	8.7	9	1.42
Minor diameter(mm)	12.5	6.3	5.5	5.75	1.3
Weight (g)	0.52	0.024	0.025	0.025	0.6
Geometric mean	7.07	2.025	1.10	1.6	16.9
Roundness(mm)	52.6	31	29	25	8.1
Sphericity (%)	71.34	31.5	15.75	17.34	13.34
Volume(cm^3)	0.64	0.75	0.45	0.42	17.1
Solid density (g/cm^3)	0.13	0.033	0.0125	0.05	0.16
Bulk density(g/cm^3)	0.225	0.0446	0.0382	0.052	0.16
Porosity	0.0085	0.22	0.245	0.23	0.08
Repose angle(degree)	46	17.5	17.5	17.5	2.1
Coefficient of friction on	-	-	-	-	
1.plywood	0.0835	0.28	0.31	0.29	0.13
2.mild steel	0.023	0.185	0.215	0.21	0.14
3.glass	0.1035	0.295	0.0605	0.32	0.71

The Plates Below Showed The Four Varieties Of Phaseola Species.



Plate 1. PHASEOLUS LUNATUS BEANS



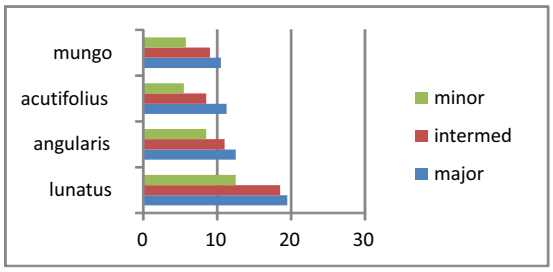
Plate2.PHASEOLUS ANGULARIS BEANS



Plate 3. PHASEOLUS ACUTIFOLIUS BEANS



Plate 4. PHASEOLUS MUNGO BEANS



The Diameter of 4 Varieties of Phaseola sp.

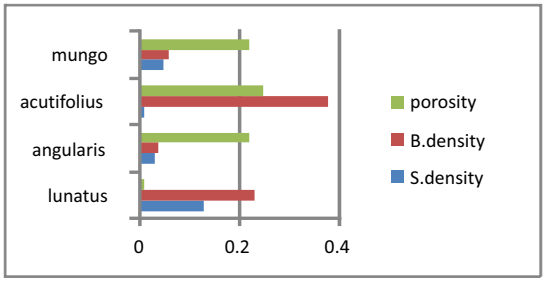


Fig.2 The Solid Density, Bulk Density and Porosity of the 4 Varieties of Phaseola sp.

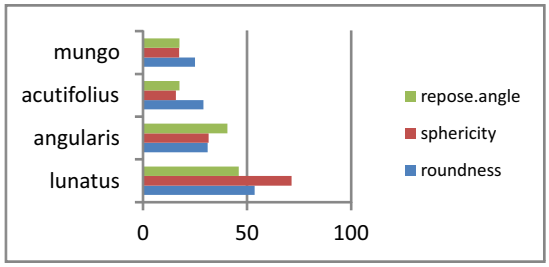


Fig.3 The Roundness, Sphericity and Repose Angle of The 4 Varieties of Phaseola sp.

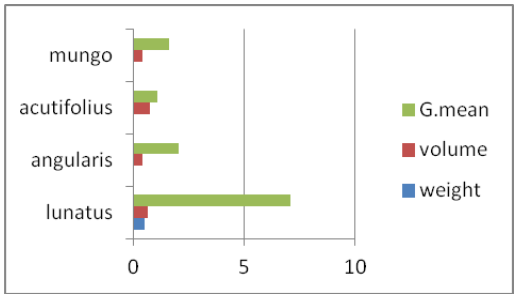


Fig4 The Weight, Volume and Geometric Mean Diameter of the 4 Varieties of Phaseola Sp.

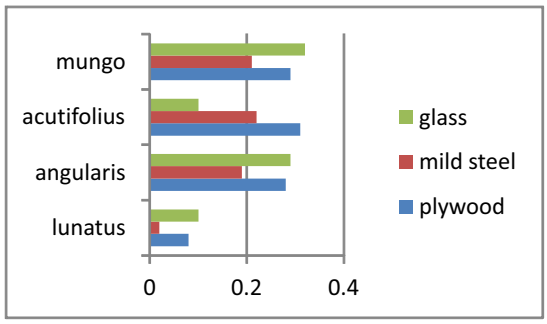


Fig.5 The Co-efficient Of Friction On Plywood

PEELING OF CASSAVA (*Manihot esculenta crantz*) USING CHEMICAL AND MECHANICAL METHODS

Judith Ebegbulem, P. O. Ngoddy and A. F. Alonge
Dept. of Agricultural and Food Engineering
University of Uyo, Uyo, Nigeria

ABSTRACT
In an attempt to address the challenge of Cassava peeling, two chemical dips (solutions of a base and an acid) were used to loosen the peels of the root (TMS 30572 variety) and a rotary brushing machine which is expected to remove the loosened peels of the roots was designed. The optimal concentration temperature and time of root immersion in dilute sodium hydroxide (NaOH) were obtained as 15%, 60^0C and 20 minutes respectively. The roots were also dipped in dilute hydrochloric acid (HCL) at the corresponding concentration, temperature and time to neutralize the effect of the base. The results were used as a basis for the design of the rotary brushing machine. The machine consists of the following: a hopper, a conveyor, a peeling chamber, a rotary brush, a slit and inclined tray, a collection tray, a transmission system and a 2Hp engine. The capacity of the machine based on design calculations employed was estimated as 44,064Kg / day.

Keywords: Cassava, Peeling, Sodium Hydroxide, Hydrochloric Acid and Rotary Brushing Machine.

1.0 INTRODUCTION
Cassava (*Manihot esculenta Crantz*) is a perennial woody shrub of the Euphorbiacae family and is designated in different countries as manioc, mandioca, tapioca or yucca. It is grown mainly for its swollen roots which provide a cheap source of energy and raw material for industries (Dahniya et al., 1994). It is also utilized as food for humans in processed forms such as starch, gari, lafun, fufu and abacha, while some sweet (low cyanide) varieties are eaten raw, boiled or roasted as snacks. Cassava can also be used for industrial purposes such as starch, alcohol, adhesives and livestock feed. There are prospects that it can also earn foreign exchange. The roots contain 25 to 35% starch and the leaves which are not as important as a source of calories, contain a significant amount of protein and other nutrients (FIIRO, 2006). These roots may range in length between 120mm and 400mm and from 18.8mm to 88.5mm in diameter (Adetan et al., 2003). The roots consist of four parts which are the corky periderm or tissue, cortex, flesh, and the fibrous pith as shown in figure 1. The corky periderm is a thin outer papery layer that can be rubbed-off easily while the cortex is a thick cellulosic layer of tissue material. The corky periderm and the cortex together make up the peel. The peel is removed by a process called "peeling" in order to have access to the starch and soft flesh which is of maximum interest to the processor.

A major problem associated with Cassava usage arises from the fact that Cassava roots exhibit appreciable differences in weight, size and shape. There are also differences in the properties of the Cassava peel which vary in thickness, texture and strength of adhesion to the roots flesh. Thus, it is difficult to design a Cassava peeling machine that is capable of efficiently removing the peel of all roots due to wide differences in the properties of the roots from various sources. Mechanical peelers are best suited to roots of a regular shape. Irregularly shaped roots have high peeling losses or require hand trimming to finish them off.

Chemical peeling (lye peeling) and steam peeling (exposing the roots to steam to loosen and soften peels) which are well developed for peeling Irish and sweet potatoes (Simplot, 2006) in the food processing industries, have been considered. A major reason why these methods may not be suitable for Cassava peeling is that a higher temperature and more root immersion time will be needed. Other reasons adduced include the possible of contamination of the roots, partial gelatinization of the outer layer of the roots, the inconvenience of handling, and the high cost associated with the processes.

Manual peeling of Cassava has been shown not only to be inefficient but also wasteful (Anekwe, 1984). A solution to the peeling problem is urgently needed and so it has become imperative to explore different methods of solving the problem. How to achieve this is the agenda of this paper. This paper aims at exploring ways of maximizing efficiency and minimizing losses in Cassava peeling by using a combination of two chemical dips (solutions of a base and an acid) followed with wet mechanical brushing.

This can be achieved by carrying out an analysis to know the concentration, time and temperature required for proper digestion of the peels by chemicals used as dips (to loosen and soften the peels) without reacting with the fleshy part of the root, then designing a rotary brushing machine that will remove the loosened peel of the Cassava roots. The design obtained will be applied to fabricate the machine possibly in a follow-up study. If successful, this method will be a breakthrough not only for the Nigerian economy but also for the world as cassava will then be processed efficiently with minimal losses into any food and / or non-food product.

2.0 MATERIALS AND METHODS

2.1 Selection of Agricultural Materials

The Cassava roots used in this study were harvested from the research farm of the University of Uyo, Uyo, Nigeria. The cultivar is a high yielding Tropical Manioc Selection (TMS 30572) variety with high pest and disease resistance. The roots were washed to remove soil particles on them.

2.2 Determination of the Concentration, Temperature and Time of Root Immersion Needed to Loosen the Peels.

2.2.1 Materials and apparatus

The materials and apparatus used for this work are glass rod, heating mantle, stainless steel bowls, acid resistant gloves, measuring cylinder, volumetric flask, beakers cassava peels, thermometer, tripod stand and water.

2.2.2 Dipping in chemicals

Two types of digestive chemicals for cellulose were used, namely: Acid (Hydrochloric acid) (HCL)) and Base (Sodium Hydroxide (NaOH)). The chemicals were prepared as follows:

All NaOH solutions were prepared in the laboratory from solid NaOH pellets. All HCL solutions were also prepared in the laboratory from concentrated HCL as imported. It had a purity of 37% and its specific gravity (Wt per ml) was 1.18g. Both acid and NaOH dissolution in water were exothermic. Solutions were cooled to room temperature for final preparation in volumetric flasks.

2.2.3 Procedure

Dipping of peels: Dilute solutions of sodium hydroxide (also designated as lye) at 5%, 10%, 15% and 20% concentrations respectively were made. The cassava roots

peeled to obtain the peels which were used for the determination. The Cassava peels were immersed in bowls containing the prepared lye solutions at predetermined concentrations, at temperatures (50^0c, 55^0c and 60^0c) for different time intervals (4mins, 8mins, 12mins, 16mins and 20mins) respectively. Also peels were immersed in bowls containing prepared dilute hydrochloric acid at the same concentrations, temperatures and times. All observations were recorded.

Dipping of unpeeled Cassava roots:

With hands properly protected with acid resistant gloves, a root was immersed in lye at the optimum concentration, temperature and time. The treated root was washed with water and immersed in dilute HCL at corresponding concentration, temperature and time. This was done to neutralize the effect of the base to form salt. Washing of this root also took place again to dissolve the salt. The extent to which peeling occurred was checked by removing the peels on the root with a brush.

2.3 Design Considerations For the Rotary Brushing Machine

According to Olukunle et al., (2005), a rotary brushing machine was designed based on the following considerations:

1. Affordability: it should be low –cost and within the buying capacity of the common man or local farmers.
2. Safety: it should be safe for use.
3. The machine should be made with easily and readily available materials.
4. It should not be tedious and time- consuming as in the case of traditional method of peeling.
5. The capacity should be high compared to manual operations.

2.4 Design Calculations

Conventional engineering design principles were applied for the design of the rotary brushing machine. The components include hopper, shafts, slited and inclined tray, collection trays, the transmission system (pulley and gear design), electric motor, rotary brush and the conveyor belt.

2.4.1 Shaft design

The best material for the design of the shaft is alloy steel (nickel, nickel-chromium e.t.c.) since it provides the shaft with high strength.

1. The speed of shaft (S) required is 424 rpm
2. The torque transmitted by the shaft (T) and the diameter of shaft drive (D) were obtained using the relationship in (1) and (2).

$$T = (p \times 60) / (2\pi S) \quad (1)$$

$$D = [(16T) / (\pi\tau)]^{1/3} \quad (2)$$

π – Constant (3.142), τ – maximum permissible shear stress which was taken as 42mPa (ASME (American Society of Mechanical Engineers) code for design of transmission shaft with allowance for key way),

2.4.2 Pulley design

The material for the pulley is cast iron or mild steel (dry). The design of pulley is as described:

1. A flat belt was used in the design since it transmits a moderate amount of power from one pulley to another when the two pulleys are not more than 8m apart. A centre distance of 1m was used.
2. The best material for the belt is leather. This is because it is strong, durable and has

high coefficient of friction.

3. Light belt drive is used to transmit small powers at belt speed of 10 m/s as in agricultural machines and small tools, hence a belt speed of 10 m/s was chosen for the design.
4. Coefficient of friction between belt and pulley is 0.25, since the belt material is leather oak tanned and the pulley material is cast iron or mild steel (dry).
5. The velocity ratio used was 3 : 1
6. The diameter and speed of the driver and driven pulleys were obtained using the relationship in (3) and (4).

$N_1 / N_2 = D_2 / D_1 = V.R$ (3)

$N_1 = (60V_1) / (\pi D_1)$ (4)

Where D_1 – diameter of the driven pulley was designed as 150mm, D_2 – diameter of the driven pulley, N_1 – speed of the driver pulley, N_2 – Speed of the driven pulley, V_1 – Belt speed and V.R is Velocity Ratio of pulleys.

7. The length of the open belt drive (L) was obtained using (5) below.

$L = \pi/2 (D_2 + D_1) + 2X + [(D_2 - D_1)^2/4X)]$ (5)

Where X – Centre distance between pulleys.

8. The angle of contact between the belt and each pulley (θ) was obtained using (6) and (7).

$\text{Sin}\ \alpha = (R_2 - R_1) / X$ (6)

$\theta = (180^0 - 2\alpha)\ \pi/180$ rads (7)

Where α – Angle of wrap in degrees, R_1 – Radius of the driver pulley and R_2 – Radius of the driven pulley.

9. The tensions in the tight and slack side of the belt T_1 and T_2 were obtained using (8) and (9).

$P = (T_1 - T_2) V_1$ (8)

$2.3\ \text{Log}\ (T_1/T_2) = \mu\theta$ (9)

Where μ is coefficient of friction between belt and pulley.

2.4.3 Gear design

The machine considered best for the manufacture of gears is cast iron. This is due to its good wearing properties, excellent machinability and ease of producing complicated shapes by casting method.

1. The Gear Ratio (G. R) used was 2:1
2. The diameter of the larger wheel or gear (D_G) was obtained using (10)

$D_G / D_P = G.R$ ..... (10)

Where the diameter of the smaller wheel or pinion (D_p) was designed as 150 mm.

2.4.4 Power requirement

Power of 1500 Watts = 1.5Kw = 2hp was used (A small prototype was considered) (Khurmi et al., 2005).

2.4.5 Brush requirement

1. Volume of peels to be removed by a bristle (V_{br}) = $L_{br} \times T_{rp} \times L_{rp}$ (11)
2. Total volume of peels to be removed (V) = $2\pi r \times T_{rp} \times L_{rp}$ (12)
3. Number of bristles required on the brush to effectively remove peels (N_b)

$N_b = V / V_{br}$ (13)

Where L_{br} – Length of a bristle, T_{rp} – Thickness of the root peel, L_{rp} – Length of a section of the root peel and r – Average radius of root.

2.4.6 The mass (M) to be carried by the hopper at a time T

There are four forces acting on a load resting on a rough horizontal surface as seen in figure 2 and they are: weight of the load W_L acting vertically down, horizontal pull P_1, vertical reaction of the surface (R) acting upward, horizontal friction (F) due to the roughness of the surface.

Considering the surfaces in contact in this case being the Cassava peels and leather which is the material of the belt, coefficient of friction of surfaces was introduced. Since the peels of the roots are somehow woody in nature, and the conveyor belt material is leather, the coefficient of friction between wood and leather was chosen to calculate the mass using the relationships in (14 – 16b).

$F = \mu_1 \times W_L$ (14)

$T = F \times R_2$ (15a)

$F = T / R_2$ (15b)

$F = \mu_1 \times M \times g$ (16a)

$M = F / (\mu_1 \times g)$ (16b)

Where μ_1 – Coefficient of friction between peels and leather and g – Acceleration due to gravity.

2.4.7 Processing time (t)

The processing time (t) of a root was obtained.

1. The designed length of the conveyor belt (L_C) was 3m
2. The speed of the belt was chosen as 10 m/s
3. The time taken for the root to reach the entrance of the drum (t_1) was obtained using (17)
   $t_1 = L_C / V_1$ (17)
4. One revolution of the brush will remove the peel on the root, so the time required for the brush to complete one revolution was obtained as t_2.
5. The processing time (t) for the root was obtained by using (18)
   $t = t_1 + t_2$ (18)

2.4.8 Capacity of the machine (C)

1. The weight of the root used in obtaining the processing time (t) was taken and recorded as W_R. Since W_R will be completely peeled in time t, the processing time (t_3) for 1Kg was obtained using (19)
   $t_3 = (1\ Kg \times 1\ s) / W_R$ (19)
2. If 1Kg will be peeled in time t_3, then the weight (W) to be peeled in 1s was obtained using (20)
   $W = (1\ Kg \times 1s) / t_3$ (20)
   The capacity of the machine (C) is W (Kg / s), W (Kg / day) or W (tons / day).
   It should be noted that factor of safety and the slip of the belt were ignored for this design work.

3.0 RESULTS AND DISCUSSIONS

3.1 Effects of Dilute Hydrochloric Acid on Peels

The following results were obtained as shown in Table 1 through Table 4.

3.2 Effects of Dilute Sodium Hydroxide (lye) on Peels.

In determining the concentration, temperature and time of root immersion required to soften the peels of the roots used, the following results were obtained as shown in Table 5 through Table 8. The optimum concentration, temperature and time finally obtained are

shown in Table 9.

3.3 Conceptual Design of Brushing Machine

Figure 3 is a conceptual perspective drawing of the brushing machine. It has the following components: a hopper, a conveyor, a peeling chamber, a rotary brush, a slit and inclined tray, a collection tray, a transmission system and a 2Hp engine. A 2 Hp engine was chosen as the drive. The rotary brush rotating at 637 rpm mounted on a 16mm shaft is driven by this engine rotating at 1273 rpm. The brush rotates faster at a speed of 637 rpm while the conveyor moves at 424 rpm. The drive system consists of a belt and pulley arrangement with a speed ratio of 3:1 between the driver and the driven pulley, and a gear arrangement with a speed ratio of 2:1 between the larger wheel called the gear and the smaller wheel called the pinion. As the roots are fed into the inlet tray, the conveyor by the help of the belt conveys the roots into the peeling chamber one after the other. The brush rotates in the opposite direction to the roots and as such imparts a rotary motion on the roots to effect the required peeling. The motion of the brush in the opposite direction is due to the gears introduced. The width of the peeling chamber adjusts itself so as to accommodate variations in root sizes and shapes. The peels pass through the slits and are collected while the peeled roots fall into the tray with handle and then are washed manually.

3.4 Discussion

Table 1 through Table 4 show the effect of dilute hydrochloric acid on Cassava peels. It was observed that HCL had no visible effect on the peels at the concentration, temperatures and times employed. Table 5 through Table 8 show the various effects of NaOH solutions on the peels when dipped in lye at the listed concentrations, temperatures and times. Observations such as change in colour of lye from colourless to brown, softening of the cortex, detachment of the corky periderm from the cortex were reported. The optimum concentration, temperature and time of root immersion were recorded in Table 9. It was observed that processing time was the most important parameter that affected the process and this is in line with the suggestion of Floros et. al., (1987). It was also observed that the peels of the roots were removed at the optimum concentration, temperature and time. Table 10 shows the effect of the optimum concentration, temperature and time on the unpeeled Cassava roots used. The corky periderm was completely removed and the cortex got soft. Table 11 shows all the data obtained from design calculations which were prerequisites for the rotary brushing machine. Table 12 presents the part list of the rotary brushing machine. The capacity of the machine as estimated was 0.51kg / s which when converted is equivalent to 44,064kg / day or 44.064tons / day (though excessive). With this capacity, there is no doubt to say that the design work for this machine is highly efficient.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Cassava roots can be efficiently peeled using two chemical dips in the nature of solutions of a base and an acid followed with wet mechanical brushing. Preliminary laboratory tests carried out indicated that the optimal concentration, temperature and time of root immersion for TMS 30572 in lye were 15%, 60^0C and 20 minutes respectively. These values are sufficient to loosen peels of this root. A rotary brushing machine was designed to remove the loosened peel of the roots. The capacity of the machine was estimated as 44,064Kg / hr which is very encouraging compared to 23kg / hr (552Kg / day) recorded in manual peeling by Alade (2005) and 500Kg / hr (12000Kg / day) for the

Recommendations

The following recommendations can be made from the study:

1. That the data obtained from the design calculations be used in a follow-up study to fabricate the machine and that the fabricated machine be tested.
2. Due to some constraints, it was not possible to introduce pressurized water nozzle at the top of the brush and drainage to collect the waste below. On this note, it is recommended that an improved design be carried out.
3. More attention should be given to the study of peeling using chemical dips followed with wet mechanical brushing.

REFERENCES

Adetan, D. A., Adekoya, L. O., Aluko, O. B. (2003): "Characterization of Some Properties of Cassava Root Tuber". Journal of Food Engineering, 59; (2003) 349 – 353.

Alade, O. (2005): Performance Evaluation of an Indigenous Cassava Peeling Machine. Unpublished B. Eng Thesis. Department of Agricultural Engineering, of Technology, Akure, Nigeria.

Anekwe, S. N. (1984): Conversion of Cassava Roots Washing Machine into a Continous System Peeling Machine. An Unpublished MSc. Thesis, Agricultural Engineering Department, University of Nigeria, Nsukka.

Dahniya, M.T., Akoroda, M.O., Alvare, M.N., Kaindaneh, P.M., Ambe – Tumanteh J., Okeke, J.E., Jalloh, A. (1994): "Development and Dissemination of Appropriate Root Crops Packages to Farmers in Africa." In Proceedings, Ninth Symposium of the International Society of Tropical Root Crops. 20 – 26 October 1991, Accra, Ghana. F. Ofori and S.K. Hahn, eds. ISTRC, Wageningen, the Netherlands, Pp. 2 – 9.

FIIRO (2006): Cassava: Production, Processing and Utilization in Nigeria. In Commemoration of the 50th Anniversary of Federal Institute of Industrial Research Oshodi, Pp.10, 83 – 85

Floros, J. D., Wetzstein, H. Y., Chinnan, M. S. (1987): "Chemical (NaOH) Peeling as viewed by Scanning Electron Microscopy: Pimiento Pepper as a Case Study." Journal of Food Science, 52 (5), 1312 -1316, 1320.

Khurmi, R. S. and Gupta, J. K. (2005): "A Textbook of Machine Design." Eurasia Publishing House (P) Ltd., 7361, Ram Nagar, New Delhi – 110 055, Pages 509 – 513, 677 – 711.

Odigboh, E. U. (1983): "Cassava Production, Processing and Utilization". In H. T. Chan (Ed); Handbook of Tropical Foods (Chapter 4, Pp. 145 – 200). New York: Marcel Dekker.

Olukunle, O. J., Ogunlowo, A. S.,Agbetoye, L. A. S., Adesina, A. (2005): "Development of Self – Fed Cassava Peeling Machine (Model A)." Journal of Agricultural Engineering, Federal University of Technology, Akure, Pp. 1 – 4.

Olukunle, O. J., Ademosun, O. C., Ogunlowo, A. S., Agbetoye, L. A. S. and Adesina, A. (2006): Development of Double Action Cassava Peeling Machine Proceedings of the

International Conference on Prosperity and Poverty in a Globalized World: Challenges for Agricultural Research". Deutscher Tropentag 2006, Bonn, Germany. http://www.tropentag.de/abstracts/full/312.pdf

Simplot (2006): "Educational Resources". Simplot Australia Pty. Ltd. www.simplot.com.au

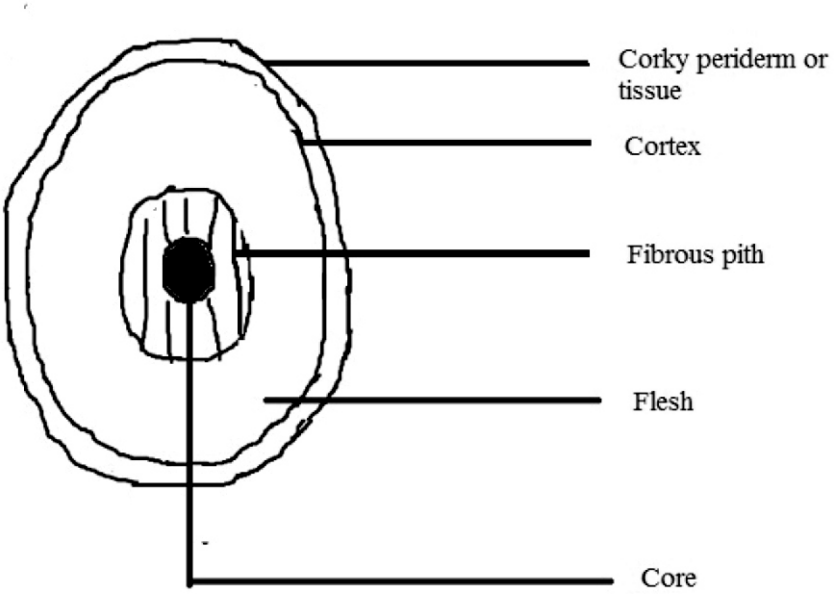


Fig. 1: A Transverse Section of the Cassava Root
Source: Adapted from Odigbo, 1983

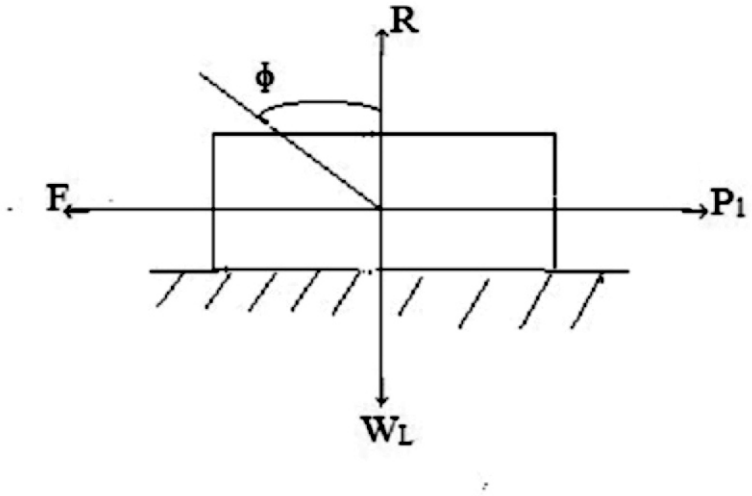


Fig 2: Forces Acting on a Load Resting On A Rough Horizontal Surface.

Table 1: Effects of 5% Concentration of Dilute Hydrochloric Acid on Peels at the Listed Temperatures and Times.

Time / Temp.	50^0C	55^0C	60^0C
4 mins	No visible effect	No visible effect	No visible effect
8 mins	No visible effect	No visible effect	No visible effect
12 mins	No visible effect	No visible effect	No visible effect
16 mins	No visible effect	No visible effect	No visible effect
20 mins	No visible effect	No visible effect	No visible effect

Table 2: Effects of 10% Concentration of Dilute Hydrochloric Acid on Peels at the Listed Temperatures and Times.

Time / Temp.	50^0C	55^0C	60^0C
4 mins	No visible effect	No visible effect	No visible effect
8 mins	No visible effect	No visible effect	No visible effect
12 mins	No visible effect	No visible effect	No visible effect
16 mins	No visible effect	No visible effect	No visible effect
20 mins	No visible effect	No visible effect	No visible effect

Table 3: Effects of 15% Concentration of Dilute Hydrochloric Acid on Peels at the Listed Temperatures and Times

Time / Temp.	50^0C	55^0C	60^0C
4 mins	No visible effect	No visible effect	No visible effect
8 mins	No visible effect	No visible effect	No visible effect
12 mins	No visible effect	No visible effect	No visible effect
16 mins	No visible effect	No visible effect	No visible effect
20 mins	No visible effect	No visible effect	No visible effect

Table 4: Effects of 20% Concentration of Dilute Hydrochloric Acid on Peels At the Listed Temperatures and Times

Time / Temp	50^0C	55^0C	60^0C
4 mins	No visible effect	No visible effect	No visible effect
8 mins	No visible effect	No visible effect	No visible effect
12 mins	No visible effect	No visible effect	No visible effect
16 mins	No visible effect	No visible effect	No visible effect
20 mins	No visible effect	No visible effect	No visible effect

Table 5: Effects of 5% Concentration of Lye on Peels At the Specified Temperatures and Times.

Time / Temperatures	50^0C	55^0C	60^0C
4 mins	The only visible reaction that occurred was that the corky periderm was bleached such that the solution changed from colourless to brown but the cortex remained intact.	The corky periderm became a bit soft though it was still firmly attached to the cortex which remained tough. Change in solution occurred from colourless to brown.	The corky periderm was a bit soft but remained firmly attached to the cortex which remained hard.
8 mins	Same as at 4 mins above.	Same as at 4 mins but the corky periderm became softer.	The corky periderm became softer and could be easily detached from the cortex, the cortex was still tough.
12 mins	The corky periderm became a bit soft but was still attached to the cortex. The cortex remained tough and the solution changed to brown.	The corky periderm was soft but was still attached to the cortex which remained tough.	The periderm was completely detached from the cortex, the cortex was still tough.
16 mins	Same as at 12 mins but the corky periderm became softer.	The corky periderm was easily detached from the cortex by hand. The cortex remained tough.	Same as at 12 mins above.
20 mins	The periderm was easily detached from the cortex. The cortex remained tough..	Same as at 16 mins above.	The periderm was detached from the cortex, the cortex became a bit soft.

Table 6: Effects of 10% Concentration Of Lye On Peels At The Specified Temperatures And Times.

Time / Temperature	50^0C	55^0C	60^0C
4 mins	The peel remained the same, change in colour of the solution also occurred from colourless to brown.	The peel remained the same as the corky periderm was still firmly attached to the cortex. The cortex was still tough.	The periderm became soft though it was still attached to the cortex. The cortex remained tough.
8 mins	The peel remained tough.	Same as at 4 mins above.	The corky periderm became softer but was still attached to the cortex, which remained tough.
12 mins	The corky periderm became a bit soft but was still attached to the cortex. The cortex remained tough.	The corky periderm became a bit soft but was still attached to the cortex which was still tough.	The corky periderm was soft enough to be easily detached from the cortex, though the cortex remained tough.
16 mins	Same as at 12 mins but the periderm became softer.	The corky periderm was easily detached from the cortex by hand, the cortex remained tough.	Same as at 12 mins but the cortex became a bit soft.
20 mins	The periderm was soft but was still attached to the cortex. The cortex was still tough.	The corky periderm was detached from the cortex, the cortex remained tough.	The periderm was easily detached from the cortex which got a little softer.

Table 7: Effects of 15% Concentration Of Lye On Peels At The Specified Temperatures And Times.

Time / Temperature	50^0C	55^0C	60^0C
4 mins	The corky periderm remained firmly attached to the cortex and the cortex remained tough	The peel remained tough	The corky periderm became soft and was easily detached from the cortex, the cortex remained tough.
8 mins	Same as at 4 mins above.	Same as at 4 mins above.	Same as at 4 mins above.
12 mins	The periderm became a bit soft but was still attached to the cortex which remained tough.	The periderm became a bit soft but was still attached to the cortex. The cortex remained tough.	The periderm was completely detached from the cortex, the cortex was still tough.
16 mins	The periderm was softer but was still attached to the cortex. The cortex still remained tough.	The periderm was completely detached from the cortex, the cortex was still tough.	Same as at 12 mins but the cortex got a bit softer.
20 mins	The corky periderm was easily detached from the cortex, the cortex remained tough.	The corky periderm was completely detached from the cortex, the cortex became a bit soft.	The periderm was completely detached from the cortex and the cortex got softer and at this time could be removed by using a brush.

Table 8: Effects of 20% Concentration Of Lye On Peels At The Specified Temperatures And Times.

Time / Temperature	50^0C	55^0C	60^0C
4 mins	The corky periderm was still firmly attached to the cortex, the cortex remained tough.	The periderm became soft but was still attached to the cortex which remained tough.	The corky periderm became soft and could be easily detached from the cortex, the cortex remained tough.
8 mins	Same as at 4 mins above	Same as at 4 mins but the periderm got softer.	Same as at 4 mins but the periderm got softer.
12 mins	The corky periderm was soft and could be easily detached from the cortex which remained tough.	Cortex remained tough, the periderm was easily removed from the cortex.	The cortex became a bit soft and the periderm was removed from the cortex.
16 mins	The corky periderm was completely detached from the cortex, though the cortex remained tough.	The cortex became a bit soft, the periderm was completely detached from the cortex.	The cortex got softer and the corky periderm was completely detached from the cortex.
20 mins	Same as at 16 mins	The cortex became a bit softer and the periderm was completely detached from it.	The peel was soft to the extent that it broke into pieces.

Table 9: The Optimum Concentration, Temperature And Time Obtained For Softening Of The Peels.

Concentration (%)	Temperature (^{0}C)	Time (mins)
15	60	20

Table 10: Effects Of Lye On Unpeeled Cassava Root.

Concentration (%)	Temperature (^{0}C)	Time (mins)	Effects
15	60	20	The corky periderm was completely removed. The cortex got soft and was easily removed using a brush.

4.3 Machine Design Data From Calculations

Data resulting from design calculations for the machine are presented in table 11

Table 11: Data Obtained From Design Analysis Of The Rotary Brushing Machine.

Parameters	Values	Units	Parameters	Values	Units
X	1.000	m	D_p	150.000	Mm
V_1	10.000	m / s	V_{br}	8.840	mm^3
μ	0.250	-	V	73,133.940	mm^3
V.R	3 : 1	-	N_b	8, 273.000	-
S	424.000	rpm	M	51.000	Kg
N_1	1273.000	rpm	μ_1	0.300	-
N_2	424.000	rpm	g	9.810	m / s^2
D_1	150	mm	R_1	225.000	Mm
D_2	450	mm	R_2	75.000	Mm
P	1500	W	F	150.000	N
T	33.780×10^3	N-mm	t_1	0.300	Secs
T	42.000	mPa	t_2	0.096	Secs
D	16.000	mm	t3	1.980	Secs
L	2.960	m	T	0.396	Secs
α	8.627	degrees	W_R	0.200	Kg
θ	2.840	rads	W	0.510	Kg
T_1	294.648	N	C	0.510	Kg / s
T_2	144.648	N	G.R	2.1	-
D_G	300.000	mm	L_C	3.000	M

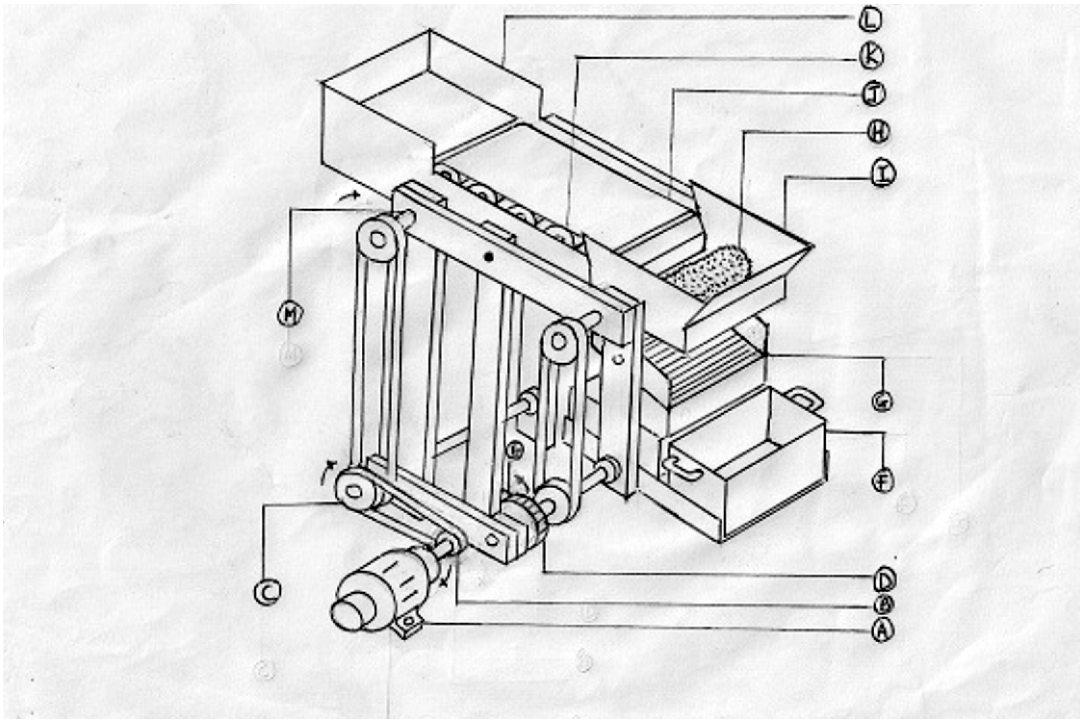


Fig 3: Perspective Drawing of Proposed Brushing Machine.

Table 12: Part List For The Rotary Brushing Machine

S/No	Part No.	No. Off	Part
13	M	9	solid shafts
12	L	1	Hopper
11	K	8	Rollers
10	J	1	Conveyor belt
9	I	1	Peeling chamber
8	H	1	rotary brush
7	G	1	slit tray
6	F	2	collection trays
5	E	1	smaller wheel (pinion)
4	D	1	larger wheel (gear)
3	C	5	driven pulleys
2	B	1	driver pulley
1	A	1	electric motor

EFFECT OF RELATIVE HUMIDITY ON FUNGAL LOADS OF POST- HARVEST TOMATO FRUITS IN BAUCHI METROPOLIS

Atanu, O.S., Ohanwe, C.N and Saleh J.Y
Agricultural and Bio-Environmental Engineering Department
Federal Polytechnic, Bauchi.
osatanu@yahoo.com
070396231534, 08138376588

ABSTRACT
The effect of relative humidity on fungal loads of post harvest tomato fruit (Lycopersicum esculentum) in Bauchi metropolis was investigated. The fungi were also cultured on 100, 91, 85, 75.5 and 63% relative humidity regimes. The development of fungal pathogens was observed to increase with increase in relative humidity and vice versa. Rhizopus SPP, Botrytis cinera, mucor SPP and Alternaria SPP were the major rot pathogens found in tomato fruits. The highest relative humidity of 100% was found to support the highest growth of these organisms. There was significant difference (P=0.05) in the fungal loads at the different relative humidity regimes. Potato Dextrose Agar (PDA) was the media used and was also found to support the growth of pathogenic organisms isolated from tomato fruits. Results of the regression analysis show a positive linearity between mean rot area and relative humidity.

Keywords: Relative Humidity, Fungal load, Post-Harvest and Tomato.

1.0 INTRODUCTION
Tomato (*Lycopersicum esculentum*) is an herbaceous, usually sprawling plant in the solanaceac or night shade family that is typically cultivated for the purpose of harvesting its fruits for human consumption. The tomato is now grown worldwide for its edible fruits, with thousands of cultivars having been selected with varying fruits types and for optimum growth in different growing conditions (Roberts, 1990). Most of the people in Nigeria use the fruit in their cooking. It is being cultivated mostly in the northern part of Nigeria particularly in Bauchi, Kano, Plateau provinces because of the favourable climatic conditions of these areas for the growth and production of the crop. Ohanwe (1996) reported that Nigeria produced 225,000 metric ton per year of tomato on 25,000ha of land between 1973 and 1977; and in 1986/87 the production level reached 6,000,000metric ton per year on 50,000ha of land. Fungi are filamentous microorganisms commonly known as molds. In nature, they often appear thread-like, cottony, or as yeast-like scum. Many fungal species can cause fruit decay in tomatoes and, like bacteria, usually flourish under warm moist conditions. Fungi are generally more difficult to eradicate than bacteria in part because fungal cells are much larger and produce spores that are highly resistant to drying and other environmental stresses (Kader, 1992). Spores are single- to few-celled reproductive structures that may be dispersed by water or wind as well as animals and equipment (USDHHS, 1998).

Fruit and vegetables must be transferred from the field to the table, to arrive in a state that is acceptable to the consumer. Although traditional farm- and orchard-gate sales still can provide a useful income, the increasingly lucrative demand for year-round supplies from urban dwellers and international markets requires that there has to be an increasing level of handling, transportation, and storage of products. Unlike cereals, fruit

Bauchi town. Muda-Lawal market was chosen because it serves as the distribution point for other markets in Bauchi metropolis. A total of 40 samples were collected for examination. The diseased tomato fruits were collected in a sterile polythene bags to prevent any contamination during transportation was immediately transported to the Food Science and Technology laboratory of the Federal polytechnic, Bauchi for microbial analysis.

2.1.1 Isolation of fungi from diseased tomatoes

The sample was homogenised in water, phosphate buffer or 1g per litre of peptone water and substances were diluted serially. In pour plating method 1ml of the diluted sample was added to sterile dish. The dishes were immediately swirled to ensure adequate mixing. Purified cultures were maintained on agar slants; also a portion of diseased tomato fruits can be pressed directly on agar medium as reported by Onions et al. (1981). The seeded plates were incubated for 5 days at room temperature and the growth of different organisms was conducted by using lactophenol as reagent on clean slide with the aid of a microscope and a chart showing the characteristics of many fungal pathogens on different types of solid media.

2.1.2 Plate count

Potato Dextrose Agar (PDA) acidified to a pH of 3.5 by the addition of tartaric acid (about 3 to 4ml of acid per 100 ml of agar) was used. The sterile acid solution was added to the flask after the agar has been sterile and just prior to being poured in to plates was incubated in an inverted position at room temperature and the resulting colonies were counted and reported as yeast or mould per gram of PDA. If only a yeast count was desired 0.25% of sodium propionate was added to the inhibitory to mould growth. This experiment was conducted as reported by Keeth (1990).

2.1.3 Isolation of micro-organisms

When preparing culture media, 10ml were reserved for antibiotics to prevent bacteria growth. Isolation of the fungi involves seeding of a portion of the area showing advanced rot on PDA plates. Control was done by seeding a healthy portion of similar dimension on PDA plate. The culture were incubated at room temperature for one week and observed for growth. Subsequent sub-cultures were done to obtain pure isolate which serve as sources of culture (back up) when the culture deteriorate or was lost.

2.2 Relative humidity and rot development:

The effects of various regimes of 100% 91%, 75% and 63% relative humidity on the growth and development of rot on tomato was investigated in accordance with the methods of Kim and Xiao (2005). Agar discs (4mm in diameter) of 7 days old culture of the diseased tomato were placed at the centre of sterile Petri dishes containing Czapek-Dox agar medium. The inoculated plates were placed in the upper chambers of the desiccators, to prepare the required relative humidity regimes. Then 250ml each of distilled water, potassium nitrate, sucrose, sodium nitrate and magnesium chloride were placed in the lower chambers of the desiccators and allowed to stand for 4hours to attain the relative humidity regimes of 100% 91%, 75% and 63% respectively (Winston and Bates, 1960).

3.0 RESULTS AND DISCUSSIONS

Diseased tomato fruits collected from the market showed different types of rots and mostly the rot tend to be soft and messy and also some leakage of the content may occur. In some instances, the mycelium of the infecting moulds may have penetrated the

and vegetables are essentially highly perishable commodities. Most fruit and vegetable crops begin to deteriorate as soon as they are harvested, and most are particularly prone to handling damage at all times (Chinoko and Naqvi, 1989). In general, the level of susceptibility of these products to handling damage is greatly underestimated, usually because the effects of mishandling do not appear until sometime after the damage occurred. Any physical damage to produce provides an ideal entry point for such pathogens. A wide range of fungi and bacteria contribute to postharvest losses in fruit and vegetables throughout the world, especially in situations in which cool-chain management is inadequate. These postharvest pathogens may infect produce at various pre-harvest stages through plant or fruit development, at harvest, or after harvest while products are in store or in transit to market.

Estimates of postharvest losses are difficult to make. Generally accepted values are 25% to 50% of production in less-developed countries and around 10% to 25% elsewhere (Kader, 1992; Mogaji and Fapetu, 2011). Poor handling and storage can easily result in a total crop loss anywhere. However, not all losses are due to poor handling, but handling damage is known to accelerate other types of deterioration, particularly the development of molds and rots (USDHHS, 1998).

Ihekoronye and Ngoddy (1985) studied the proximate composition of fresh tomato and the result is as presented in Table1. The data in table 1 underscores the importance of tomato in our daily diet. Tomato fruits suffer a lot of storage problems and storage losses. High temperature and humidity contributes to the difficulty of ambient storage (Mogaji and Fapetu 2011; Roberts, 1990). Several studies were conducted on the effect of environmental factors on the growth of the pathogen (Malik and Singh 2004; Kim and Xiao, 2005; Ibrahim et al., 2011; Mogaji and Fapetu 2011). Environmental factors such as relative humidity and temperature were reported to have a profound influence on the infectiveness of a variety of fungi. Growth rate of fungi vary depending on temperature and relative humidity values. Ibrahim et al (2011) reported that a temperature of 30^{o}C and 92.5% to 100% relative humidity were most suitable for the growth of *H. fulvum*. Similarly, Sharma and Sharma (2009) reported that temperature of of 28^{o}C to 30^{o}C and relative humidity of 95% supported maximum growth of *Trichophyton mentogrophytes*. It is worthy of mention that the environmental temperature prevalent within Bauchi metropolis during the period of investigation ranged between 28 – 32^{o}C.

The harvesting method, the packaging and also transportation as well as handling are the major factors that lead to the loss of tomato fruits. Most of these fruits get wounded on the farm during harvesting, thus giving access for pathogenic organism to penetrate and initiate the loss of tomato fruits. Very high percentage of tomato fruits suffer from fungal loads thereby affecting the quality of tomato fruits and subsequently its market value. These affect both farmers and traders income as well as consumers health (Olurunda, 1983). To this end, the effect of relative humidity on fungal loads of post harvest tomato fruit was investigated This may contribute in reducing heavy produce and financial losses incured annually by peasant farmers as a result of the devastating effect of fungal pathogens on postharvest tomato.

2.0 MATERIALS AND METHOD

2.1 Procurement of Diseased Tomato Fruits

The diseased tomato fruits samples were purchased from Muda-Lawal market in

interior but only the epidemic has been damaged. In some cases, the mycelium was observed to cover the outside and may be brightly coloured. The soft rot was mostly encountered and was found to be watery and emit some foul odours. Most of the pathogens gains entry where bruises and wounds developed probably due to transportation or method of harvesting or handling; some of the pathogens could have gained access as a result of pest sucking the fruit on the farmland before harvesting. Diseased tomatoes showed a variety of fungal pathogens. This may be due to chemical composition of these commodities providing a better growth medium for various fungal pathogens as shown in the Table 2. Tables 3,4 and 5 show the rate of growth of Rhizopus SPP Aspergilluis SPP and Penicilium SPP on solid media respectively.

3.1 Effects of Relative Humidity on Rot Development

Four different levels of relative humidity of 63%, 75.5%, 91% and 100% respectively were used. For the three pathogens, the mean rot area is proportional to the relative humidity used.

This simply indicates that moisture is an important factor that determines the growth of these pathogens. This is the reason why most fresh fruits with high moisture content are highly susceptible to fungal loads, attack and deterioration.

4.0 CONCLUSION

During the studies, the highest rot was observed at relative humidity of 100% for the fungal pathogens and with the least at 63% during seven days of incubation at room temperature. The fungal pathogens are those that survive most in wet conditions. This confirms the study by Ibrahim et al (2011). At the onset of wet season incidence of rot caused by fungal pathogens is usually high resulting in high losses in stored tomatoes in Bauchi metropolis and the attendant high cost of tomatoes during this period. Roberts (1990) reported that biological activity occurs only in the presence of moisture. It is evident from the study that relative humidity of the environment where the fruits are kept is very important in the post harvest rot of tomato fruits. The result obtained from this study showed that Aspergillus SPP, Mucor SPP, Rhizopus SPP etc were responsible for losses of tomato fruits at Muda – Lawal Market in Bauchi Metropolis. This agrees with that reported by Somme et al (1991).

The authors therefore recommend that further work be carried out on the control of these pathogens so as to prevent losses during handling and storage of the fruits. Rotting in storage can be prevented by avoiding surface damage through proper handling of the fruit during harvesting and transportation prior to storage. Therefore, there is need for the research to be undertaken so as to determine appropriate temperatures for storage of tomato fruits to reduce the post harvest losses resulting from fungal pathogens. It is recommended that tomato fruits be stored at low relative humidity and temperature to avoid attack by fungal pathogens as this will contribute significantly in controlling the huge losses due to fungal infestations and thus reduce cost of tomatoes. The rate of growth of pathogens on solid media indicates that Aspergillus and Rhizopus SPP were found to utilize the media in the petri dishes. Rhizopus, however was found to be fastest growing organism.

REFERENCES

Chinoko, V. D and Naqvi, S. H. Z (1989): Studies on fungi associated with postharvest rots of tomato (*Lycopersicum esculentum) in* Southern Nigeria. *Niger. J. Bot.* 2: 124-128

Ibrahim, M., A.B. Rabbah, B. Liman and N. T Ibrahim(2011). Effect of temperature and relative humidity on the growth of *Helminthosporium fulvum*. *Nigerian Journal of Basic and Applied Science* 19(11): 127 – 129.

Ihekoronye, P.E and P.O. Ngoddy (1985). Intergrated Food Science and Technology for the Tropics. Macmillan publishers, Ibadan. Nigeria. Pp. 306 – 309.

Kader, A.S (1992). Postharvest Technology of Horticultural Crops. (2nd ed), Publication No. 3311, University of Califonia, Berkeley, CA., U.S.A, Pp. 228 – 345.

Keeth, A.S (1990) Isolation of filamentous Fungi: "Isolation of biotechnological organisms from nature" Mc Graw Hill Inc. USA. Vol. (2) 65 – 67

Kim, V. K. and C.L. Xiao (2005). Influence of culture media and environmental factors on mycelial growth and production of *Sphaeropsis pyriputrescens. Mycologia,* 97(1): 25-32.

Malik, V. K. and Singh, S. (2004). Effect of temperature and relative humidity on teliospore germination in *Ustilago hordei. J. Mycol. Plant Pathol.*, 34: 410-411.

Mogaji, T .S and Fapetu, O. S (2011) Development of an Evaporative Cooling system for the Preservation of fresh vegetables. *African Journal of Food science.* Vol. 5(4): Pp. 255 – 266.

Ohanwe C.N. (1996) Review of Handling and Storage Techniques for fresh fruits and Vegetables in Nigeria from Farm-gate to consumers – A case study of tomato fruits. Proceedings at the Maiden National Engineering Conference. School of Engineering Technology, Federal Polytechnic, Bauchi. Pp. 213-221.

Onions, A.H.S., D. Allsopp and Smith, H.O. (1981). Introduction to Industrial Mycology, Edward Arnold, London. Pp 398

Olurunda (1983). Effect of post Harvest handling on quality attributes of tomato in the Nigerian market system. Food Chemistry Journal 10: 225 – 230

Roberts, F. S (1990). Factors influencing infection of Tomato. Appl. Biol. 30: 327 – 331

Sharma, M., and Sharma, M. (2009). Influence of environmental factors on the growth and sporulation of Geophilic Keratinophiles from soil samples of public parks. Asian J. Experimen. Sci. 23(1): 307-312.

Somme, N. F., J. Fortlag, and D. C. Edwards. 1991. Postharvest diseases of selected commodities. In *Postharvest Technology of Horticultural Crops*, ed. A. A. Kader, University of California Publication 3311, Pp. 117–160.

USDHHS (1998) U.S. Dept. of Health and Human Services. Center for Food Safety and Applied Nutrition. 1998. *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables.* Washington DC. Available at http://www.in.gov/isdh/files/GuideToMinimize.pdf.

Winston, P. W. and Bates, D. H. (1960). Saturated solutions for the control of humidity in biological research. Ecol. 41: 332-337

SURVEY OF RICE PARBOILING PRACTICES IN KURA AREA KANO STATE, OF NIGERIA

N. A. Sale[1], N. D. Dangora[2], M. K. Othman[3] and A. O Lawal[4]
[1, 3,] & [4]- National Agricultural Extension and Research Liaison Services
Ahmadu Bello University, Samaru- Zaria
[1-] E-mail nuraalhajisale@yahoo.com
[2]- Department of Agricultural Engineering Bayero universities, Kano
E-mail naladodd06@yahoo.com

ABSTRACT
This study was conducted at Kura Area of Kano, Kura rice cluster to survey rice parboiling practices. Structural questionnaire was used to collect the data from the respondents (parboilers) within the area. The data covered salient parboiling aspect such as the materials and methods employed in the area.

Most respondents (67%) use traditional aluminum pots as parboiling equipment, while others (33%) use TADCO HANIGHA and NCRI parboilers, which are improved parboilers. The capacity of parboiling equipment in the area ranges from 1.5-7 bags per cycle. Several rice varieties are been processed in the area. The most often processed are SIPI and Wita varieties.

The parboilers in the area practice hot soaking technique. The average hot soaking temperature and the total soaking duration maintained by the parboilers are 57.11°C and 14.65 hours respectively. The average steaming duration is 48 minutes. With the prevalent practices of soaking, steaming and drying, the average percentage of breakage of the rice during milling was determined to be 17.82% at average moisture content of 15.36%(wet basis) for the paddy. The average percentage of impurities recorded for the milled rice was 1.49%.The major constraint associated with the traditional parboilers is the rapid deterioration of the aluminium pot. The improved parboilers have higher fuel energy demand. The high percentage of breakage after milling contributed much to the low quality of milled rice.

Keywords: Survey, Parboiling, Rice, Kura, Kano, Nigeria

1.0 INTRODUCTION

Rice (*Oryza sativa*) is a major commodity traded in the international commodity market. Parboiled rice is one of the most popular product in the world and become more important not only by the fact of improved it`s nutritional value but also by the important cooking and processing properties which are desired from industrial stand point (Faruq et.,2007).

Also rice is one of the most important stable food crops in Nigeria which is consumed in both urban and rural areas. It is the most widely consumed cereal after maize and sorghum in many part of Nigeria. (Onwueme and sinha, 1991, as quoted by Adeyemi, 2004).Rice grain is used as food and it could be prepared in various forms.

Rice production in Nigeria is done mainly by the peasant farmers in virtually all the agro-ecological zones under various conditions such as upland, lowland, Fadama, deep water and mangrove rice (Nnanna, 2003). This implies that rice is highly adaptable to the various water regimes in deferent part of the country.

As a result of change in diet of the average Nigerian family in favor of rice, its demand is measuring substantially. The traditional cereal research institute (NCRI) in 1992 estimated the deficit in Nigeria`s rice annual needs to be about 1.5 million metric

million metric tons (MT) per year while domestic supply has about 2.3 million MT. This led to the importation of about 687,925MT in 1998 from 300,000 MT in 1995. These import constitute a substantial out flow of funds from the Nigerian economy, amounting to a whopping US $125 million in 2001 (Nnanna, 2003; USAID, 2005). The increase, rise in rice import bills to meet up local demand, food security, socio-economic and political implication in Nigeria. This is therefore called for some intervention. Several efforts have been made and are still being made by the government to bridge the domestic supply demand gap. Some of these efforts include, provision of subsidized rice production inputs, establishment of Agricultural Development Project (ADPs), several River Basin Development Authorities (RBDAs),mandate crops include rice and active participation in the activities of West African Rice Development Association (WARDA) by Nigeria (Aminu,1999).

Also several studies (Barau, 1979, Rahman et al., 1998, Aminu 1999, Egwuds, 2000 and Aboki, 2003) have shown that rice production and processing are profitable ventures in Nigeria and what is required now is seek to encourage investment in rice processing activity. Well processed local rice would satisfy consumers demand and in turn stimulate paddy rice production. The survey carried out by USAID/WARDA revealed that rice consumers in Nigeria are ready to pay for quality (Lancon et al., 2003). WARDA (2004) said that why Nigeria should need to import such vast quantities of rice? Considering it`s potentials of agriculture with about 60 million of rural farmers and 3.0million out of it are engage in cultivation of rice (RIFAN). Also it`s reported that over fifty (50) rice varieties would fit well in the different agro-ecological zone across the nation.

The result of these efforts, has observed by Nnanna (2003) is that over the years, rice production in Nigeria has been on a steady increase, growing at 9.3% per annum, particularly due to vast increase in rice area 7/9% per annum and a lesser extent through increase in rice yield (1.45 % per annum). Despite the effort to increase production, effort has been much encouraged to improve local rice processing so that it could develop to an industry capable of acceptable quality.

Parboiling work is carried out by the low income group i.e. women. As a result, the practice needs to be studied towards upgrading them even though studies on financial analysis of parboiling and milling technology in some areas in kano State, kura inclusive, have been conducted (PropCom,2007).There are still some constraints in the prevalent practices of parboiling . There is need to find ways of improving their technical efficiency of the practice after such interventions. Therefore it`s against the background of this study to provide the information on how the rice parboiling takes place in the area.

2.0 MATERIALS AND METHODS

2.1 Sampling Size and Procedure

Respondent (rice parboilers) were selected randomly because of the homogeneity of the parboiling tools and parboilers in the selected site of the study area. Twenty (20) questionnaires were administered in each selected site; Kura, Karfi and chiromawa. In addition, out of the twenty selected stations, three women were selected for detailed measurement of their parboiling equipment parameters.

2.2 Data Collection

The research collected both primary and secondary data. The primary data was collected using structural questionnaire and verbal discussion, the questionnaire cover issues pertaining description of method used, list of tools used, duration of parboiling one bag, price/bags, problems faced in the practices. Ten processors were interview and

wood.

TADCO Parboiler is an improved parboiler which is made from a typical cylindrical drum (made of metal sheet with a thickness of 15mm). The cylindrical drum is divided in to two parts. The smaller portion (down), commonly referred to as false bottom, is the portion which contains the water to be heated during steaming. The upper (larger) portion is the place where the paddy to be parboiled is put. What separates these portions is a perforated circular metal plate, which is covered with a screen to avoid the paddy dropping into the water. Three hollow pipes are erected from the base of the metal plate. They are provided with holes to allow passage and subsequent circulation of steam to the paddy being parboiled.

Two taps are provided on the drum: the upper tap is located at the base of the upper portion, while the lower tap is located at the bottom of the lower (down) portion. The taps are used to drain the water after soaking and steaming respectively. There is a sheet metal grid to be used to provide space for heating during parboiling. This grid is strong enough to support the weight of the drum and its contents during parboiling. The parboiler uses sorghum straw, firewood or charcoal as its energy source. The TADCO drum parboiler can accommodate 1.5-2.0 bags per cycle with a volume of 1.027m^3.

Hanigha Parboiler is also an improved parboiler which exists in different capacities (1.47m^3, 3.22m^3, etc.) with a thickness of 9mm. This parboiler is large but similar to the Tadco parboiler in terms of shape, plate and method of humidification. The main differences are in the numbers of humidifiers. Thickness is less than that of the tadco parboiler.Other additional features and equipments are: A tilting device (lever) on its two sides, thermometer and pressure gauge for measuring the temperature and pressure for different variety of paddy. The parboilers are not very common in the area and its used charcoal and firewood as energy source.

NCRI parboiler is an improved parboiler developed by National Cereal Research Institute (NCRI).This parboiler is a cylindrical tank and made with steel materials. The tank has two control valves located at the upper and lower portions. The control valves are used to allow the passage of hot water and steam through the pipe into the other tank which contains the paddy. The NCRI parboiler has a volume up to 1.36m^3 and 9mm thickness. It also uses charcoal as its energy source with a centrifugal fan. The fan supplies air to raise the flame intensity. The centrifugal fan is driven by an electric current. This parboiler needs highly skilled of operation, compared to the others.

3.2 Methods

The various methods identified for parboiling in the study area can be categorized into purely traditional and improved. The most adaptable method for parboiling is traditional method and this agrees with the survey report by PrOpcOm (2006), which said that majority of the processors in kura-Kano rice cluster (which includes kura area) use the traditional method.

Steps Involved in the Traditional and improved parboiling Methods are shown in table 1

In the traditional method shown in the table above, the first traditional method mostly uses the aluminium pot parboiler while the second method mostly uses the Galvernized iron pot parboiler. The main difference between the two methods is the washing of paddy before soaking to reduce the impurities (immature seed, chaff and sand). The improved method comprises the use of TADCO, HANIGHA and NCRI. These methods have almost the same step but the main difference is in the equipment used.

In the NCRI parboiler, the water is boiled in a separate tank and then later transferred to the other tank in which the paddy is placed, while in the Tadco and Hanigha parboilers, the water and paddy are boiled together in the same equipment.

2.3 Instrumentation

The moisture content of paddy was determined using grain moisture meter model GT88 digital type. Moisture content of paddy before soaking and after drying before milling was recorded. The temperature of soaking and steaming were obtained using mercury in glass thermometer (110°C T44, model).Venire caliper was employed for taking the thickness of the materials. 15 meters measuring tape was also used for taking the dimension of the materials. While the duration of soaking and steaming were obtained by using a stopwatch digital type (JVEREC digital timer).15 litters plastic bucket was used for measuring the initial water used and amount of water that was drained after soaking before steaming. Electrical weighing balance (Adam, PW 254, max 250g d=0001) was employed to measure the weight of 100g sample for the determination of percent breakages and impurities.

2.4 Determination of Breakages/Impurities

The parboiled rice was milled and the percentage of breakages/impurities in the milled rice sample was determined according to Gupta (1981).100g sample of milled rice was taken; the broken rice was isolated manually and then measured. The percentage breakages were then calculated... Similarly impurities percentage was also determine from each sample as described. This enabled the basic assessment of the effect of different techniques used in parboiling on the quality of the milled rice.

$$\text{Percentage of breakages were determine as gupta (1981)} = \frac{Qb \times 100}{Qt} \quad 1$$

Where:

Qb = quantity of broken grains in sample (kg)
Qt = Total quantity of grain in sample (kg)

$$\text{Percentage of impurities similarly as determine by gupter (1981)} = \frac{Qb \times 100}{Qt} \quad 2$$

Where:

Qb = quantity of impurities obtained in sample (kg)
Qt = Total quantity of grain in sample (kg)

3.0 RESULT AND DISCUSSION

3.1 Materials and Method Used For Rice Parboiling

The materials used for rice parboiling in the area include: Aluminium pot parboiler, Galvanized iron parboiler, Tadco parboiler, Hanigha parboiler and NCRI parboiler. The most commonly used parboiler in the area is the aluminium pot parboiler, followed by Galvanized iron pot parboiler. Tadco, Hanigha and NCIR are improved parboilers which need skill for operation.

The aluminium pot parboiler it's made of aluminium and exist in various capacities range from a minimum of $0.94m^3$ to a maximum of $1.50m^3$. The average thickness of each is 8mm. The volumes used to parboil 1.5-3 bags per cycle.

One of the factors that make this parboiler popular in the area is its good heat conductivity which minimizes the energy source used. The energy source used by majority of the user of this parboiler is paddy bran, sorghum straw, maize and millet straw.

The Galvanized iron pot parboiler is made with galvanized iron and has a thickness higher than that of the aluminium pot (10mm). It has larger capacity up to $3.9m^3$.This capacity could handle up to six (6) bags per cycle. The energy source here is mostly fire

3.2 Varieties of Rice Being Processed in the Area

The major rice variety being processed in the area are shown in table 2
The most common rice variety being processed in the area is SIPI followed by Wita and Yar das. While Jamila is mostly being processed in Karfi

3.3 Percentage of Breakages

Broken rice is the one which its kernel is less than 6/8 of its active size (Sahay and Singh,2001) the Table 3 below shows the percentage of breakage at milling and moisture content for SIPI variety (after drying before milling)

We can understand from the result that rice of the same variety may have different percentages of breakage due to different moisture content and methods of drying. This agrees with the statement made by Faruq et al (2007). From the data, the highest percentage of breakage was 29.88%. This rather high value would drastically lower the quality of Kura rice. Even the lower value as obtained in Karfi (9.08, 10.36), are on the high side as far as quality is concerned. Hence high percentage of rice at milling is one of the major qualities problems of milled rice in the Kura-Kano rice cluster. The paddy should be dried to 12-14% moisture content wet basis for safe milling (Faruq et al., 2007). Rapid drying influences the development of internal stress in the grain and causes breakage during milling. After drying is complete, paddy should be allowed to stand for at least several hours, preferably for one or two days be it is milled to permit internal moisture differences and stress to equalize (Faruq et al., 2007). Therefore, these high breakages may be due to drying below or above the required range. The paddy, after drying is not allowed to stand for several hours in order to permit internal stresses to equalize because the processors in the area are anxious to mill their rice and get return as quick as possible. Again, rapid drying occurs in most parts of the studied due to the fact that they practice direct sun drying without shade. All these contribute to this high percentage of breakage.

3.4 Constraints of the Existing Material and Processing Techniques

There are many constraints/problems identified in the processes and materials. These are discussed below:

- Aluminium pot parboiler: This parboiler uses high amount of water during steaming. This causes the paddy to be partially cooked. As a result, the rice becomes dark after milling. This affects the quality of rice and became undesirable to the consumer. According to the processors, if small amount of water is used for steaming, the heat affects the pot, making the holes at the bottom thereby decreasing its life span.
- Tadco parboiler: The problem of this parboiler is the deterioration of membrane (cotton seal) that is used to seal the paddy going down and getting mixed with the water to be used steaming. This affect the quality of rice because as it escapes to the boiling water. It gets cooked. Also, the steam passage is sometimes blocked thereby affecting the process.
- Hanigha and NCRI: The problems of these parboilers are use of high energy such as charcoal or wood. Also the have high cost of purchase and need operational skill for which the majorities of the users do not have.
- Drying: The drying in the area is mostly done using open sun drying. The steamed paddy is spread on the floor, tarpaulin sack or mat, and exposed to direct solar radiation, wind and dust without shade. This influences the rapid drying of the paddy and causes internal stress in the paddy gain, thereby influencing the breakage of the rice after milling, according to Faruq et al (2007). Also, in the absence of shade, the rain makes it difficult to carry out the drying processes during the rainy season.

4.0 CONCLUSION

Rice parboiling in the study area is an established business that is gradually expanding because of rice production activities within the Kura-Kano rice cluster. But there are lapses in the parboiling method and equipment. If these areas are properly improved and utilized, it would enhance better competition between local and imported rice. This will give local rice better price that is reflective of those additional services and it means higher returns to the processor. Deliberate effort is needed to transform the system from its present state into a quality driven one. Such effort, if initiated and sustained, is bound to succeed and bring about positive growth in the activity because of the years of experience the processors have accumulate

The government should support the business by providing them the improved milling machine such as Thailand milling machine which is already exist in some places around the research area. Also the process should under some training on effective way of uses and maintenance of the modern machine for better out come. The indigenous engineers should put their effort on research to develop the better milling machine that suits our local system.

REFERENCE

Aboki.P.M. (2003). "Economic Analysis of Small Scale Rice Processing Industry in Lafia Local Government Area of Nasarawa State, Nigeria". An unpublished MSc. Thesis. Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

Adeyemi. K.A. (2004) "Optional farm plan and resources Productivity: An analysis of Rice Production in Niger State" A Research proposal presented in the Department of Agricultural Economic and Rural Sociology, Ahmadu Bello University Zaria.

Aminu. A. (1999). "Economic Analysis of upland Rice production in Jigawa State". An unpublished MSc. Thesis, Department of Agricultural Economic and Rural Sociology, Ahmadu Bello University Zaria.

Barau. A. D. (1979). "The Economics of Rice Processing: A case study of the small–scale processing industry in the wukari Local Government Area of Gongola State of Nigeria". An unpublished MSc. Thesis, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

Egwuds.J.(2000) "An Economic Analysis of law land Rice Production in Ibaji Local Government Area of Kogi State". An unpublished MSc. Thesis Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

Faruq .M., Shazal M., Basra, B. and A. Abdul Wahid (2007). Rice Parboiling Improves.
Gupta, (1981). Review of Storage and Processing of Rice in Asia; mimeographed Paper No.72-01, IRR, Los Bonos Philippines.

Loncon. G. O James, O.O and Patrice O. E (2003). Nigeria Rice Economy in a Competitive World: Constraints, Opportunities and Strategies Choices. Rice Processing in Nigeria: A survey Sponsored by NISER, WARDA and USAID

Nnanna.O.J (2003). "Overview of Rice Production in Nigeria" A Paper Presented at the Central Bank of Nigeria Seminar on Sustainable Rice Development in Nigeria Held at Hamdala Hotel Kaduna from 14-15 January

PropCom (2006). Making Agricultural Markets Work for poor. Quality. Down-Business www.dawn.com

United State Agency for International Development (USAID) (2005). "Rice Fact Sheet" : A publication of the Project: "Maximizing Agricultural Revenue and Key Enterprise in Targeted Site (MARKET) in Nigeria". Vikas publishing House PVT Ltd. New Delhi
West Africa Rice Development Association (WARDA), (2003). Comprehensive Rice Study. Pp 510

APPENDIX
List Of Table

Table 1 Method Of Parboiling

TRADITIONAL METHODS		IMPROVED METHOD
1	2	
1. Paddy is immersed in a pot with 70-90 litres of water.	1. Paddy is thoroughly washed with water before soaking.	1. Paddy is thoroughly washed with water before soaking.
2. Immersed paddy is heated at 50^{o}C for 15-16 hrs	2. The washed paddy is immersed in a pot with 72 litres of water.	2. The washed paddy is immersed in parboiling equipment with 70-75 litres of water.
3. 20-30 litres of water are withdrawn using a container.	3. Immersed paddy is heated at 50-55^{o}C for 19-20 hrs.	3. The immersed paddy is heated at 80-85^{o}C (day soaking) or 60-70^{o}C for overnight soaking with duration of 6-8 hrs or 5-6 hrs respectively.
4. Paddy+ remaining water are subjected to heat (90-100^{o}C) for 50-75minutes.Heat is then withdrawn after observing high volume of steam coming out of the pot.	4. 42 litres of water is withdrawn by taking it away using a container. Alternatively, the water is completely drained out and new, clean water is added, 30 litres for 2.5 bags	4. 50-52 litres of water are drained out by using tap or control valve attached to the equipment.
5. The paddy is removed and conveyed to the drying area (open sun drying).	5. Paddy + remaining water are subjected to heat (90-103^{o}C) for 20-60 minutes. 6. The paddy is removed and conveyed to the drying area (open sun).	5. Paddy + remaining water are subjected to heat 6. (110^{o}C) for 45-60 minutes. 7. The paddy is removed and conveyed to the drying area which is mostly under the shade.(shade drying)

Table 2: Rice Varieties Processed At Kura Area

Varieties of Rice	Site and Frequency Kura Frequency	Karfi Frequency	Chiromawa Frequency	Row Total	Total Responses	Percentage (%)
SIPI	20	14	16	50	60	83.33
Wita	16	8	6	30	60	50.00
Yar das	4	8	4	16	60	26.67
Yar saina	2	4	2	8	60	13.33
Yar banki	2	0	0	2	60	3.33
Yar tinni	2	0	0	2	60	3.33
Yar gaidan	2	0	0	2	60	3.33
Yar kamaru	2	0	2	4	60	6.67
Jamila	0	4	0	4	60	13.33

Table 3: Percentage of Breakages

Site	Location	Moisture content (after Drying, Before Milling) (% Wet basis)	Breakages at Milling (%)
KURA	RA1	20.30	29.88
	RA2	20.00	24.52
	RA3	15.64	17.72
KARFI	KF1	19.83	24.85
	KF2	10.20	9.08
	KF3	13.20	10.36
CHIROMAWA	CH1	10.52	13.44
	CH2	13.24	14.53
	CH3	18.22	16.00

List Of Plate



Plate 1: Aluminium Pot Parboiler



Plate 2: Galvanized Iron Pot Parboiler



Plate 3: Tadco Parboiler

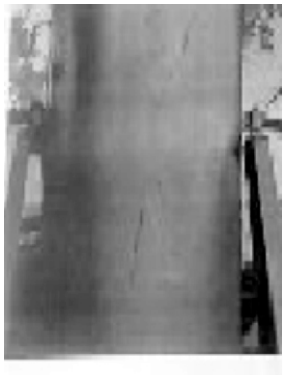


Plate 4:Hanigha Parboiler

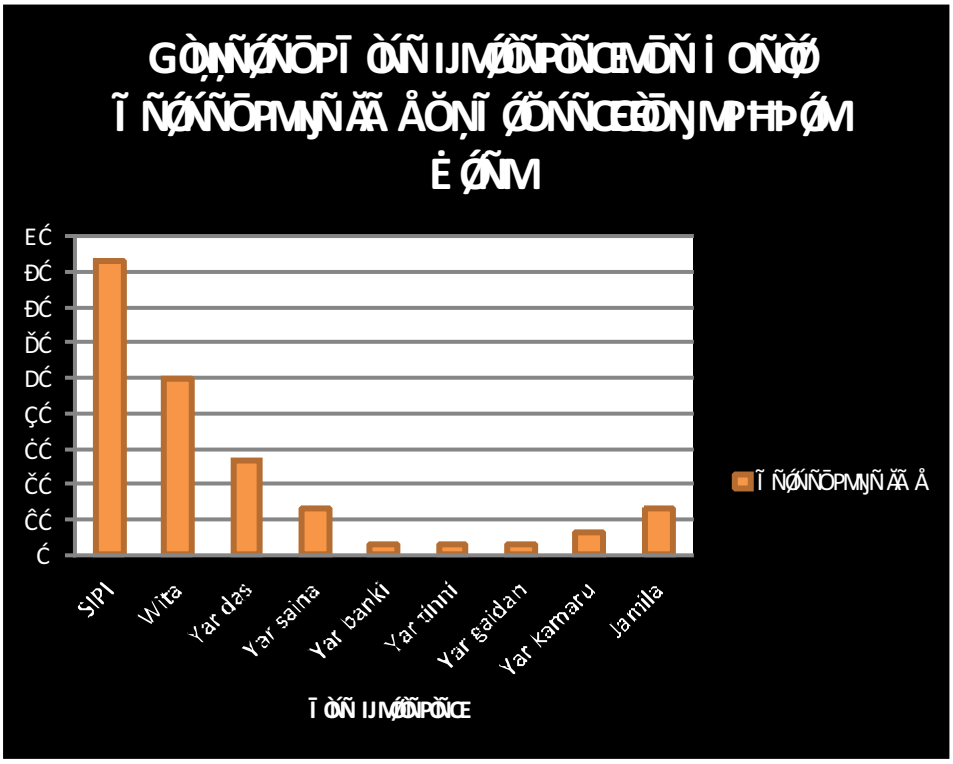


Figure 1: Rice Varieties Processed At Kura Area,

DEVELOPMENT AND PERFORMANCE EVALUATION OF A MOTORIZED GARI SIFTER

Ologunagba, F. O., *Ale, M. O. and Lawson, O. S
Department of Agricultural and Bio-Environmental Engineering Technology
Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.
*Corresponding author: *alebosunenator@gmail.com, francolog2@yahoo.com

ABSTRACT
A motorised gari sifter was designed, constructed and evaluated. The test results showed that the machine operating speed and the cassava mash moisture content have significant effects on the sifting efficiency. Polynomial relationship was observed between the sifting efficiency and operating speed while the sifting efficiency decreased with increase in moisture content. The machine had highest sifting efficiency of 89% and output capacity of 163.69kg/hr at 500rpm operating speed with cassava mash of 35% moisture content. All materials used for fabrication were sourced locally and the cost of producing a unit of the gari sifter as at the time of fabrication was estimated to be thirty thousand naira (?30,000) excluding the cost of the 1.12KW electric motor. The use of the machine is feasible and therefore recommended for both small and medium scale gari processors.

Keywords: Cassava, Development, Evaluation, Garri, Sifter

1.0 INTRODUCTION

Cassava is primarily a source of carbohydrate and contains very little protein and fat. The approximate composition of the cassava tuber is starch, 20-30% ; water, 75-80%; fat, 0.1%; fibre, 1.0%; and ash, 1.5%(Iherekonye and Ngoddy,1985). Cassava is a woody shrub of the Euphorbaceae (spurge family) native to South America, which is extensively cultivated as an annual crop in the tropical and subtropical regions for its edible, starchy and tuberous root. Cassava is the most perishable of roots and tubers and can deteriorate within two or three days after harvesting.(FAO, 1990). The potential disadvantages of cassava roots are their bulk and rapid perishability, low protein content and the presence of cyanogenic, glucosides, linamin and lotaustralin in variable proportions that is toxic(Bolarin et al, 2004). The cyanogenic glucosides should be reduced to a level that is acceptable and safe for consumption. For these reasons cassava is usually sold as a processed product while other roots and tubers are most frequently sold as fresh product (FAO, 1998). Processed cassava products can be divided into two main groups; Dry products; (chip, gari, farinha, cassava bread); These are generally the least time consuming to produce and the most practical processed form, with a longer storage shelf life. They are also the most economically remunerative for the processors. Moist products (Atticke, batons) take longer time to prepare than the dried product, and their shelf life is relatively short (Ihekeronye and Ngoddy, 1985),

The processing method comprises combination of some of the following activities: peeling, washing, grating, fermentation, pressing, sifting, frying, cooling, sieving, packing and storing (IITA, 2005; Samaila, et al, 2010).

Traditionally, cassava products are processed by a variety of methods into different products according to local customs and preferences. Compare to fresh cassava, processed products have increased shelf life, are easier to transport and market, contain less cyanide and are more palatable (Nweke, 1996). Gari(toasted granules) production processes are laborious and cumbersome, with the production methods varying from one locality to another resulting in products of non uniform quality. Gari is the common name

among the West African countries except in Cot d'Ivoire where it is called atoukpoto. Fresh roots are peeled and grated, the grated pulp is put into sacks and the sacks are placed under heavy objects for 3 to 4 days to drain excess liquid from the pulp while is fermenting. The dewatered and fermented lumps of pulp are sieved and the resulting fine pulp is roasted in a pan. Palm oil is often added to stop the pulp from burning. This has the additional effect of changing the colour from white to yellow (Nweke, 1996).
Sifting is a very important operation in gari processing. It is the pulverization of pressed mash carried out as a necessary measure to achieve efficient heat transfer during frying. It is equally important as it ensures the homogeneity of the finished product and reduces the energy used during the frying process. In addition sifting allows the production of different grades of gari that is suitable to different class of consumers depending on local custom and tradition (Odigbo, 1983). It is pertinent that there is the need for large scale production of gari for the geometric population of the country, and sifting as a very important operation in gari production has to be mechanized. Therefore, the objectives of this project are to design, fabricate and evaluate a gari sieving machine.

2. MATERIALS AND METHODS

2.1 Machine Description and Operation

The cassava mash (gari) sifter consists of the frame, crumb breaker, sieving unit, hopper, concave (housing), collecting tray and the prime mover.
The frame is the unit of the machine on which all other components are mounted. It is made of 50x50mm angle iron. The coverage area of the frame is 450mmx900mm.

The sieving unit is made of galvanized metal sheet of 400mm width by 500mm length; the sieve aperture is 5mm in diameter. The hopper is the unit of the machine where cassava mash is being loaded into the machine. It is trapezoidal in shape with dimensions of 500x300x300x200mm. The concave (housing) is the unit of the machine that houses the crumb breaker. The collecting tray is the unit of the machine where the sieved cassava mash or gari is collected. A 1hp petrol engine is suitable as the prime mover while belt and pulley are the power transmission components. The pictorial view of the sieving machine is as shown in figure 1.

2.2 Design of the Motorised Sieving Machine

2.2.1 Design considerations

Properties of Gari: The properties of gari like crumb weight, grain texture; moisture content and type were considered in material selection and design.
Availabity of Materials: The materials used for the construction of the machine were those readily available.

Properties of Fabrication Materials: The strength, rigidity, reliability and durability of the materials were considered alongside availability. Production Cost: the cost of the materials selected was moderate so as to have an overall production cost that would be affordable by intending users.

Ease of Assembly and Dismantling: The machine was constructed in a way that will ease assembling and disassembling through the use of temporary fasteners for easy transportability and maintenance.

Ease of Operation: the machine was designed to suit the convenience of the user.
Other factors considered are ease of maintenance, aesthetics and safety.

2.2.2 Design Features

The frame:

The frame was made of angle iron with length, width and height of 900, 490 and 800mm respectively.

The hopper:

The hopper is truncated square pyramid, which serves as input unit. It is designed to provide smooth supply of cassava mash (gari) to the pulverizing unit. Volume/capacity of the hopper as calculated is $10.34 \times 10^{-2} m^3$

Concave (housing):

It was made of galvanized iron sheet of gauge 1.5mm. Its dimensions were 490 x 550mm. The pulverizer made of shaft on which beaters are welded is housed by the concave.

The sieve:

It was made of stainless steel of 1.5mm with aperture of 3mm in 400 x 500 x 50mm. It is operated by the crankshaft as it was designed to work by oscillation.

Collecting/receiving trough:

This is where the sieved cassava mash or gari is collected. It was made of 1.5mm stainless metal sheet and dimension 900 x 600 75mm. The waste is collected manually.

2.3 Test and Running of the Machine

The motorized cassava mash sifter was tested at the teaching and research farm of Rufus Giwa Polytechnic, Owo with varying speed of 400, 450, 500 and 550rpm at predetermined moisture content of 35, 39 and 45 and 48%.The moisture content (wet basis) was determined using a moisture meter(HTC L5KC-608)) at the Crop Processing Laboratory of Agricultural and Bio-Environmental Engineering Department, Rufus Giwa Polytechnic, Owo. The throughput capacity, output capacity and sifting efficiency were calculated using the following equations;

$$\text{Thruoghput Capacity, } T_p = \frac{W_1}{T} \quad \text{.....1}$$

$$\text{Output Capacity, } Oc = \frac{W_2}{T} \quad \text{.....2}$$

$$\text{The Sifting Efficiency (\%)} = \frac{W_2}{W_1} \times 100 \quad \text{.....3}$$

Where; W_1 = Initial weight of the cassava mash (kg); W_2 = Weight of sifted cassava mash (kg); and T = Time of sifting (min)

3.0 RESULTS AND DISCUSSION

The performance test was conducted at operating speeds of 430, 480, 500 and 570rpm respectively using cassava mash samples of 35, 39, 45 and 48% moisture content (wet basis). The highest output was observed at 500rpm operating speed and35% moisture content. It was observed from figure 2 that sifting efficiency had polynomial relationship with the operating speed as the sifting efficiency increased with increase in operating speed and later decreased. While an inverse relationship was observed between the sifting efficiency and the moisture content (figure 3) as the sifting efficiency decreased with increase in moisture content. The lowest sifting efficiency (79%) was recorded at 570rpm and 48% moisture content respectively. All the sifting efficiencies recorded in the research can be described suitable as they vary from 79 to 89%.

4. CONCLUSION

The cassava sifter was found appropriate at all the operating speeds except at 570rpm. It can therefore be concluded that the sifter can perform efficiently between 430 and 500rpm at all tested moisture contents. The highest sifting efficiency (89%) was obtained at 500rpm and at 35% moisture content which is within the range recommended by IITA, 1990.

The sifting efficiency decreased with increase in moisture content of the cassava mash. The sifter is therefore considered suitable for use by all categories of cassava farmers.

REFERENCES

Bolarin, F. M., Anekwe, S. O. and Ayuba, L. O. 2004.Determination of functional properties of NCAM processed gari. Proceedings of the 5th international conference of the Nigerian Institution of Agricultural Engineers. 26: 381 - 386.

FAO. 1990. Roots, tubers, plantains and bananas in human nutrition. Food and agricultural organization of the united nation, Rome, Italy. pp198. http://www.fao.org/docrep/toz7e00.htm.

FAO. 1998. Storage and processing of roots and tubers in the tropics. food and agriculture organization of the united nation, Rome, Italy. http://www.fao.org/docrep/X5415E00. htm

Ihekeronye A. L and Ngoddy, P. O. 1985. Integrated food science and technology for the tropics. Macmillan publishing Ltd. London.

IITA. 2005. Integrated Cassava Project. International. Institute of Tropical Agriculture, Ibadan, Nigeria. www.cassavabiz.org/posharvest/Gari01.htm

IITA. 1990. Cassava production in tropical Africa; A reference manual. International Institute of Tropical Agriculture, Ibadan Nigeria, pp 176.

Nweke, F. I. 1996. Cassava processing in sub-saharan Africa: Implications for expanding cassava production. IITA Research No.12 March 1996.

Odigboh E. U. 1983. Cassava production, processing and utilization. In. chan Jnr., H.T(ed) A hand book of Tropical Foods. Marcel Decker Pub. Inc., 270, Madison Avenue, New York. pg 145-200.

Samaila, S. R., Ogunjirin, O. A. and Olowonibi, M. M. 2010. Development and performance evaluation of a motorized sifter. Journal of Agricultural Engineering and Technology (JAET). 18(2): 46-54.



Figure 1: Isometric View of the Gari Sieving Machine

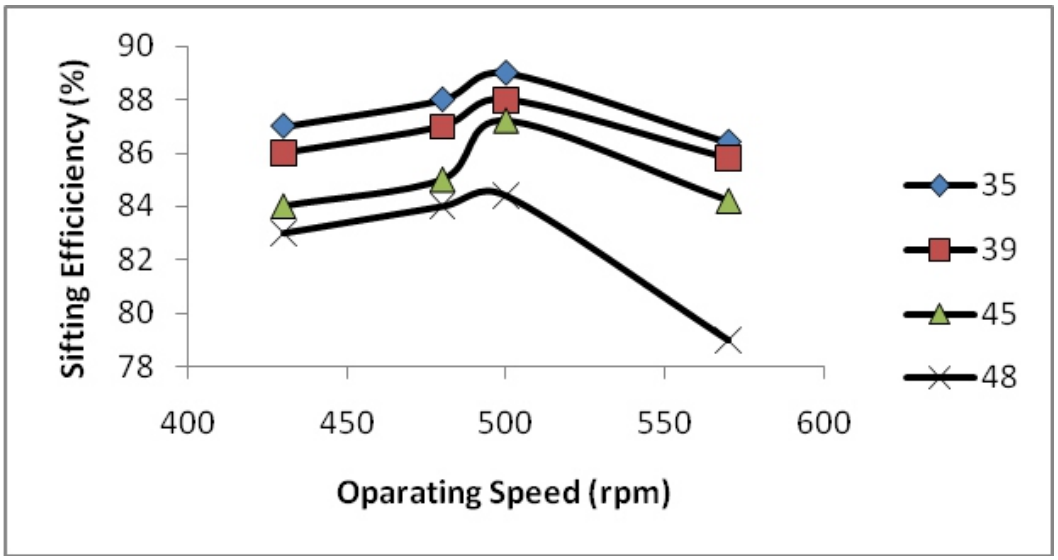


Figure 2: Sifting Efficiency Versus Operating Speed

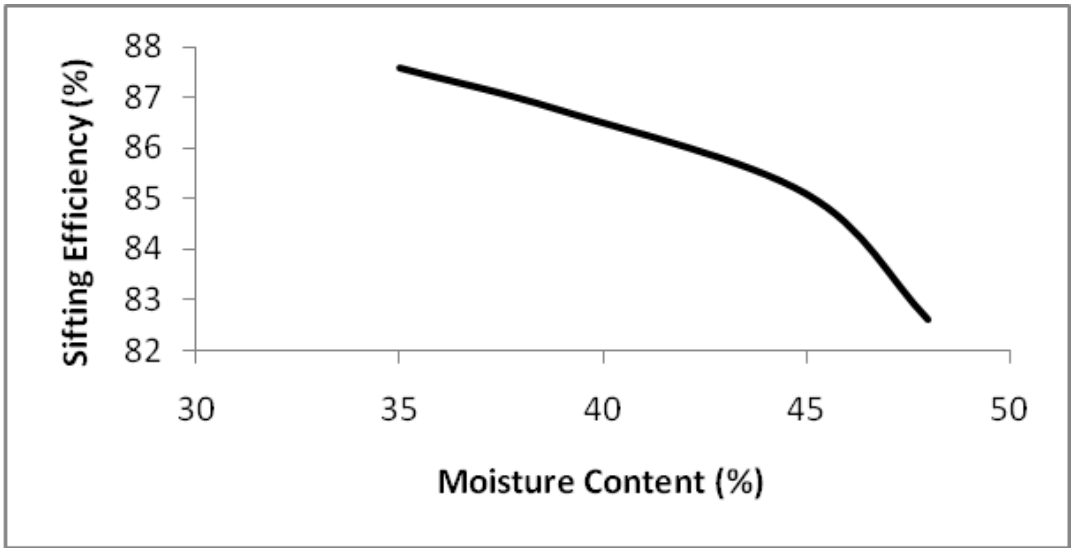


Figure 3: Sifting Efficiency Versus Moisture Content

SORGHUM THRESHING VIS-À-VIS WOMEN PARTICIPATION IN KANO STATE

M. A. Ali[1], M. M. Bello[2]
[1]Department of Agricultural Engineering,
Bayero University, Kano
[2]Centre for Dryland Agriculture
Bayero University, Kano
Corresponding author: mmbello.cda@buk.edu.ng, +2348038872599

ABSTRACT
Sorghum (*Sorghum bicolor*) is one of the important dryland crops and is popularly grown and use as a staple food in Nigeria. In fact Nigeria is among the largest producers of sorghum in the world and Kano state is an important area of sorghum production. Although some level of mechanization is practiced in the production of the sorghum, this study reveals that the processing, particularly threshing and winnowing are largely done manually using traditional tools such as pestle and mortar, stick and calabash. Women are actively involved in the threshing as well as winnowing operations. The women employed pestle and mortar for threshing with a resultant average output of 12 kg/hr whilst the men used stick beating technique with an average output of 50.4 kg/hr. Thus women are at a disadvantage due to their low capacity and tediousness of the method they use. The winnowing operation, however, is done wholly by women and involves the use of basin and calabash. The winnowing operations as well as the subsequent cleaning processes are quite tedious and time consuming. Therefore women are left with the more difficult tasks in the sorghum processing. Therefore there is need to develop/introduce simple threshing equipment so as to ease the drudgery faced by women as well as increase their capacity

Keywords: Sorghum Threshing, Women Participation, Stick Beating, Pestle and Mortar, Winnowing

1.0 INTRODUCTION

Sorghum (*Sorghum bicolor)* is one of the important food crops grown in the dry land areas of the world, with Nigeria being the second largest producer. Sorghum has 1.5 degree of tolerance to aridity on the scale of 0 to 3 (Creswell and Martin, 1998) and is thus popularly grown even in the dries part of Nigeria. Sorghum is grown at subsistence level in Nigeria and its uses are somewhat limited to food and animal feed, with limited use in beverage production. In other parts of the world, where sorghum is used largely for commercial beverages and ethanol production, it is production has been mechanized, and individual farmers are able to cultivate large acreage and therefore increase their income level. In Nigeria, however, the level of mechanization is low, and coupled with non commercialization of the product, the farmers are not able to cultivate much. A study in Kano state revealed that most of the farmers have production capacity between 1 to 20 bags of sorghum per season (Bello, 2007). Although the use of machines and tools in the sorghum cultivation is not uncommon in Nigeria, the post harvest processing is still done manually, with women actively involved in the processing. Threshing, an important unit operation in sorghum post harvest processing, and which determines to large extent the quality of the grain (Dangora, et.al., 2006), is still done manually with resultant heavy workload in terms of energy expenditure of 41.87kJ/min and heartbeat of 150 beats/min

(Ali 1986; Hassena et.al., 2006) and considerable cleaning process (Hopten, 1968). Thus women are subjected to this heavy workload. The traditional method of threshing and the subsequent grain separation is physically demanding on the person performing the operation, which did not encourage high production and often results in a low quality (Ege, 1978; Desta and Mishra, 1990). Desta and Mishra,(1990) also pointed out that indigenous threshing of sorghum is one of the most time consuming, laborious and uneconomical activities. However, there are mechanical threshers in the market, but their prices are out of reach of the local farmers (Ali, 1999). For proper mechanization, the processing technologies should be in tandem with production technologies. This paper presents findings of a survey on existing threshing methods in Kumbotso Local Government area and women participation in the sorghum processing.

2.0 MATERIALS AND METHODS

Study area: The area selected for study was Kumbotso local government, located on 11^0 53' 17" N 8^0 30' 10" E and having a population of about three million.

Questionnaire design and administration: A questionnaire was used for data collection from the local farmers. Open format questions were used and the questions were clear, succinct and unambiguous. The focus of the questionnaire includes:

- To find out how the farmers thresh their produce.
- To find the level of women participation in the threshing and subsequent winnowing
- To find the types of tools they use for the threshing and their performance level.

Thirty respondents were selected at random from the study area and the questionnaires were administered to them in a number of trips taken to the areas.

Field study and observations: Ten respondents were further selected at random and field study and observations were performed on them during threshing operation in the field. These were done during harvest period, which is the time the farmers normally thresh their products. Aspects or parameters observed or evaluated include:

i. Quantity Threshed (Kg/hr):

For each farmer, a stop watch was set off just as he started the threshing and after an hour the quantity of the product threshed by the farmer is gathered and put in a sack. This quantity is then put on a weight scale and its weight was read and noted.
If Q is the quantity of the product threshed per unit time, then

$$Q = \frac{q}{t} \quad \text{..... (1)} \qquad \text{(Heytson, 2003)}$$

Where,

Q = Quantity of the product threshed per unit time
q = quantity threshed (kg)
t =time taken to thresh the given quantity (hr).

I. Scatter loss, SL (%): this is the loss due to grain scattering around the threshing unit during threshing operation:

$$SL = \left(\frac{q_L}{q_T}\right) \times 100 \quad \text{..... (2)} \qquad \text{(Heytson, 2003)}$$

Where,

Q_L = quantity of grains scattered around the threshing unit (not on the sacks (kg)

Q_T = total quantity of grain in sample (kg)

For each operation, QL was determined and the scatter loss calculated.

I. Mechanical Grain Damage, MD (%): this can be determined by collecting the broken grains in a sample and dividing by the total quantity of grain in the sample. The mechanical damage MD is given by:

$$MD = \left(\frac{Q_b}{Q_t}\right) \times 100 \quad \ldots\ldots\ldots\ldots (3) \qquad \text{(Heytson, 2003)}$$

Where,

Q_b = quantity of broken grains in sample (kg)

Q_t = total quantity of grain in sample (kg)

3.0 RESULTS AND DISCUSSION

Production level: The production levels of the interviewed sorghum farmers are shown in Table 1 below. The number of the respondents together with the corresponding percentage and production level are as shown in the table.

The production levels of the sorghum farmers are relatively low with 73.3% of the respondents having production levels of between 1 to 20 bags per season. About 6.7% of the respondents produce 80 to 100 bags per season. However the mean production level of the respondents is about 24 bags per season. This also shows that almost all the sorghum farmers interviewed are small scale farmers and by inference majority of Kano state sorghum farmers are small scale producers

Women participation in sorghum threshing: Women are actively involved in the sorghum threshing. About 16 % of the respondents are women and they participate in the threshing operation. The women used a different approach from that used by men. This approach, which involves the use of pestle and mortar, resulted in women having lower threshing capacities than men. Furthermore, all the cleaning processes (winnowing) are done by the women. The fact that sorghum threshing is laborious (Desta and Mishra, 1990) makes it a source of concern since women participate actively. Also as postulated by Hopfen (1968), the cleaning process is much more difficult than the actual threshing and therefore women are subjected to more drudgery. From the fore going, there is need for simple technology so as to reduce the drudgery in threshing, particularly in the winnowing operation.

Threshing operation: Two distinct processes are used in threshing the sorghum depending on whether men or women are going to do it. The men follow the same procedure where they employed a technique using stick beating whilst the women employed the use of pestle and mortar in threshing the sorghum. These techniques are explained below.

Stick beating employed by men: The sorghum sheaves are taken to the threshing point. The threshing floor is either a cleaned ground or sacks spread on the ground. The sheaves are laid on the threshing surface and the ear head portion of the sorghum is beaten continuously with sticks until the grain separates from straw (plate 1). The straws are then gathered and removed with hand. The grain, together with chaffs and other debris are then taken for winnowing. All the interviewed men followed this procedure of sorghum threshing.

Bello, M.M. (2007). Rice and Sorghum Threshing: A Study Towards Upgrading the Current Practices in Kano State. Unpublished B. Eng Thesis. Bayero University, Kano, Nigeria.

Creswell, R. AND Martin, F. W. (1998). Dryland farming: Crop and Techniques for arid regions. ECHO technical note. ECHO, 1739 Durrance Rd., North Ft. Myers FL33917, USA.

Dangora, N.D., Sulaiman, M.L., Mohd, U.S. AND Yusuf, D.D. (2006). Modification of IAR Maize Dehusker Sheller for Sorghum Threshing. Proceedings of the Seventh International conference of Nigerian Institution of Agricultural Engineers. 28: 106 - 109

Desta, K. AND Mishra, T. N. (1990). Development and Performance Evaluatio of a Sorghum Thresher. Agricultural mechanization in Asia, Africa and Latin America. 21(3): 33-37

Ege, M. T. (1978). Threshing and Separation Performance of a Locally Built Cowpea Thresher. Journal of Agricultural Engineering Research 23: 45-51

Hassena, M., Ensermu, R., Mwangi, W. AND Vekuiji, H. (2000). A Comparative Assessment of Combine Harvesting vis-à-vis Conventional Harvesting and Threshing in Arsi Region, Ethiopia. Mexico D. F. International Maize and Ethiopia Agricultural Research Organization (EARO)

Heytson, R. D. (2003). Performance Evaluation of Soybean Thresher. An Unpublished B.Eng. Thesis Ahmadu Bello University, Zaria, Nigeria.

Hopten, H. J. (1969). Farm Implement of Arid and Tropical Regions. Agricultural Development paper. No 91, FOA, Rome.

Table 1 Production Level Of The Sorghum Farmers

S/no	Production level (bag)	Number of respondents	Percentage (%)
1.	1 – 20	22	73.3
2.	21 – 40	1	3.3
3.	41 – 60	4	13.2
4.	61 – 80	1	3.3
5.	81 - 100	2	6.7

Pestle and mortar employed by women: However about 16% of the respondents (who were women) adopt a different approach in their threshing. They explained that they usually place a given quantity of the sorghum ear heads into a mortar and beat it continuously with a pestle (plate 2). After the grain is separated from the straw, the resultant product is removed and taken for winnowing operation, and another batch of sorghum ear head is placed in the mortar.

Winnowing: The winnowing is wholly done by women. The women are mostly old, though some middle age women are also found. The winnowing process is the same in both cases. Basin and/or calabash are used for the winnowing. The mixture is poured from slightly above the operator's height whereby the grain falls into the basin placed on the ground and the light materials are blown away to a greater distance by the wind breeze.

Tools used for threshing: All the respondents use the same traditional tools for threshing their product and none of them indicated the use of any mechanical threshing device. The types of tools they use are listed with their functions in table 2.

Threshing performance of respondents: Ten respondents were selected for field observation, five men for stick beating and 5 women for pestle and mortar threshing. Table 3 below shows the performance levels for stick beating, whilst table 4 shows the performance levels for pestle and mortar threshing.
It can be seen from table 3 and table 4 that the average threshing capacity using stick beating is 50.4 kg whilst that of pestle and mortar used by women is 12 kg. This shows that the production level of women is quite low compared to that of men. Women threshers have more tedious work and yet their capacity is low when compare to men who used a better method. The average scatter loss is higher in the case of men using stick beating technique (0.46 %) than that of women using pestle and mortar (0.028 %). This is so because in the case of stick beating the sorghum is spread on a sack and thus more potential for spillage whilst beating compared to the sorghum contained in the mortar in the case of pestle and mortar technique. The mechanical damage is, however, higher in pestle and mortar technique (2.26 %) when compared to the stick beating technique (1.34 %). This is likely due to the fact that the sorghum is subjected to more impact as it is beaten between the pestle and mortar whereas the impact is less when it is beaten by the stick.

4.0 CONCLUSION

The study indicated that sorghum processing in Kano state is still done manually as against the practices elsewhere, where mechanization is being practiced, and that women are actively involved in the processing. The tediousness of the threshing, particularly the winnowing which is mostly done by women calls for at least a development of local and affordable technology in order to increase processing capacity and reduce drudgery in the threshing.

REFERENCES

Ali, M. A. (1986). Comparative Ergonomics Studies of Male and Female Operations on Selected Farm Operations. Unpublished MSc Thesis. Ahmadu Bello University, Zaria. Nigeria.

Ali, M. A. (1999). Maize dehusker-Shelter Development and Women Users Participation. Samaru Journal of Agricultural Mechanization 1(i), 43-51.

Table 3 Threshing Performance Using Stick Beating Technique

S/N	Quantity threshed, (kg/hr)	Scatter loss (%)	Mechanical grain damage (%)
1	44	0.20	1.00
2	46	0.31	1.20
3	50	0.15	2.00
4	52	0.60	0.90
5	60	1.00	1.60

Table 4 Threshing Performance Using Pestle And Mortar

S/N	Quantity threshed, (kg/hr)	Scatter loss (%)	Mechanical grain damage (%)
1	10	0.01	2.1
2	10	0.002	1.7
3	13	0.008	2.6
4	15	0.10	3.0
5	12	0.02	1.9



Plate 2 Pestle And Mortar Threshing



Plate 1 Stick Beating Threshing

Table 2: Tools For Manual Threshing

S/No	Tool Type	Function of Tool
1	Pestle and mortar	For threshing
2	Stick	For threshing
3	Basin/calabash	For winnowing

DEVELOPMENT AND PERFORMANCE EVALUATION OF AN ORANGE JUICE EXTRACTOR

ABSTRACT

The design and construction of orange Juice extraction was undertaken with the aim of achieving the extraction of pure orange Juice, free of squashed seeds and peels. The extractor consists of the cutting chamber which is made up of rotary shaft, knives attached at both ends and an inclined tray. While the squeezing chamber is made up of crankshaft, the rammer and a sieve. The machine has a shaft diameter of 12mm, torque and power transmitted as14252Nmm and 1.5kw respectively. The pulley has a linear speed of 10.74m/s, the cross sectional area of the squeezing chamber (flat plate) was 12,000mm^2 with a force of 5.32N on the plate due to pressure from the orange. While the net force acting on the plate was 3059N.The machine performance evaluation was carried out using tangelo and Tiv orange varieties. The actual efficiency of the machine was found to be 76.04% with a capacity of 6 l/hr (5.73kg/h). It was concluded that efficient Juice extraction would be better achieved with the use of this kind of machine than with a turning screw.

Keywords: Orange Juice, Cutting Chamber, Squeezing Chamber, Extraction, Crank Shaft.

1.0 INTRODUCTION

Citrus (Citrus sinensis) fruits are second only to apple in world trade and have been grown for millennia in their area of origin. They belong to six genera namely; fortunella, Eremocitrus, clymenia, poncitrus, microcitrus and citrus (Chapot, 1973), but from an economic point of view, only furtunella, poncitrus and citrus fruits are important and the major commercial citrus fruits are eight species of the genus citrus. They are probably the most sought after fruits and consequently the most eagerly developed fruits in advanced as well as developing countries, climate permitting (chapot 1973).

The group (genus) citrus, comprises species in which sweet orange, grape fruits, lemon and lime are included. In the sweet orange, good varieties include Valencia, Washington Navel, king, Ibadan sweet, Nigerian green skin and tangelo. The fruit tree is grown very extensively in the southern guinea savanna and high rainfall areas of Nigeria (AERL, 1987). Although the plant is well adapted to area with high rainfall, it can be grown further north as an irrigated tree crop.

Orange (citrus sinensis osbek) is the must popular among the citrus family. Every parts of the orange including the ring have some nutritional value (Morton, 1987). The fruit can be consumed raw or in form of juice, after peeling the ring. Orange Juice has become an indispensable part of our daily breakfast, it is considered as a fresh and perfectly nutrition way to start a day (Sonia, 2011). Like any other citrus fruits, oranges are also loaded with vitamin C. It contain minerals like calcium, sodium, potassium magnesium, phosphorus, copper, and sulphur. An orange also contains 15.4gms of carbohydrate, 12.2gms of sugar, 3gms of dietary fiber, 1gm of protein and 0.2gm of fat (Sonia, 2011). Apart from the vitamins and minerals, orange contains more than 170 phytonutrients, which include carotenoids, terpenoids, limonoids, glucarates,and flavanoids. Flavanoids, posses' anti-inflammatory, anti- tumor and anti- carcinogenic properties. They also prevent blood clotting and thereby reduce the chances of coronary thrombosis. The carotenoids which have antioxidant properties help in the prevention of blindness after 65. As orange contain a good amount of fiber, they help in digestion and in

lowering blood sugar level. They fight colon cancer and diarrhea, prevent kidney stone formation, rheumatoid arthritis and cancer (Sonia, 2011).

Today many people drink orange juice for breakfast, while lots of oranges waste due to inadequacy in the processing and preservation in the mist of great demand. In other words, there are few machines to match the growing demand for this product. Hence, the need to design and construct a hand-operational machine capable of extracting juice from the orange fruits.

2.0 MATERIALS AND METHODS

2.1 Description of the Orange Juice Extractor

The main feature of the extractor is shown in figure 1 which include the cutting chamber and the squeezing chamber working side by side each other. The cutting chamber is made up of flat metals attached to a rotary shaft fixed at both ends to the bearing, with knives held at 90° to a fixed base. When the orange rolls over an incline tray, it stops at the base of the knife edges where the rotary flat metal pushes it through the knives to produce orange fragments at the other end, which then fall off the cutting chamber into the squeezing chamber. The squeezing chamber is made up of crankshaft, rammer and sieve with the fragmented oranges in the chamber. The rammer by means of a reciprocating rotary motion of the crankshaft, squeezes the juice out of the orange, the juice exuding through the sieve is pure.

The materials used for the construction of the orange juice extractor with a capacity of 5.73kg/h, are: 26 gauge mild steel sheet, 8mm mild steel rods, ½ inch brackets, 2mm sieve (stainless steel) and stainless steel knives with a shear strength of 41 to 48 GN/m^2 (Redford, 1975). The choice of these materials was based on their unique properties that are adoptable to particular sections of the machine such properties include; durability, availability, machinability, cheapness light weight and malleability. The machine comprises the following components; shaft, pulley, hub, bearings, plunger (squeezing chamber), key and main body (frame).

2.2 Design Calculations

Design of shaft:

The extractor consist of two shafts, the cutting shaft and the squeezing shaft (James, 1983). The shaft diameter is determined using equation (1) (Mott, 1985).

$$D^3 = (16/\bar{\lambda}Ss\sqrt{(KbMb)2} + (K_tM_t)^2 \quad \cdots\cdots \quad 1$$

Where, D = diameter of shaft.mm
S_s = shear stress, Nmm^2
K_bK_t = Combine shock and fatigue factors applied to the bending and torsion moment respectively.
M_t = torsional movement, Nmm
M_s = bending movement, Nmm

Torque transmitted through the shaft is obtained from equation (2).

$$T = \frac{\bar{\lambda}cd3}{16} \quad \cdots\cdots\cdots\cdots \quad 2$$

Where, N = number of Red
T = Torque Nmm

Design of pulley:
The pulley standard chamber and width of 200mm and 25 mm as given by James (1983). The linear speed of the pulley was obtained from equation (4)

$$\text{Linear speed (v)} = \frac{\bar{\lambda}DN}{60} \quad \ldots\ldots\ldots 4$$

Where, D = diameter, mm
N = number of rev.

Design of hub:
The diameter and length of the hub where obtained from equation (5) and (6) respectively.
Diameter of hub (δ) = 2d ------ 5

$$\text{Length of hub (L)} = \frac{\bar{\lambda}d}{2} \quad \text{-------- 6}$$

Where, d = diameter, mm
L = length of hub, mm.

Design of key:
The width, thickness and length of key where also obtained from equation 7, 8 and 9 where,

$$\text{Width of key (w)} = \frac{d}{4} \quad \ldots\ldots\ldots\ldots 7$$

$$\text{Thickness of key (t)} = \frac{2w}{3} \quad \ldots\ldots\ldots 8$$

$$\text{Length of key (l)} = \frac{\bar{\lambda}d}{2} \quad \ldots\ldots\ldots\ldots 9$$

Where, d = diameter, mm,
w = width, mm

Design of bearing:
Approximate service life of bearing (in revs)

$$L = (\frac{c}{w})k \times 10^6 \quad \ldots\ldots\ldots\ldots\ldots\ldots 10$$

Where, c = dynamic radial load rating of ball bearing (144.25N)
k = 3. (For ball bearing).
Reliability of the bearing ®

$$\text{Log}_e\left(\frac{1}{R}\right) = (\frac{L}{a})b \text{ ------- 11}$$

Where, L = life span of bearing
a = 6.84, and b = 1.17

Squeezing chamber (plunger):
Cross sectional area of flat plate

A = L × B…… 12

Where, L = length of plate
B = breadth of plate.

Force in the plate due to pressure from orange.

F_L = P × A 13
= P × L × B 14

Where, p = axial load (N)
A = area of plate (mm^2)

Ratio of length of connecting rod to radius of crank.

$$N = \frac{L1}{r} \quad \ldots\ldots\ldots\ldots \quad 15$$

Where, L_1 = length of connecting rod.
R = radius of crank.

Net force acting on the plate.

$F_p = f_L + F_1$ 16

Where, F_c = force on plate due to orange.
F_1 = Initial force of reciprocating part.

Force in connecting rod (f_c)

$$Fc = \frac{fp}{cos\theta} = \frac{\sqrt{(1-(sin\theta)2}}{n2} \quad \ldots\ldots\ldots 17$$

2.3 Performance Evaluation.

The performance evaluation of the juice extractor involves evaluation of the machine's capacity and efficiency. The parameters investigated includes capacity (kg/h) and efficiency (%). The parameters were calculated using two varieties of orange, namely: tangelo and Tiv orange weighing 141 and 148g respectively. The orange weight and volume of whole orange peeling were determined, while orange weight and volume of juice collected and extracted, % by weight of juice extracted and orange squeezing time was all determined after subjecting the oranges to the machine.

3.0 RESULT AND DISCUSSION

Table 1 shows the design and calculated result while table 2 shows the average orange juice yield for the two orange varieties.

The power transmitted by the shaft was found to be 1.5kw, while torque transmitted by the shaft was 14252Nmm. The linear speed of pulley was 10.74m/s and they had diameter and length were 24 and 19mm respectively. The key width, thickness and length were found to be 3, 2 and 19mm respectively while reliability of the bearing was obtained at 72%. The cross sectional area and force on the flat plate due to pressure from orange (squeezing chamber) where 12,000 mm^2 and 5.32N respectively. The net force acting on the plate and the force in the connecting rod were 3059 and 3090N respectively.

The orange juice extraction was found to have a capacity of 6 *l/hr* (5.73kg/h) and an efficiency of *76*.04%.

CONCLUSION

The development of the juice extraction was carried out with the aim of achieving efficient and quality juice extraction. The performance evaluation of the juice extractor showed that it can be used effectively for extracting juice from different varieties of oranges especially tangelo and Tiv orange. The actual capacity of the extraction was 6 *l/hr* (5.73kg/h) with an efficiency of 76.04%. The juice extraction could overcome the waste due to inadequacy in processing and presentation of the orange as well as bridging the gap between demand and supply of orange juice.

REFERENCE

Chapo. H. (1973). The citrus plant; plant production and protection division. FAO. Rome, Italy.

Agricultural Extension and research liaison sources (AERLS1987). A guide to the production of citrus, Ahmadu Bello University, Samaru Zaria.

Morton, J (1987). Fruit of warm climate Miami, FL, PP 134-142.

Sonia, N. (2011). Nutritional factors about oranges; ---- in oranges. http//www.ons-grn.900legi-bin/npgs/html. Retrieved on 6/08/12.Redford 1975.

James, H.E (1983). ENGINEERING DESIGN Graphics (4th edition).

Mott, R.C (1985): Machine element in mechanics design, Charles. E. Merril publishing company. A. Bell and Havell company Columbia Tironf.

Table 1: Design Parameter

S/N	DESIGN PARAMETERS	RESULT
1	SHAFT DESIGN	
	Torgue transmitted through shaft, Nmm	14252
	Power transmitted, kN	1.5
2	PULLEY DESIGN	
	Linear speed m/s	10.74
3	DESIGN OF HUB	
	Diameter of hub, mm	24
	Length of hub,mm	19
4	Design of key	
	Width of key, mm	3
	Thickness of key, mm	2
	Length of key, mm	19
5	BEARING DESIGN	
	Life span of bearing, rev	10^6
	Reliability of bearing, %	72
6	Squeezing chamber (plunger)	
	Cross sectional area of flat plate,mm2	12000
	Force on the plate due to pressure from orange, N	5.32N
	Ratio of length of connecting rod to radius of crank.	6.67
	Net force acting on the plate, N	3059
	Force in connecting rod, N	3090
	Calculated parameter	
	7 capacity (L/m	6.00
	8 Efficiency (%)	76.04

Table 2: Average Juice Yield for Two Orange Varieties.

Orange varieties	Av. wt. of whole peeled orange	Av. of whole peeled orange (cm3)	Av. wt of juice collected (g)	Av. of juice extracted (cm3)	% by wt of juice extracted (%)	Av. squeezing time (s)
Tangello	141	150	72.20	50.30	58.2	30
Tiv orange	148	152	67.46	48.60	52.7	30

Table 3: Cost Analysis

ITEMS	Quantity	Unit cost(#)	Amount (#)
Angle iron	1 length	1400	1400
Bearings	4pieces	250	1000
Shaft	2×500mm	1000	2000
Metal sheet	1length	600	600
Weiding eletrate	1lump	200	200
Paint	-	1000	1000
Labour	-	-	
transportation	-	-	

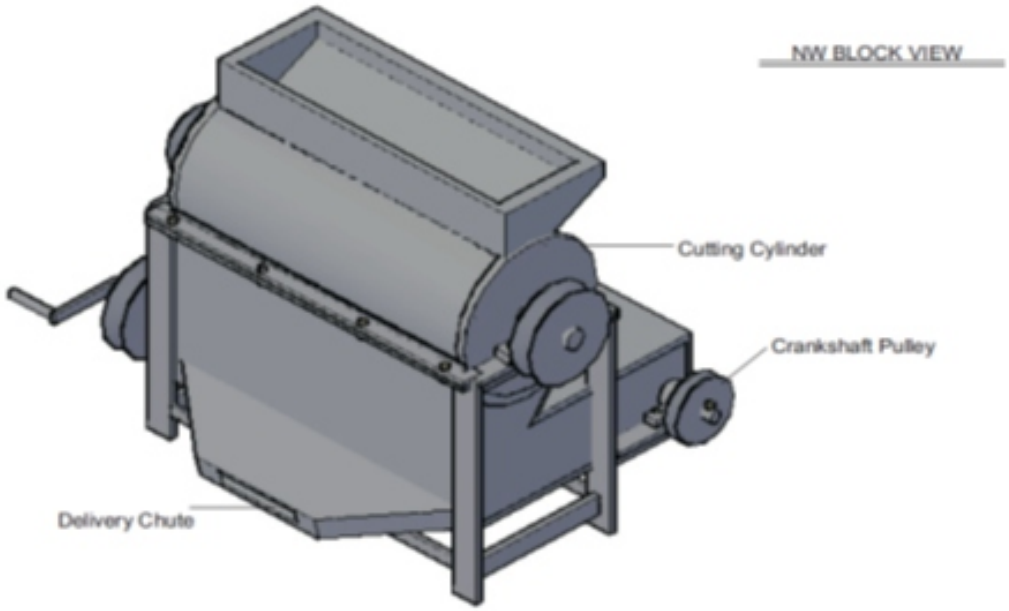
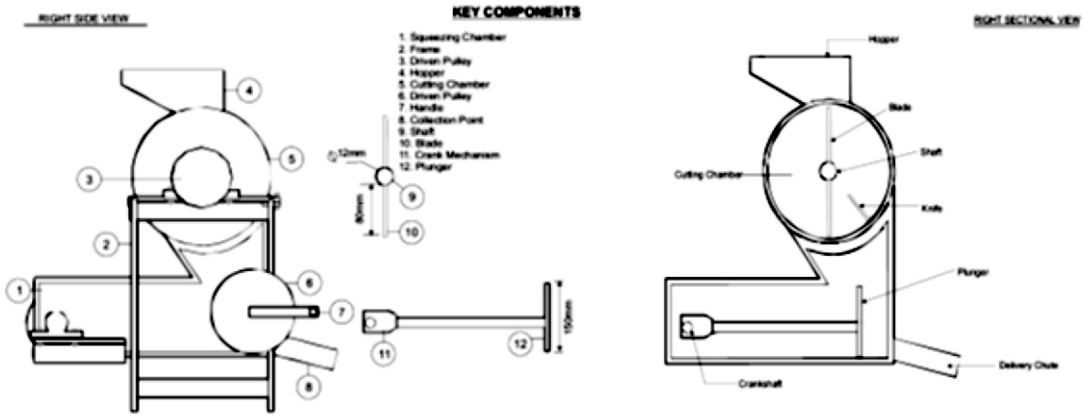


Fig. 1



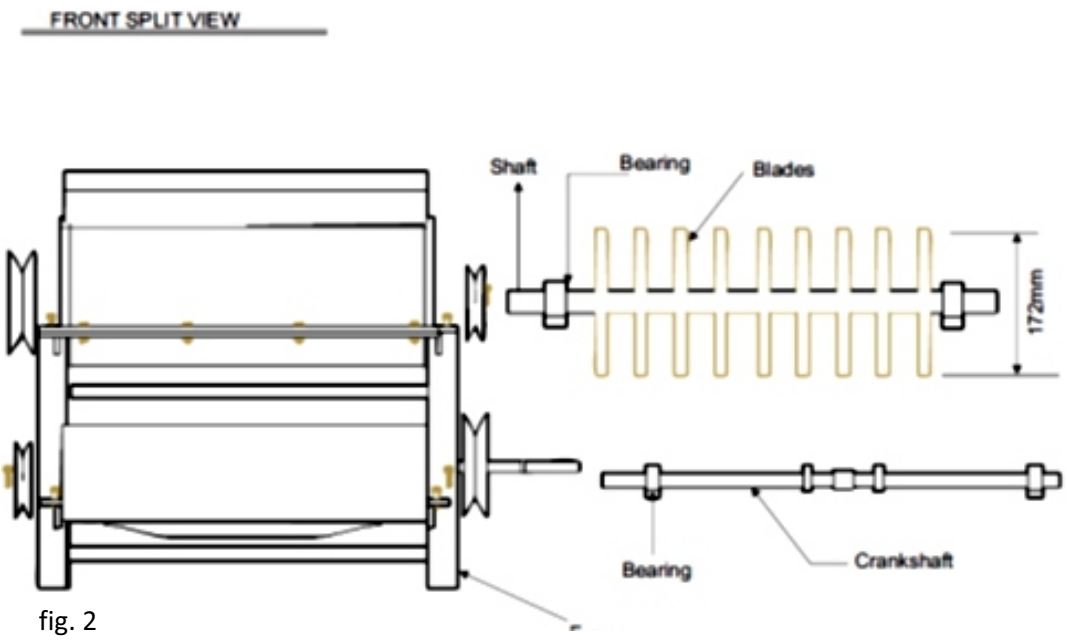
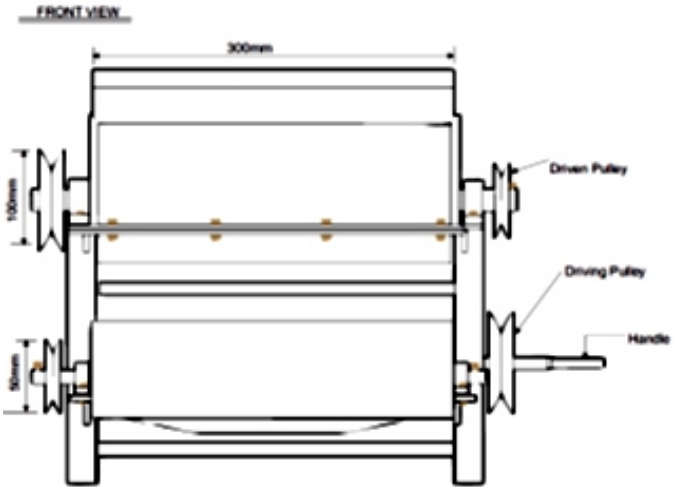
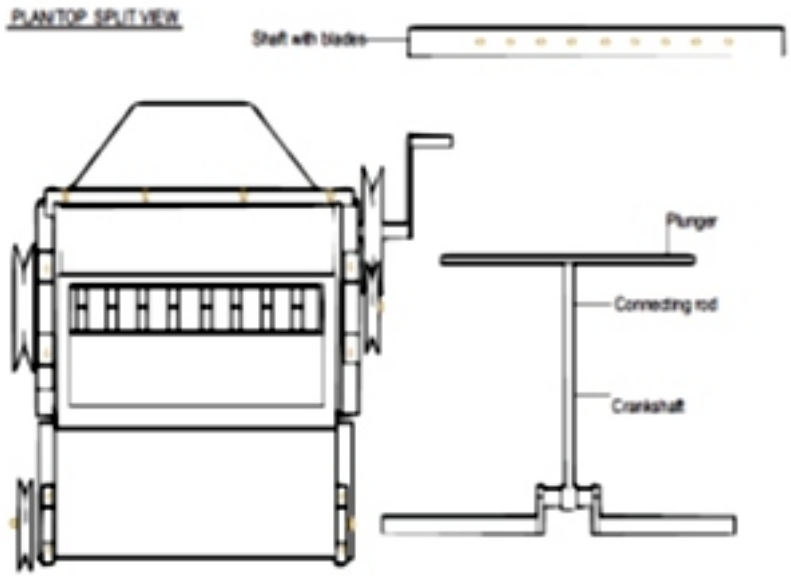

FRONT SPLIT VIEW
Shaft
Bearing
Blades
172mm
Bearing
Crankshaft

fig. 2


FRONT VIEW
300mm
100mm
50mm
Driven Pulley
Driving Pulley
Handle


PLAN/TOP SPLIT VIEW
Shaft with blades
Plunger
Connecting rod
Crankshaft

DESIGN OF A MANUALLY OPERATED DE-SKINNING/WINNOWING MACHINE FOR ENHANCED PRODUCTION CAPACITY OF THE TRADITIONAL GROUNDNUT OIL PROCESSORS

***M. A. Ali and B. A. Ayuba**
Department of Agricultural Engineering, Faculty of Engineering, Bayero University, Kano.
*Corresponding author dralimohd@yahoo.co.uk 080-33153491

ABSTRACT
The traditional groundnut oil processing is a popular commercial value addition activity, especially amongst women in Northern Nigeria. The process comprises of seven sub-processes, which include roasting, de-skinning, winnowing, milling, kneading, frying and forming of groundnut cake. To upgrade this traditional process, a de-skinning and winnowing machine was designed and constructed. Comparative evaluation, by de-skinning and winnowing 28kg of roasted groundnut, initially using the traditional process and secondly using the developed machine revealed that average de-skinning efficiency was 98 % with the machine whilst it was 97% by the traditional process; winnowing efficiency with the machine was 99.8% and 96.3% by the traditional process; and time wise the machine exhibited clear advantage by requiring only 50% of the time expended by the traditional process for the same quantity of roasted groundnut. Operationally, the processor worked continuously whilst processing 28kg of roasted groundnut with the machine, but intermittently paused to take rest while processing same quantity by the traditional process; indicating that the human energy requirement (i.e. drudgery) was comparatively less whilst working with the machine. In effect, the de-skinning and winnowing machine exhibited clear advantages in lesser production time and lower level of human drudgery, thus creating an opportunity for enhanced production capacity of the processors.

Keywords: Groundnut Oil, Value Addition, De-Skinning/Winnowing Machine, Efficiency and Production Time.

1.0 INTRODUCTION
Groundnut is an important crop grown in different parts of the world because of its seed. It is directly consumed as food or processed to remove oil. After the oil extraction it remains a meal which is very rich in high protein and it's a consumable derivative. Smart (1994) as cited by Ola (2000) found the percentage oil content as 42-53.8%, 45 – 58.6%, and 41 – 53.6% respectively for the three main varieties of groundnut, namely Spanish, Virgina and Runner. The oil is the important product of the crop, with about 40% of the world production crushed for oil (Ola, 2000).

Groundnut oil extraction is carried out in the Northern states of Nigeria by women in rural areas using the traditional process. It was found that amongst 436 processors of groundnut oil in three Northern states, (Niger, Kaduna and Kano), 74% claimed that they were processing for income generation (Nalumansi and Kaul, 1992). Thus, the processing represents an important economic activity for the women.

The traditional processing comprises seven sub-processes, which include roasting, de-skinning, winnowing, milling, kneading, frying and forming of groundnut cake. A detailed study of the entire traditional process revealed that there is scope for

improvement of each sub-process that could result in better efficiency, time saving and higher economic returns (Ali et al., 2012). Thus this work is aimed at improvement of the de-skinning and winnowing sub-processes.

2.0 MATERIALS AND METHODS

2.1 Materials

Materials used to carry out the study included: **Stop clock** - for noting the time taken to carry out a given process**; Weighing balance** - for measuring the weight of the groundnut and products derived from the deskinning and winnowing sub-processes; **Tachometer** – for measuring speed of rotation of the machine; **Traditional grinding stone -** for deskinning of roasted groundnut; **Shelled groundnut** - the main raw material for deskinning and winnowing; **Flat raffia plates –** for traditional winnowing.

2.2 Methods

2.2.1 Study of the traditional process of de-skinning and winnowing

The traditional method of de-skinning and winnowing were studied in detail by observing a processor, whilst processing different quantities of groundnut. This study was a detailed observation of the process in order to properly understand the traditional process and to identify area(s) of improvement of the process. Therefore, information collected was the detailed step by step procedure, types of tools used and areas that need modification.

2.2.2 Development of a de-skinning and winnowing machine

i. **Design aims:**

The improvements intended on the traditional system of de-skinning and winnowing of groundnut were:

- To reduce the inherent drudgery and work posture in the traditional de-skinning and winnowing.
  This could be achieved through use of devices with mechanical advantages; similarly, the machine will be ergonomically designed so that the operator can operate it whilst sitting or standing (i.e. better posture).
- To enhance quantity of output per unit time.
  In the traditional method, de-skinning and winnowing are done separately; the processor first completes de-skinning before she embarks on the winnowing. To fasten the process, the two operations could be combined; the machine will do the two operations simultaneously.

ii. **Establishment of design parameters:**

Dimensions of the frame:

Ergonomic considerations were used in determining dimensions of the frame. To allow a standing posture during operation of the machine, the height of the frame and the height of the operating arm above ground level were determined using vital dimensions of a population sample. Using 5th percentile of pelvic height, to accommodate many processors, the height of the operating arm above the ground should not exceed 86.0cm; similarly, using 5th percentile of elbow height, the frame height should not exceed 90.0cm (Ali, 1986). The height of the frame was taken as 88cm and the arm level as 80cm. Other dimensions of the frame were 76cm for length and 36cm for width.

Height of hopper:
Similarly ergonomic consideration was used for determining height of hopper opening from the ground. To enable easy feeding of groundnut into the hopper, the height of the hopper opening should not exceed 5th percentile of the height of the sample population i.e. 144.0cm (Ali, 1986). The height of the hopper opening was taken as 104cm. The hopper was trapezoidal in shape with length of 27.7cm at the top and 27cm at the base; the width at the top is 25cm and 15cm at the base.

Width of operating arm:
To enable proper grip and transfer of manual power for effective rotation of the machine, the arm width should be properly dimensioned in accordance with anthropometric guidelines. In accordance with finding of Wagami (1983), the width of the arm should be equal to 2 x 0.06H, where H is the 95th percentile of the height of the relevant population. The width for H = 167cm was 2 x 0.06 x 167.0= 20.0cm.

Diameter of the operating arm:
According to a recommendation by Wagami (1983), operating arm diameter (D) should be equal to C/π, where C is circumference, which represents hand length i.e. 0.11H (H is 95th percentile of height of sample population). D was calculated as 5.8cm. The design value was taken as 6cm.

Size of the belt:
The size of the belt was determined using the relationship,

$$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1 - d_2)^2}{4x} \quad \text{.....khurmi and Gupta (2005).....(1)}$$

Where L =Total length of the belt
d_1 =Diameter of the larger pulley (a pulley of diameter 16cm was chosen for this work).
d_2 = Diameter of the smaller pulley (a pulley of diameter 10cm was chosen).
x = Distance between the centres of the two pulleys (x is 32cm).

$$L = \frac{3.14}{2}(16 + 10) + 2x32 + \frac{(16-10)^2}{4 \times 32} = 105.1\text{cm}$$

Size of scrubber shaft:
The following equation (Mott, 1985 as cited by Iya et.al., 2010) was used to determine the scrubber shaft diameter,

$$D^3 = \left(\frac{16}{\pi s_s}\right)\sqrt{((k_b\ M_b)^2 + (k_t M_t)^2)} \quad \text{.....(2)}$$

Where, D=shaft diameter (m), S_s =shear stress(N/mm^2), k_b &k_t =combined shock and fatigue factors applied to the bending and torsional moments respectively, M_t=torsional moment (Nmm), M_b=bending moment (Nmm)
D was computed as 0.02m. Thus, an available shaft of diameter 22mm was selected and used.

Size of fan shaft:
Equation 2 was also used to determine the diameter of the shaft, based on the loading on the shaft. Computed D was 0.018m. A shaft of 22mm was selected.

iii. **Construction materials:**
The materials used for the construction of the de-skinning and winnowing machine were metal sheet, angle iron, plywood, pulley, shafts and steel bearings. These materials were selected based on suitable engineering properties, cost effectiveness, availability locally, and machinability.

2.2.3 Comparative Performance Evaluation of the Machine and the Traditional De-skinning and Winnowing Processes

The parameters used in the comparative performance evaluation of the improved and the traditional deskinning and winnowing process were the de-skinning efficiency (E_d) %, cleaning efficiency (E_c) and throughput capacity (kg/hr). A processor, conversant for many years with the process, was asked to de-skin and winnow 28g using the machine and then repeating same using the traditional process. For each method, the time taken to de-skin and winnow the groundnut was recorded using stop watch; the quantities of de-skinned groundnut and cleaned groundnut were all recorded using weighing balance. Mathematical expressions used in evaluating the performances of the methods were:

$$E_d = \frac{M_d}{M_t} \times 100$$ (Kebede and Mishra, 1990)………………………………………. (3)

Where,

E_d = De-skinning efficiency, (%)
M_d = Mass of de-skinned groundnut, kg
M_t = Total Mass of groundnut, kg

$$E_c = \frac{M_c}{M_t} \times 100$$ (Kebede and Mishra, 1990)…………………………………(4)

Where,

E_c = Cleaning efficiency, %
M_c = Mass of Clean de-skinned groundnut

$$Q_t = \frac{M_o}{t}$$

Where,

Q_t = Throughput capacity, (kg/hr)
M_o = Total weight of output, kg
T = Time, hr

3.0 RESULTS AND DISCUSSIONS

3.1 Study of the Traditional Process of De-Skinning and Winnowing

3.1.1 Description of the traditional processes

The sub-processes of de-skinning and winnowing in the traditional method of groundnut oil extraction, as observed, could be described as follows:

i. De-skinning: The processor performed the de-skinning of the groundnut using two grinding stones-comprising of a rectangular one (about 15x5x2cm) and a small one with flat surface on one side and a curved surface on the other (plate 1). The roasted nuts to be de-skinned are collected in a heap at one end of a jute bag. A small amount of it is picked and placed on the rectangular stone, then the processor places the small stone, flat face downwards, on the groundnut on the large stone, then places her two hands on the curved surface ad lightly rubbed and pushed forward the groundnut. The aim is to split the nuts thereby detaching the skin. The motion continues with backward rubbing; the continuous backward and forward motion causes separation of the nuts and the skin. When satisfactory separation is achieved, another batch is collected from the heap and placed on the large stone; same process is then repeated. The process continues until the whole heap is processed.

ii. Winnowing: The processor uses a flat raffia basket of about 0.4m in diameter (plate 2). The winnowing was achieved by collecting some quantity of de-skinned groundnut on the raffia basket; this quantity is thrown up about 0.5m up into the air and then allowed to fall back into the basket by gravity. The processor repeats this action at a frequency of about 1.27 times per second. The basket is apparently hinged at its bottom end and seems to revolve about this hinge but slanted at an angle of 25° to the horizontal. This motion causes the skin to fall forward off the basket and the nuts to slide off backward, thus achieving the separation. After completion of the initial winnowing, the nuts were rubbed between the palms to remove the skin which still remains on some. Then the processor carries out a second round of winnowing to complete the separation of the skin from the nuts. The processor then retrieves nuts from the skins, which fell forward, through another round of winnowing.

3.1.2 Tools used for the traditional de-skinning and winnowing

The tools used by the processors include a grinding stones, raffia basket and containers (see plates 1 and 2).

3.1.3 Areas identified for improvement

From the detailed observation of the traditional de-skinning and winnowing, the following were identified as areas of improvement:

i. Level of drudgery and work posture.
ii. Quantity of output per unit time.

3.2 Development of a De-Skinning and Winnowing Machine

3.2.1 Description and operation of the de-skinning and winnowing machine

Table 1 gives the design results. The machine, with overall dimensions 76cmx88cmx38cm, was constructed to de-skin and winnow in one operation (Plate 3). Accordingly, the machine has two main components- a de-skinning chamber for de-skinning and a blower for winnowing. The two components are mounted on a common frame with the de-skinning component on top and the blower below. The machine is manually operated through a lever arm which provides rotational power to two pulleys joined by a belt; one of the pulleys rotate a shaft that operates the blower and the other pulley rotates a crank that reciprocates the scrubber within the de-skinning chamber i.e. a scrubber. Groundnut for processing is fed through a hopper located above the de-skinning component; it then moves through the de-skinning chamber and then through a delivery unit into the blower, after which the clean de-skinned groundnut is collected in a suitable container. The blown skin moves out through another opening onto the ground. Detailed description of the two most important components are as follows:

i. The de-skinning chamber, where de-skinning takes place, is made of a rectangular metal sheet box with two rough surfaces, through which the ground nut passes to be de-skinned. The upper part of the box, which is stationary, forms one of the surfaces and is roughened by gumming a carpet on it; the second rough surface is a scrubber made of plywood and roughened with rough carpet gummed to it. The scrubber reciprocates on the lower part of the box; the reciprocation is facilitated by wheels, made of 1.5cm diameter bearings, mounted underneath the scrubber and which are adjustable so as to vary the clearance between the two de-skinning surfaces. The movement of the scrubber is guided by the sides of the rectangular metal box.

ii. The blower, which performs the function of separating the skin from the nuts, is situated below the de-skinning chamber. The blower is made up of a fan, with three blades, and a fan chamber constructed using 17 gauge (0.8mm) metal sheets.

In operation, the operator turns the lever arm continuously to actuate movements of the scrubber and the blower. Groundnut is poured through the hopper into the de-skinning chamber, where the reciprocating scrubber moves it in-between the two rough surfaces. De-skinned nuts exit from between the two rough surfaces and move downwards, through a connecting delivery unit, into air stream from the blower. The skin is blown away and the clean nuts move downwards into a suitable container.

3.2.2 Cost of materials

Table 2 below shows the various materials used and their cost.

3.3 Comparative Evaluation

The results of the comparative evaluation of the two different processes are given in table 3 below. For same quantity of groundnut (i.e. 28kg), the table shows that all the performance indexes were better while processing with the de-skinning and winnowing machine. Note that for the machine, there was 50.0% saving in time.

During the evaluation, it was also observed that the operator rested intermittently whilst processing 28kg through the traditional process, but processing same weight with the machine was continuous. This is an indication of higher level of drudgery for the traditional method, necessitating the need for a pause to rest.

4.0 CONCLUSION

The machine was developed and evaluated by de-skinning and winnowing 28.0kg of groundnut. For comparison same quantity of groundnut was also processed using the traditional process. Comparative analysis of the results obtained revealed improvement in de-skinning and cleaning efficiencies whilst operating with the machine; of major significance was the time saving of 50% from use of the machine. These improved efficiencies and time savings, achievable with the machine, could enhance the production capacities of the processors, thereby further empowering them economically.

REFERENCES

Ali M. A., 1986. Comparative Ergonomic Studies of Male and Female Operators on Selected Farm Tasks. Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria.

Ali M. A., I. I. Ibrahim, I. W. Muhammad, I. Lawan and M. M. Bello (2012): Technological Intervention in the Traditional Groundnut Oil Extraction. Proceedings of the 46th Annual Conference of the Agricultural Society of Nigeria "Kano 2012". ISBN: 0300368X.

Iya S. A., H. U. Kabri, B. Aliyu and A. Umaru (2010). Development and Evaluation of a Prototype Manual Precision Planter for SmallHolder Farmers in North-Eastern Nigeria. Arid Zone Journal of Engineering, Technology and Environment. August, 2010; Vol.7, 59 – 66.

Kebede, D and T.N. Mishral (1990). Development and performance evaluation of a sorghum thresher. Department of Farm Machinery and power Engineering, College of Technology, Pantangal, India.

Khurmi R. S. and J. K.Gupta (2005). A Textbook of Machine Design. Thirteenth Edition. Published by Eurasia Publishing House (P) Ltd. 7361, Ram Nagar, New Delhi-110055. ISBN:81-219-0501-X

Mott R. L. (1985). Machine Elements in Mechanical Design. Charles E. (ed). Merril Publishing Company. A Bell and Howell Company Columbia Toronto.

Nalumansi S.R. and R.N Kaul (1992) "studies on the tradition sysyem of groundnut oil extraction and possible improvement" (Nigerian Agricultural Mechanisation Research Programme, IAR/ABU-Zaria).

Ola, F.A (2000). "Development of a motorized groundnut oil extractor". A master thesis submitted to department of agricultural engineering, ABU, Zaria.

Smart, J. (1994): The Groundnut Crop: a Scientific Basis or Improvement Pub. By Chapman and Hall, London, pp 482-542 Samuel son and Nordhaus (2002). Economics (second edition).

Wagami Y. S., 1983. Selected Ergonomic Studies of commonly used manually operated farm tools. Unpublished M.sc Thesis. Department of Agricultural Engineering., Ahmadu Bello University, Zaria.



Plate 1: Traditional Groundnut De-Skinning

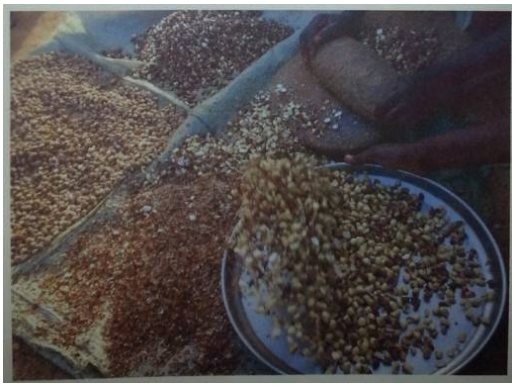


Plate 2: Traditional Groundnut Winnowing



Plate 3: The De-Skinner and Winnowing Machine

Table 1: Design Parameters

S/no.	Parameters	Design Values
1	The height of the frame	88 cm
2	Height of the hopper opening	104 cm
3	Width of operating arm	20.0 cm
4	Operating arm diameter	6.0 cm
5	Total length of the belt	105.1 cm
6	Scrubber shaft diameter	22 cm
7	Fan shaft diameter	22 cm

Table 2: Cost of Materials

Description	Quantity	Size	Unit Cost (N)	Total Cost (N)
Metal sheet	1	17gauge(0.8mm)	1,800.00	1,800.00
Angle iron	3	4x4	700.00	2,100.00
Plywood	1	70x50cm	150.00	150.00
Bearings	5	1.5cm dia.	100.00	500.00
Bolts and nuts	4	13mm	20.00	80.00
Pulley	2	16cm and 10cm	500.00	1,000.00
Hinges	2		30.00	60.00
Electrode	6dozens		40.00	240.00
Shafts	2	22mm	500.00	500.00
Belt	1	105.1cm	400.00	400.00
Other costs				4,000.00
Total				10,930.00

Table 3: Comparative Performance Evaluation of the Two De-skinning and Winnowing Processes

S/N	**Traditional de-skinning and winnowing method**			**De-skinning and winnowing machine**		
	E_d (%)	E_c (%)	Qt (kg/hr)	E_d (%)	Ec (%)	Q_t (kg/hr)
1	96.6	99.9	27.2	96.1	95.7	14.3
2	98.6	100.0	29.8	97.8	98.5	14.1
3	98.8	99.5	28.2	97.1	94.7	13.9
Ave.	98.0	99.8	28.4	97.0	96.3	14.1

DESIGN AND DEVELOPMENT OF AN EFFICIENT FISH SMOKING KILN FOR SMALL SCALE FARMERS

Lawal, A.O[1]., M. Abdulsalam[2], T. Andefiki[2], and N. A. Sale[1]
[1]National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria.
[2]Agricultural Engineering Department, Ahmadu Bello University, Zaria.
Correspondent: daniyasalam@yahoo.co.uk
+2348036052632

ABSTRACT
Fish is an important source of food and income to many people in developing world, specifically Nigeria. It is a highly perishable food commodity and its rate of spoilage is further enhanced by ambient tropical temperature. The high moisture content of fish renders it extremely perishable which result to post–harvest losses due improper handling and processing of the captured fish and the effect of transportation is significant. This led to the design and fabrication of an improve fish smoking kiln which involves mainly the modes of heating, heat and mass transfer from charcoal to the product, prevention of heat from the smoking chamber to the outside wall of the kiln , the trays and the air flow rate design to ensure uniform heat distribution. The heat was generated from the burning charcoal and enters the smoking chamber through perforated pipes inside the smoking chamber. The kiln maintained a relatively uniform temperature of 60°C at all the tray level and provided quality smoked product. The fuel consumption rate was 1.25kg/hr and thermal efficiency obtained was 93.6%. It was successfully used to smoke ice fish satisfactorily within 4 hours and the dripping fish oil was collected. The rate of moisture losses from the fish in each layer is equally. The recorded changes in the weight of the fish in the two layers were subjected to statistical analysis using paired sample t-test to determine if the differences in the changes in weights are significant or not. At both 1 and 5 % level of significant differences, the rate of change in weight of the fish in each tray is equal. The fan can be powered using AC power source or Liquid cell battery (12 volt). The kiln is not limited to fish smoking a lone, meat and similar products can also be dried in the kiln.

Keywords: Smoking, Kiln, Fish, Heat, Flow Rate.

1.0 INTRODUCTION
According to Akinneye et al. (2007) and Davies and Davies (2009) the development of appropriate fishing machinery and techniques that ensure effective production, handling, processing and storage, cannot be over emphasized especially now that aqua-cultural development is gaining popularity in Nigeria. Fish contains high levels of protein and omega-3 fatty acids. Protein helps the body build and repair tissue. Omega-3 fats boost joint and cardiovascular health. These fats can lower triglyceride levels and reduce the risk of arrhythmia. During pregnancy, omega-3 fats consumed by the mother are incorporated into fetal brain development. The body cannot make omega-3 fats, so they must be derived from food. Walnuts, flax seed, sea food and fish are the main sources of omega-3 fats in the human diet and only fish and sea food provide the forms Eicosopentaenoic Acid (EPA) and Docohexanoic Acid (DHA). Smoking combines the following three effects; cooking; if the fish are smoked at a high temperature, as in hot-smoking, the flesh will be cooked; this will destroy the enzymes and kill bacteria, drying:

The fire which produces the smoke also generates heat and this will not only cook but dry the fish as well and preservative value of the smoke: The smoke produced from burning wood contains a large number of compounds, some of which (e.g phenols) will kill bacteria. Smoked fish can be divided into two general categories;

1. Cold-smoked: During the smoking process, the temperature never rises to a level where the flesh is cooked (i.e.; the protein is denatured); this means a maximum temperature of approximately 30-40°C. Cold-smoking is practiced mainly in temperate climates.
   Tropical fish species can be cold-smoked at higher temperatures than temperate species because their proteins are denatured at higher temperature.
2. Hot-smoked: during the smoking process, the flesh is cooked .Traditional Smoking in tropical countries usually falls within this category.
   Several improved designs of kilns have been put forward to try to overcome the disadvantages of traditional smokers. These includes the Altona oven, Ivory Coast kiln, Adjetey oven and Chorkor oven all of west Africa. Others like Nyesi kiln and Mechanical smoker were developed to improve the efficiency of smoking fish. The equipment's or tools used in modern practice are as follows; Adjetey oven, Altona oven, Ivory coast oven, Nyegezi oven, Chorkor oven and Mechanical smokers.

2.0 METHODOLOGY

2.1 Design Consideration and Material Selection

The factors considered in the design and fabrication of the improved fish smoking kiln are: material of construction, others like Galvanized steel pipe 24mm and 44mm in diameter, Mild steel sheet 1.5mm and 3.0 mm thickness,1inch square pipe, Electrode 2.5mm, Electric arc welding machine, Gas welding machine, Cutting disc, Tape and Square rule.

The methods consider are; air flow system, heat distribution, spacing, smoking (drying) temperature, total weight of products, air leakage, ease of loading and unloading, vapour condensation, hygiene and durability and welding.

2.1.1 Material of construction

Charcoal as fuel has high heating value ranging from 27,912 to 30,234kJ/kg (Eyo, 1997). As a result, mild steel sheet 2 to 3mm gauge was considered for the construction of the combustion unit and mild steel 1.5 to 2.0 mm gauge was considered for the construction of the kiln body and cabinet which can withstand such a range of calorific valves. Also mild steel was considered in selecting collector and galvanize pipe was used in heat distribution in order to prevent corrosion of the material. Even heat distribution is achieved when fan blows sufficient air from the surrounding to the charcoal housing to ensure well burning of the charcoal fuel with fire, the heat generated from the burning charcoal fuel are uniformly distributed as hot air through perforated pipes (hot air vents) with the aim of forced air convection As charcoal requires air for combustion, an opening hole from fan housing connected to charcoal housing was allowed so that air generated from the fan can burns the charcoal and later be conveyed to the oven for even distribution. The spacing arrangement of the hot air vents, smoking trays and collectors were done in such manner that spaces are allowed for convenient and easy loading and unloading of the oven (cabinet). The estimated smoking (Drying) temperature considered in this design range between 60 to 120?c. A chimney is provided at the top centre of the oven to prevent vaporized moisture condensation on the products during smoking

(drying). The weight of about 7.0 to 8.0kg of products was considered to estimate the size of the tray and oven supports in order to withstand bending and static stresses due to direct loading.

2.1.2 Design calculations

a. Determining the thickness of material to be used in the combustion chamber.

Ndirika (1994) gave the expression for the heat input as in the equation below thus;

$$Q = M_f C_f \quad \text{----------2.1}$$

Where

Combustion rate charcoal (Mf) = 14.1 kg/hr (Khoshmanesh, 2006)
Heat valve of charcoal (Cf) = 30,238 Kj/kg
Therefore heat input Q will be
= 14.1kg/hr × 30,238 kj/kg
= 4.263558 ×106 KJ/hr

This valve ignores heat loss to the surrounding.

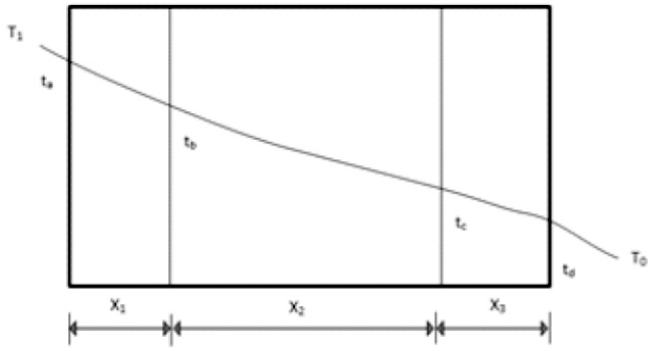
$$Q = -kA\,dt/dx$$
$$= kA(T_1 - T_2)/X \quad \text{---------- 2.2}$$

Where
k = 45.5 w/m k for a mild metal steel (Encyclopedia, 1996)
T_2 = Smoking temperature (0C)
T_1 = ambient temperature ($_0$C)
X = Material thickness (mm) of mild steel
A = Area = L × B ----------2.3
L = Length of charcoal box (250mm)
B = Width of charcoal box (210mm)
From equation 3.8, area of the charcoal box is computed as
A = 0.25 × 0.21
= 0.0525m^2

Considering it as frustum it become 1.2m^2
Sub stituting the valve of A, k, T_1 and T_2 in equation 2.2
X = 2.63mm
From the value of X obtained above, 3.0mm could be sufficient for the material thickness used in the combustion chamber.

b. Heat transfer analysis

The heat existing in the chamber is assumed to have uniform temperature distribution, resulting in a constant thermal property of air. There is heat loss in this chamber by conduction and thus loss could be calculated by considering the transferring of heat from inside the kiln's heat source (charcoal housing) to the kiln through the wall of the kiln which is made up of mild steel.



U = over all heat transfer coefficient and

$1/U = I/hc + hr + X_1/K_1 + X_2/K_2 + \text{----------} + X_n/K_n$ ----------3.4

Where

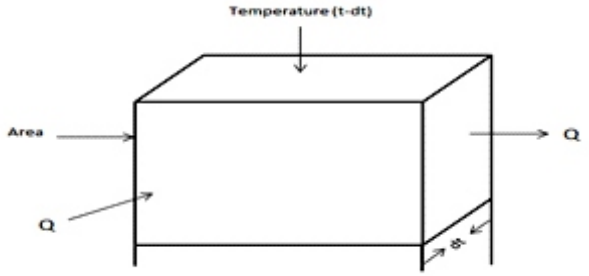
hc = convective heat transfer coefficient w/m^2 ?C

hr = radiation heat transfer coefficient w/m^2?C

K_1, K_2 and K3 are thermal conductivity of first, second and third material respectively all in w/m ? C.

X_1, X_2 and Xn are thickness of first, second and other material respectively all in meter (m).

This only occur in multi-layer wall, where the insulator is exposed to hot air A on the side with the temperature t_1 while the side at the temperature to is exposed to cooler air B.
In the case where only one layer is used as shown below,



$Q = -kA\,dt/dx$

By integrating the above equation will give

$$Q\,dx = -A\int_1^2 K\,dt$$

$Q = kA(t_1 - t_2)/X$ ---------- 2.5

In this case since only one layer was use , therefore from the equation 3.4 X_1, K_1 to Xn and Kn will be zero and the equation change (2.5)

Therefore total heat loss from the smoking chamber can be determined thus;

Area of top = area of bottom

$= 2(0.4 \times 0.5) = 0.4m^2$

Area of sides = $2(0.4 \times 0.7)$

$= 0.28m^2$

Area of front = area of back

$= 2(0.5 \times 0.7)$

$= 0.35m^2$

Total area = $0.4 + 0.28 + 0.35$

$= 1.03m^2$

Using equation 3. 5

$Q = kA(t_2 - t_1)/X$

$Q = 45.5 \times 1.03\,(60 - 32)/0.0015$

Q = 874813.33 Watts

If 1 watt = 1 J/hr

Then heat dissipated = Q / Processing time

= 874813.33/4

= 218703.33 joules/ hour

Total heat dissipated from the smoking chamber = heat dissipated × total area

= 218703.33 × 1.03

= 225264.43 j/hr

= 225264.43/1000

= 225.26kj/hr

c. Heat generated

The heat generated can be calculated by the expression below ;
Calorific value of charcoal = 7600kj/kg (Eyo, 1997)
Total processing time = 4 hours
4 hours (4×60×60) = 14400 seconds
Mass of charcoal used (burnt) = 5.0kg
Heat generated by burning 5.0 kg of charcoal will be = 7600 ×5 = 38000 kj

Therefore the heat generated in kilo joules per hour will be $= \frac{heat\ generated\ by\ the\ charcoal}{processing\ time} = \frac{38000}{4}$
= 9500 kj / hr

d. Heat dissipated by the charcoal box

From the equation above

$$Q = \frac{KA\,(t1-t2)}{x}$$

Where ;

K = thermal conductivity of mild steel 45.5 w/mk
A = area of the charcoal box 1.2 m^2
T_1 = temperature of the charcoal in the fire box
T_2 = temperature of outside wall of the charcoal box
X = thickness of the mild steel 3.0mm = 0.003m

Therefore, $Q = \frac{45.5\times 1.2\times(260-190)}{0.003}$

Q = 1092000 watts

But , 1watt = 1 J/hr

Therefore, heat dissipated by charcoal box = $\frac{Q}{Processing\ time}$

$= \frac{1274000}{4}$
= 318000 joules per hour
Amount of heat dissipated = heat dissipated × area
= 318500 × 1.2
= 382200 joules per hour
= 382200/1000
= 382.2 kj/ hr

The total heat dissipated = heat dissipated by the kiln smoking chamber + heat dissipated by the charcoal box

Total heated dissipated = 225.26 + 382.2
= 607.64 kj / hr

e. Thermal efficiency of the kiln

The fuel efficiency of the kiln can be calculated as

Useful heat = heat generated - total heat dissipated
= (9500 - 607.64) kj/hr
= 8892.36kj / hr

Therefore, thermal efficiency $= \frac{useful\ heat\ output\ (\frac{kj}{hr})}{heat\ \ generated\ (\frac{kj}{hr})} \times 100$

Fuel efficiency = $\frac{889.23}{9500} \times 100 = 93.6\%$

f. Fuel consumption rate

This determined the rate at which fuel (charcoal) is used up.

$$\text{Fuel consumption rate} = \frac{\text{amount(mass) of charcoal used(kg)}}{\textit{processing time(hour)}}$$

$$\frac{5.0\ kg}{4\ hour} = 1.25 \text{ kg/hr}$$

Therefore the fuel consumption rate = 1.25kg/ hr

g. Volume of the smoking chamber

The volume of the smoking chamber is the product of cross- sectional area of tray and height of the chamber. Therefore volume of smoking chamber is the product of cross sectional area of tray and height of the smoking chamber.

$= (370 \times 480) \times 700$
$= (177600 \times 700)\text{mm}$
$= 124320000\text{mm}^3$
$= 124.32 \times 10^{-3}\ \text{m}^3$

h. The capacity of the kiln

The capacity of the kiln was determined from the preliminary test, where the weight of three (3) samples of fresh fish were determined by using an electronic weighing balance.

Sample number	weight (g)
1	252.82
2	221.11
3	236.22

Average weight $= 252.82 + 221.11 + 236.22 / 3$
$= 710.15\text{g}/3$
$= 236.72\text{g}$

Therefore total capacity that the kiln can accommodate is the product of the number of fish occupied by the two trays and the average weight of the sample.
If 30 fish per tray was used then 236.72g × 30 × 2 (number of trays).

Total capacity of the smoking kiln = 14203g
Divide 14203g/1000 = 14.203kg

The total weight on the trays per load or batch will be 14.203kg. For each tray will carry 14.203kg/2 = 7.10kg

i.Air Flow Rate

For the design , appropriate fan selection to move large quantity of air into the smoking chamber is one of the essential parameter to considered, since the blower runs at the speed of the motor (1740rpm), then the velocity of air supplied by the blower is given by,

$$V_{air} = (\pi DN/60)\ \text{ms}^{-1}$$

Where,

V_{air} = peripheral speed of the blade (ms^{-1})
D = distance from centre of the shaft to the top end of the blade
N = revolution per minutes of the blower
Length of blade = 8.0 cm (0.8m)
Diameter of the shaft(rotor) is 2cm (0.02m)

Total diameter $(D) = (1 + 0.8)\,cm = 0.9m$
Using the above equation
Vair $= (\pi \times 0.9 \times 1740/60)$
Vair $= 81.99\,ms^{-1}$

To calculate the volume of air that must be delivered by the blower, that is,
Air flow rate = cross sectional area of blade × velocity
Where

Width of blower $W = 0.04m$
Blower length $L = 0.8m$
Velocity $V = 8.011ms^{-1}$
Volume of air $= L \times W \times Velocity$
$= 0.8 \times 0.04 \times 81.99$
$= 2.62\,m^3s^{-1}$

Since there are six blades, then we have
$2.62 \times 6 = 15.74\,m^3s^{-1}$
Allowing for 30% excess air, actual volume of air $= 0.7 \times 15.74$
$= 11.02\,m^3s^{-1}$

j. Pressure on the floor of the tray weight

Weight of material with the tray = 139.33 N
Cross sectional area of tray $= 0.48m \times 0.37m$
$= 0.1776\,m^2$
Pressure on the floor of each tray can be estimated from equation below;

$P = F/A$ 2.6

Where

P = pressure (N/m^2)
F = load on the tray (N)
A = cross sectional area of the tray (m^2)
$P = F/A = 139.33 / 0.1776$
$= 784.52\,N/m^2$

The calculated pressure 784.52 N $/m^2$ is a large value, in order to avoid sagging of the mesh wire, galvanize material was used to resist this effect and that of rusting.

k. Determining the size of the tray supports

In order to avoid deflection due to applied loading, the correct size of support is necessary to maintain balance weight.

Total weight on the support = weight of the pan + weight of fish
Weight of pan (mesh wire) = 0.40 kg
Weight of two pans = 0.80 kg
Weight of fish for the two pans = 15.003 kg
Total weight on a tray = 14.203 kg
$= 14.20 \times 9.81\,N = 139.30\,N$

Distributed load on the tray $= \frac{139.30}{2} = 69.65\,N$

Total length of tray = 0.48 m

Weight per unit length W $\frac{69.65}{0.48}$

$= 145.10\,N/m$

The reactions at the supports $R_1 = R_2 = \frac{WL}{2}$ 2.7

Maximum bending moment (Mmax) $= \frac{WL^2}{8} = 4.19$ N/m

Ultimate strength of mild $S_Y = 483$ MN/m^2

Section modulus = ... 2.8

Using the above equation $\frac{Mmax}{Sy}$ suming a factor of safety to be 2.7, the section modulus of the support will be

$$Z = 2.7 \frac{Mmax}{Sy} \quad \text{..... 2.9}$$

$= 0.0234$ m

For a circular section of a support, the section modulus,

$$Z = \frac{1}{32}\pi D^3 \quad \text{..... 2.10}$$

Where D = diameter of the support.
we have d = 0.0234 m
Therefore, it is much safe to use 0.025 m diameter support rods to maintain stability of the pan in the oven.

2.2 Description and Working Principle of the Oven (Fish Dryer).

The oven consists of two trays (layers) made from mild steel sheet metal eight angular supports, combustion unit , door and fan. The oven is rectangular in shape, the oven is simple, efficient and capable of holding charcoal fuel for 4 hours and above with uniform supplied of air (revolution speed)when using electricity but varies when using battery as the cell get weaker.

The oven has a capacity to carry the pan content of about 8.0 ? 16.0 kg product per batch fish smoking, the oven is easily manipulated in terms of function. There is provision for adjusting the trays (mesh wire) depend on the sizes of the fish to be smoked. The overall dimensions of the oven is 50cm length, 40cm width and 80cm high with handles for lifting purpose latch for locking the oven cabinet.

Plate 3.1 shows the back view of the fabricated oven while plate 3.2 shows the front view. The fan (blower) powered by a DC motor supplies ambient air from the surrounding to the burner (combustion chamber) containing the desired quantity of charcoal. Heat from this combustion chamber is distributed by forced convection to the product on the trays through the perforated pipes (hot air vent). Moisture removed from the fish escape to the atmosphere through the chimney to provide quick drying of the product in the cabinet. Smoking could be completed without refueling. Even when it is necessary to refuel during the smoking (drying) process, provision is made for easy refueling.

3.0 RESULTS AND DISCUSSIONS

The curing process of the fish was as accomplished, salted and finally placed on the wire mesh trays and water allowed to drip off weighed and recorded. The fish were then loaded into the smoking chamber ready for smoking. Heat was supplied to the kiln by forced convection from a fan blowing air through the combustion chamber, containing ignited charcoal into the perforated heat distribution pipes. Results of performance test using AC to power the designed fan are shown on the table 4.1 below. The table 4.1 shows the detailed of the weight of fish on each layer (tray), oven temperature and relative

humidity during the smoking (drying) period. From the results recorded in the table average uniform temperature of 60 °C was achieved. The weight of the fish in each layer were determined at regular interval of ten (10) minutes and recorded as shown on the table 4.1. The rate of moisture losses from the fish in each layer is equally. The recorded changes in the weight of the fish in the two layers were subjected to statistical analysis using paired sample t-test to determine if the differences in the changes in weights are significant or not. At both 1 and 5 % level of significant differences, the rate of change in weight of the fish in each tray is equal.

From the figure 3.1 the relationship between the changes in temperature with respect to change in period of smoking fish can be deduced. The oven temperature increased progressively to the point of stability (after 3 hours), the oven temperature remained constant at 60°C. Figure 3.2a and 3.2b shows the change and differences in weight of the fish in the layers (trays) during smoking period. The losses in weight of both layers on the trays indicate that there was a progressive drying of the fish within the smoking chamber and that the rate of drying is uniform. The test was carried out with environmental relative humidity of 80% at starting time which later reduced to 57% indicating that the product (fish) loose appreciable water.

4.0 CONCLUSIONS

An improved fish smoking kiln was designed and fabricated. Performance evaluation gave a thermal efficiency of 93.6%. The kiln attained an internal temperature of 60°C after about 3 hours and maintained it afterwards. The fish from each layer reduced from 1.10kg to 0.4kg after smoke - drying for four hours. The smoked fish was neat and uniform in colour. Fish oil flowing out during the drying process was collected. This is a major advantage over the traditional smoking process where the oil cannot be collected as it drips into the fire. Fish oil has several uses. The kiln is not limited to fish smoking alone; meat and similar products can also be dried in the kiln.

REFERENCES

Akinneye, J.O., Amoo, I.A. and Arannilewa, S.T. (2007). Effect of drying methods on the nutritional composition of three species of (Bonga sp, Sardinella SP and Heterotis niloticus). Journal of Fisheries International, 2(1):99-103.

Akinola, O.A., Akinyemi, A.A. and Bolaji, B.O. (2006). Evaluation of Traditional and solar drying systems towards enhancing fish storage and preservation in Nigeria (Abeokuta Local Government as a case study) Journal of Fisheries International 1(2-4): 44-49.

Davies, R.M. (2006). Mechanization of fish industry in Nigeria status and potential for self-sufficiency in fish production. A paper presented at a one-day workshop on intensive fish farming. 19th August, 2006. 10pp.

Davies, R.M. and Davies, O.A. (2009). Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria. European Journal of Scientific Research, 26(4): pp. 539-548.

Encyclopedia Britannia (1996). The oxford press Ltd.

Eyo, A.A. (1997). Post-harvest losses in the fisheries of Kanji Lake. A consultancy report submitted to Nigerian/German (GTZ) Kanji lake fisheries promotion project, March 1995, 75pp.

Okonta, A. A. and Ekelemu, J. K. (2005). A prelimnary study of micro-organisms associated with fish spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual Conference of The Fisheries Society of Nigeria (FISON), Port Harcourt, 14th-18th November, 2005.557-560pp.

Khoshmanesh, S. (2006). Design of Solar Dehydrator, Coupled with Energy Storage in Rock Bed Reservoir for Fish Drying Process. International Conference.

Table 3.1 Shows The Detail Results Obtained Containing in the Two Layers

Time (min)	tempt.C	W_{fm}, kg		W_m, kg	W_f, (kg)		change in weight of fish (kg)		RH, %
		Layer 1	Layer 2		Layer 1	Layer 2	Layer 1	Layer 2	
10	33	1.5	1.5	0.4	1.1	1.1	0	0	80
10	35	1.47	1.48	0.4	1.07	1.08	0.04	0.03	80
10	37	1.44	1.45	0.4	1.04	1.05	0.03	0.03	80
10	38.5	1.42	1.43	0.4	1.02	1.03	0.02	0.02	80
10	40	1.41	1.42	0.4	1.01	1.02	0.01	0.01	80
10	42	1.4	1.41	0.4	1	1.01	0.01	0.01	80
10	41	1.38	1.39	0.4	0.98	0.99	0.02	0.02	80
10	43	1.36	1.37	0.4	0.96	0.97	0.02	0.02	80
10	45	1.34	1.34	0.4	0.94	0.94	0.02	0.03	80
10	47	1.31	1.32	0.4	0.91	0.92	0.03	0.02	80
10	48	1.28	1.29	0.4	0.88	0.89	0.03	0.03	80
10	49.5	1.26	1.27	0.4	0.86	0.87	0.03	0.02	80
10	51	1.21	1.22	0.4	0.81	0.82	0.05	0.05	80
10	53	1.61	1.17	0.4	0.76	0.77	0.06	0.05	80
10	55	1.1	1.11	0.4	0.7	0.71	0.06	0.06	80
10	56	1.08	1.09	0.4	0.68	0.69	0.02	0.02	80
10	57	1.04	1.05	0.4	0.64	0.65	0.04	0.04	80
10	59	0.98	0.99	0.4	0.58	0.59	0.06	0.06	80
10	58	0.94	0.92	0.4	0.54	0.52	0.04	0.05	80
10	60	0.89	0.89	0.4	0.49	0.49	0.05	0.03	65
10	60	0.86	0.87	0.4	0.46	0.47	0.03	0.02	65
10	59.5	0.83	0.84	0.4	0.43	0.44	0.03	0.03	65
10	60	0.81	0.82	0.4	0.41	0.42	0.02	0.02	57
10	59	0.8	0.8	0.4	0.4	0.4	0.01	0.01	57
10	60	0.8	0.8	0.4	0.4	0.4	0.01	0.01	57

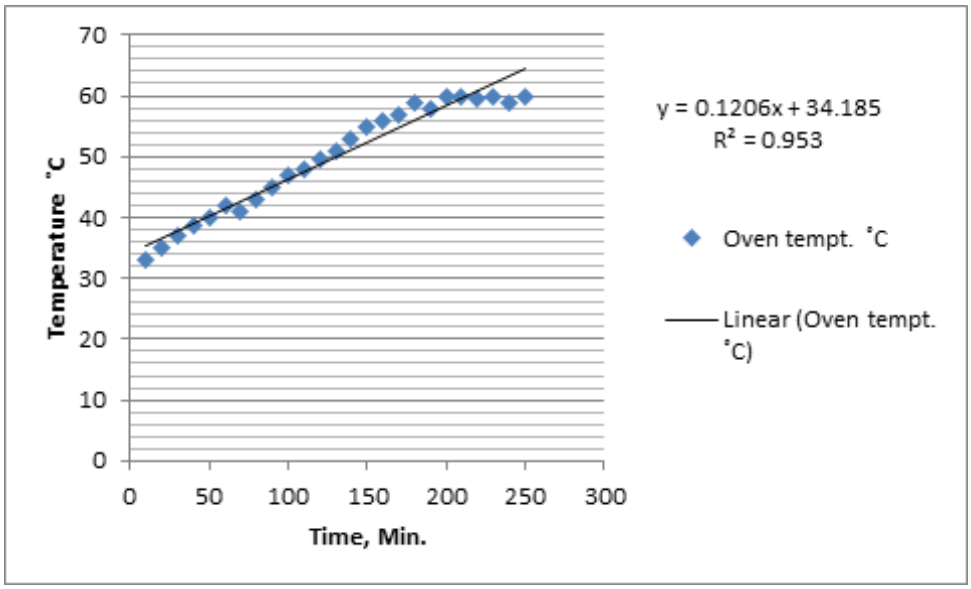


Figure 3.1 Shows The Relationship Of Temperature Against Time

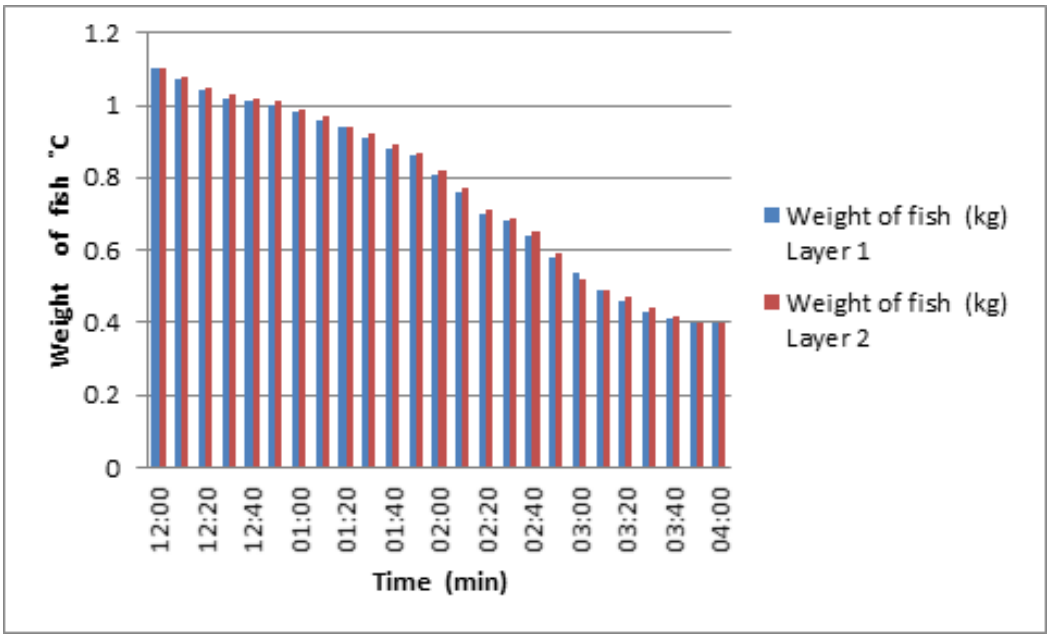


Figure 3.2 Shows The Relationship Of Fish Weight Against Time

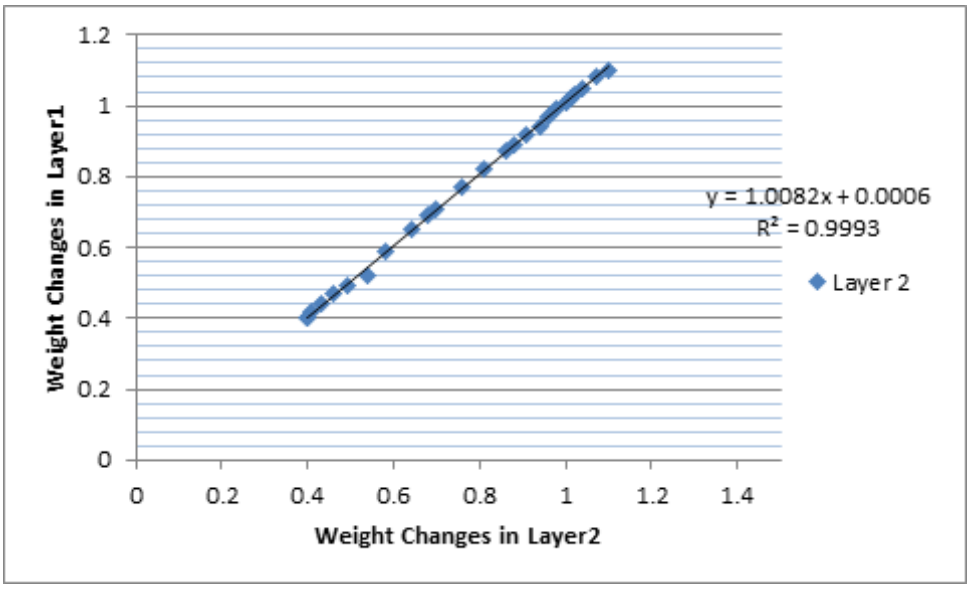


Figure 3.3 Shows The Relationship Of The Progressive Changing In Weight In Layer1 and Layer2



Back View Of The Smoking Kiln



Front View Of The Smoking Kiln

REVIEW OF HOUSEHOLD PALM OIL PROCESSING AND STORAGE IN THE SOUTH EASTERN NIGERIA

*** Onyenwoke C.A., M.C. Ndukwu, A.U. Ezenta**
Department of Agricultural and Bio Resources Engineering, College of Engineering and Engineering Technology , Michael Okpara University of Agriculture Umudike, P.M.B 7267 Umudike, Abia state.
Corresponding Author: (maigidaaus@yahoo.com, austynchuka@yahoo.com; phone: +2348068089373,)

ABSTRACT
Palm oil is an important oil seed. The method of processing and storage of the palm oil affects the quality of palm oil produced. In Nigeria major supply of palm produce is dominated by household supply chain. Various method adopted by this households presented in this paper showed the crude state of processing and storage of palm oil in Nigeria. It also reveals the dilapidated environment in which this processing and storage is done. The paper concludes that this method of processing, storage and the surroundings where they are done contribute to the low quality of the palm oil produced.

Keywords: Palm Oil, Palm Kernel Oil, Storage, Processing, Containers.

1.0 INTRODUCTION

Palm oil is acclaimed to be the world richest oil seed (Ndukwu and Asoegwu 2010). Palm oil is rich in carotenoids, (pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic; hence it is a viscous semi-solid, even at tropical ambient, and a solid fat in temperate climates. Because of its economic importance as an high-yielding source of edible and technical oils, the oil palm is now grown as a plantation crop in most countries with high rainfall (minimum 1 600 mm/yr.). In 2007, the value of world trade in oilseeds and oilseed products was estimated to be 83 billion dollars. This is equivalent to 13% of the total agricultural trade and palm and kernel oil was reported to be the third most valuable component of this total world agricultural trade, next to meat and cereals (FAO 2008).

Palm oil is produced in tropical climates and about 42 countries across the world produce and export palm oil and the by-products. Global production of palm oil mainly occurs in South-East Asia and Africa (Ndukwu and Asoegwu 2010). Several African nations are currently producing palm oil on a commercial scale but in Nigeria the supply of palm oil is dominated by households. The very few mechanized palm oil mill are either not functioning or functioning below capacity. Therefore most of the supply comes from the wide with very few palm plantations available. This is why it is difficult to classify the palm oil produced based on specie because palm oil produced mostly in the country is produced from a mixture of dura, tenera and pacifera. Nigeria is currently the third largest producer of palm oil in the world after Indonesia and Malaysia (USDA, 2011). However in the country most palm oil produced does not reach the final consumer. A lot of them were usually lost in the processing and storage stage in the supply chain. Some of them which managed to reach the market were rejected due to rancidity and other contaminations.

Because palm oil producers watch the market price, they tend to store their

produce pending when the price will be right for them to sell. As a result they adopt several storage techniques using different storage material to store this product. Some of these materials are placed in an unhygienic environment resulting in the contamination and deterioration of the palm oil. Since the rate of oxidation of the oil increases with the temperature of storage the oil is normally maintained around 50°C, using hot water or low-pressure steam-heating coils, to prevent solidification and fractionation. Iron contamination from the storage tank may occur if the tank is not lined with a suitable protective coating. The farmers because of their level of income were unable to adopt state of the art processing and storage facilities therefore achieving this storage conditions is difficult.

This paper is aimed to review the processing methods and different material used to store palm oil in Nigeria. This will highlight the untapped opportunity in this money spinning area for both local and international investors which has the potential of revolutionizing Nigeria economy and make it less dependent on crude oil. Countries in south Asia like Indonesia and Malaysia has adopted improved processing and storage of this crop to a great success and is ranked among the twenty world biggest economy. Revolutionizing palm oil processing and storage in the country can help the country to de-emphasize on crude oil exploration and production which has greatly damaged our environment.

2.0 PROCESSING OF PALM FRUIT

2.1 Threshing and Sterilization

The fresh fruit bunch consists of fruit embedded in spikelet growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelet from the bunch stem with an axe or machete. The fruit is threshed by manually separating from the spikelet by hand or beaten them with sticks after they are allowed to ferment. Children and the elderly in the village earn income performing this activity for their various quantity of harvest from the wild while some are employed as casual labourer in semi mechanized factories around the country. This method introduces a lot of debris into the process which most of the time not removed and digested together. This affects the quality and colour of the palm fruit, thus their market value. In a mechanized system a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelet on the stem.

Figure 1, shows the sterilization of palm fruits and the unhygienic environment. Sterilization or cooking is the use of high-temperature wet-heat treatment to loosen fruit. Locally cooking is done with hot water. Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation. Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed (Thompson, 2010). The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure. Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process (Thompson, 2010). The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily. The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water, when broken down by wet steam (hydrolysis), so that they can be removed during oil clarification (Thompson, 2010). Starches present in the fruit are hydrolyzed and removed in this way. During sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high

during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discolouration of palm kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake (Thompson, 2010).

Most small-scale processors do not have the capacity to generate steam for sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelet absorb a lot of water in the cooking process. High-pressure steam is more effective in heating bunches without losing much water. Therefore, most small-scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization systems thresh bunches after heating to loosen the fruits. Walking around the various processing points reveals the poor state of the vicinity where this processing is done. The method shown in figure 1 is generally used around the country and sterilizes a small quantity at a time. This method of boiling and sterilization is unhygienic, time consuming and exposes the labourers to steam or water burn and dehydration from the heat. Palm oil produced is usually not of good taste, dark coloured, not healthy for human consumption and generates a lot of sludge during clarification with low percentage of oil according to the farmers. However the farmers have no alternative since this is the only means available to them even in semi mechanized mill around.

2.2 Digestion, Pressing And Clarification of the Palm Oil

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. Digesting of palm fruit in so many households in the country takes different methods. It was observed that in some households they digest the palm fruit before pressing while some digest and press at the same time using a manual screw press. For those that digest before pressing they adopt several methods. In some households, they digest the palm fruit by matching on the cooled sterilized palm fruit with their bare feet. The digested fiber is mixed with water. The fiber and the kernel settle down while the water is scooped and clarified by boiling. In some cases the palm fruit is pounded inside the pestle with mortar (figure 2). The fiber is then separated manually with hand before manually pressing them with a spindle. All this method introduces contamination to the processing therefore requires an efficient and effective method which will produce palm fruit of high grade with high throughput.

The only advantage in this method of digestion is the low risk of iron contamination due to the use of wooden materials. Contamination from iron is greatest during digestion when the highest rate of metal wear is encountered in the milling process. Iron contamination increases the risk of oil oxidation and the onset of oil rancidity (Thompson, 2010). However some semi mechanized mill adopts the use of digester. However this digesters and press are at different state of decay with a high risk of metal wear and loss of palm fruit from broken point.

The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. Through the action of the rotating beater arms the fruit is digested. Digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits, outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilization phase. Unfortunately, most small-scale digesters does not have the heat insulation and steam injections that help maintain their contents at elevated temperatures during this operation. Therefore the quality of the oil is compromised.

Clarification of palm oil in various households, involves boiling of the crude oil with water for some time. This is usually done with steel pot placed on a triple stand and fired by wood. The boiled mixture is allowed to cool before the palm oil (figure 3) is scooped into various containers for storage. Because of the boiling of the palm fruit in water the palm oil produced will contain high percentage of water added to the poor

environment of processing that enhances microbial growth which is a problem during preservation.

3. 0 PRESERVATION AND STORAGE

3.1 The General Principles of Preservation Include:

The general principles of preservation include:

I. Destruction of enzymes (a complex organic substance which in solution produces fermentation and chemical changes in other substances apparently without undergoing any change itself) in the raw material and contaminating micro-organisms by heat (sterilization) during processing;

II. Elimination of as much water as possible from the oil to prevent microbial growth (bacterial activity, or disease-causing germs) during storage. The oil therefore has a long shelf life due to its low moisture content.

III. Proper packaging and storage of the extracted oil to slow down chemical deterioration (rancidity).

3.2 Factors Determining Selection of Material For Palm Oil Storage

Different materials are selected for the storage of oil palm. There are certain factors to be considered before selecting containers for palm oil storage. Various discussions with household palm oil producers and marketers show that the quality of stored product is in the least of their consideration when selecting container for storage. Their consideration in the order of importance includes, the quantity of palm oil, what they want to use the oil for, method of transportation, measuring material for sales, duration of the storage and available materials

3.3 Materials For Storage of Palm Oil and Palm Kernel Oil

Different materials are used for storage of palm oil in different countries. In Nigeria for example, different materials used for storage of palm oil includes tanks, drums (figure 4), tins, steel pots, jerry cans (figure 5), bottles , pails, basins and calabashes. The problem with storage of palm oil in Nigeria is the inability of those involved to maintain clean and decent environment.

4.0 CONCLUSION

Processing and storage of palm oil is facing a lot of challenges in Nigeria. The method of processing does not guarantee the expansion of the industry due to low level of processing technique. The crude methods adopted by various households are unhygienic with low output. Not all the palm oil that is produced is used up at the same time. Some are preserved for consumption; some are preserved as raw materials for industries. For good preservation to achieve, a good storage material should be used to avoid contaminating with ferrous and rust particles. In case of raw material for industries, the material that will maintain the quality of the oil throughout the storage period should be used. Strong and durable storage materials should be used to avoid damage of the material and shortage of volume of the oil. Good and decent environment should be maintained

REFERENCES

FAO, 2008. Trade Yearbook, vol. 55. Rome, Italy.

FAO (2011), New Britain palm oil plans- sustainable bakery ingredients and food service

packing operation.

Ndukwu M.C; S.N.Asogwu 2010**:** Functional performance of a vertical shaft centrifugal palm nut cracker. Research in agricultural engineering journal 56(2)77-83
Thompson. A. (2010) African Case Study: Palm Oil and Economic Development in



Figure 1: Sterilization of Palm Fruit In Eastern Nigeria With Open Steel Pot Revealing Debris Mixed With Palm Fruit Being Scooped For Digesting



Figure 2: Digestion Of Palm Fruit With Pestle In The South East



Figure 3: Clarified Palm Oil Ready For Storage



Figure 4: Drums Used In Storage



Figure 5: Different Storage Materials Of Palm Oil.

ASSESSMENT OF RICE PROCESSING OPERATIONS IN EKITI STATE, NIGERIA

Okunola, A.A. and Adekanye, T.A
Department of Agricultural and Biosystems Engineering, Landmark University, P.M.B.1001, Omu – Aran, Kwara State, Nigeria
Corresponding author abiodunokunola@yahoo.com, +234-8062294254

ABSTRACT
An investigation survey was carried out to examine factors affecting processing and quality of rice in Ekiti State, Nigeria. Nine major towns were selected from six Local Government Areas involved in rice production in the State. A structured questionnaire was used to collect information from ninety-two (92) rice processors. Findings revealed that 57% of the processors were males and their ages ranged between 30-39 years. 66.7% of the processors have family size ranged within 4 to 7 persons. Also low educational status is one of the factors affecting the rice quality and high incidence of machine breakdown, 63.78% of them have only primary education and 22.67% have no formal education. 70% of rice is gotten from middle men and 80% of the processors used their personal savings as capitals. 70% of the milling machines used was obsolete being single pass type characterized with high broken grains and 90% of the processors depend on diesel engines to power the mills because of erratic power supply while 7% had access to good storage facilities. None of the processors had accesses to a rice destoner.

Keywords: Rice Processing; Milling Machines; Operator; Storage Facilities; Power Source.

1.0 INTRODUCTION
Rice is the staple food of more than 60 percent of the world's population and the total world production of rice is estimated at 535 million tons. (IRRI, 1997). Rice is a preferred stable food in many developing countries including Nigeria. The average human consumption is 21kg / year (WARDA, 2004). Rice is a structural component of Nigeria diet and is a widely grown crop because of its economic importance. Nigeria is the highest rice producer in West Africa, producing an average of 3.2 million tons of paddy and 2 million tons of milled rice (Daramola 2005). Nigeria is also the largest consuming nation in West Africa, with the growing demand estimated to 4.1 million tons in 2002 and only about half of that demand met by domestic production (FAO, 2003) as reported by Agwu and Adeniran, 2009. About 3 million metric tons of paddy rice which constituted 80% self sufficiency was produced in Nigeria in 2000. Akande *et. al.* (2003) and it increased to 3.4 million metric tons in 2009 (FAO STAT, 2009). Nigerians prefer the locally processed rice because of its taste as well as highly nutritious (Longtau, 2002; Ibukun, 2008). Apart from the qualitative deficiencies of pebbles, chaff and broken grains which had been attributed to the low technology input in the processing methods, the product is in short supply. In reality, the demand for local rice is higher in urban areas than rural areas due to higher population and its acceptability as a delicacy in social functions and fast foods shop. Post harvest losses are common phenomena in all grain production and it is estimated to occur between 30 – 40% of total productions of all crops in developing countries (Badawi 2001). These losses occur right from the field during harvesting and throughout the processing operations.

Ekiti rice, popularly called *Igbemo* is an upland variety and has gained very wide

is that of processing activities; parboiling, drying and milling, which are of small scale where special skills and technologies are lacking.

1.1 Rice Processing in Nigeria:

Nigeria as a developing country has not fully implemented modern methods of rice processing. Most farmers and processors still practice the local or traditional methods. Akande et. al. 2003. Harvesting is done when 80% of the grain has turned to straw colour. The harvested rice are packed from the field immediately or tied into bundles and placed upright to avoid them from coming in contact with the moist soil and also preventing the germination of the paddy which have little or no dormancy. The low level technology input in rice production has contributed to high grain losses and poor quality of Nigerian rice (Akpokodje et. al. 2001; Okunola, 2011).

Processing of rice is basically divided to two methods- traditional and modern methods.

Traditional method involves beating or gentle pounding with pestle and mortar to remove grain from straw while modern method involve threshing and milling. Processing of paddy is only milled where raw paddy rice is concerned or parboiled, dried and milled for parboiled paddy rice. Polishing / whitening may be done to further improve the appearance, though some nutritious part is removed (Agidi, 2001;Okunola, 2011; Okunola and Bamgboye, 2011a). Rice processing require special skills because large percentage of broken rice are not desirable in commercial packages, yet rice is brittle, nearly one-third may be broken during milling and have to be sold at a lower price (IITA, 2004; Okunola and Bamgboye, 2011b). Milled rice consists of approximately 90% carbohydrate, 90% protein and 1% fat and fibber (Aravillo et. al, 1976; Ibukun, 2008).

Rice processing in Ekiti State involves the following steps;

1. Harvesting of the crop is done at crop maturity.
2. The produce is exposed to sun for drying in the field.
3. Threshing is done afterwards to separate the paddy rice from grain head
4. The produce is then bagged for transportation to the processing centre
5. Parboiling of the paddy rice is the first step in the processing centre
6. Sun drying of the parboiled rice
7. Milling (de-husking) of the rice is done after it has dried properly
8. Winnowing/cleaning is then carried out on the de-husk rice

Objectives of this study were to assess the present level of rice processing, identify constraints in rice processing and to identify deficient skills in rice processing in Ekiti State, a major rice producing state in South West of Nigeria. The result of this study can be utilized in improving post harvest activities of rice processors by focusing on the processing stages with low level of mechanization

2.0 METHODOLOGY

2.1 Area of Study

This study was carried out in rice producing towns in six local Government Areas (LGAs) in Ekiti State, Nigeria. The LGAs are Efon Alaye, Irepodun / Ifelodun, Ido / Osi, Gboyin, Oye and Ikole. The study region accommodates about 44.2% of the state population. Systematic sampling techniques were used to select nine towns in the State; namely, Erio, Afao. Igbemo, Ode, Ijan, Efon Alaye, Ikere, Oye and Ikole. Ninety-two (92) respondents were randomly selected from the study region. The data collected were analyzed and interpreted by using descriptive statistics.

3.0 RESULTS AND DISCUSSION

Result in Figures 1 and 2 show that both males (57%) and females (53%) were involved in rice processing in the study area. Women were involved mostly in winnowing (88%) and parboiling (83.5%) while men engaged mostly in milling (87.7%).

Figure 3 shows age of rice processors in the study area. 67% of the processors range between 30 -39 years and 28% are between 40 - 49 years. This implies that majority of the rice processors were adults and middle aged people.

Educational backgrounds of rice processors in the study area are presented in Figure 4. 30% of the respondents had no formal education, 50% of them had primary school education and 6% had post-secondary education. Majority of the rice processors had low education and this may make it difficult for them to understand technicalities involved in rice processing. The low level of education of rice processors also affects the quality of rice processed since they are unable to use modern rice processing machineries as shown in Figure 5 which shows that many of the respondents are unskilled.

3.1 Sources of Power For Rice Milling

Sources of power for rice milling are presented in Figure 6. 57% of the respondents used petrol and/or diesel fuel for milling operations, only 11% depended on electricity while 24% of the rice processors use electricity, petrol and diesel. This category of respondents was operating at low level and could not afford machines. Many of the respondents preferred diesel fuel (though it costs more than petrol) because electricity supply was not consistent in Nigeria and incessant scarcity of petrol.

3.2 Sources of Capital

Figure 7 shows sources of capital of the rice processors. 48% of the processors depend on their personal savings; 27% obtained cooperative loan; 5% were assisted by the State government through Government Assisted Project Loan; 13% of the respondents were assisted by their family members while only 2% of the processors obtained bank loans. Lack of adequate capital is a significant factor limiting rice processing in the study area. These rice processors could not accessed bank loans due to many factors like illiteracy and high interest on loans. State government and banks should assist these processors so as to boost their production.

3.3 Level of Storage Facilities

Figure 8 shows level of storage facilities. It was discovered that majority (78%) of the processors lack storage facilities while only 14% had storage facilities. Lack of storage facilities is another major constraint to rice processing as processors produced at a low level to reduce wastage or deliberately delay processing operations till market days when buyers were ready to buy. These subjects rice to contaminations whereas processors who had storage facilities could employ skilled labour and produce large quantities.

4.0 CONCLUSION

This study assessed level of rice processing as well as constraints in Ekiti State, a major rice producing state in South West of Nigeria. The constraints identified are as follows

- Low level of education.
- Inadequate capital affected the level of production of the respondents,
- Lack of storage facilities,

- Cost of rice processing machines,
- High cost of fuel and
- Contaminations most especially stones

5.0 RECOMMENDATIONS

In order to improve the quality and quantity of rice production in the study area, the following recommendations are made:

- Government should provide storage facilities to rice processors as this would increase production
- Efforts must be made to collaborate with the stake holders and ensure training programmes for skill acquisition (workshops, seminars) are conducted regularly on standard processing techniques to educate rice producers.
- Modern milling machines (multi pass) and destoners at subsidized rates should be made available to the rice processors to improve the quality and quantity of local rice thereby improving the market value.
- Government should collaborate with some research institutes such as National Centre for Agricultural Mechanization (NCAM), Nigerian Institute of Social and Economic Research (NISER) as well as Agricultural Rural and Management Training Institute. (ARMTI) to fabricate affordable rice processing plants locally and establish extension services with engineering component for operation and maintenance.
- Research works on removing stones in locally produced rice should be encouraged.

REFERENCES

Adu E. A, Isiaka A. A, Awagu E. F, Aminu M. D Olayemi F. F, Study On The Level Of Mechanization Of Rice Processing In Kano State, Nigeria 2012 International Journal of Engineering Research & Technology Vol. 1, 10, 1-15. www.ijert.org

Agidi, G. 2001. The Effect of variety and processing parameters on rice (*Oryza sativa* L) quality. Ph.D. Thesis. Dept. of Agricultural Engineering University of Ibadan, Ibadan, Nigeria. xix + 264pp

Agwu, A.E., Adeniran, A.A. (2009). Sources of agricultural information used by arable crop farmers in Isale Osun farm settlement, Osogbo Local Government Area of Osun State. Journal of Agricultural Extension, 13(1), 24-34.

Akande, T., Olokesusi, F., Akanji, B., Akpokodje, G., Adeoye, G. 2003. Final draft report

of Nigerian Rice Production. United Nation Environmental Protection. Retrieved Sept 15, 2007, from http://www/.unep.ch/etb/events2003/200319feb /RiceNigeria.pdf

Akpokodje, G. , Lancon F. and Erenstein O. 2001 Nigeria rice economy; state of the art WARDA, Bouake pp 43 – 67.

Badawi, A.T. 2001. A proposal on rice post-harvest losses. Workshop on the Development in rice agronomy and effects on yield and quality. Agriculture Research Centre, Egypt.

Daramola, B. (2005). Government policies and competitiveness of Nigeria rice economy. Paper Presented at the Workshop on Rice Policy and Food Security in Sub – Saharan Africa, WARDA Cotonou. Republic of Benin.

FAOSTAT. 2009. Food and Agricultural Organisation data base on crop production. Retrieved October 19, 2011 from http://faostat.fao.org/site/339/default.aspx

GAIN. 2007: Global Agricultural Information Network Senegal Grain and Feed Regional Rice Annual No. SG 7003.

Ibukun, E. O. 2008. Effect of prolong parboiling duration on proximate composition of rice. *Scientific Research and Essays* 3:7. 323 – 325.

IRRI 1997. Rice facts, IRRI Los Banos, Philippines.

Okunola A.A. 2011. Development of a rice cleaning and grading machine. A Ph. D. Thesis Dept. of Agricultural Engineering University of Ibadan, Ibadan, Nigeria.

Okunola A. A. and A. I. Bamgboye, 2011a. Development of a rice cleaning and grading machine CIGR Section VI International Technical Symposium Towards a sustainable food chain process Nantes, France http//www:impascience.eu/CIGR/ 510-proceedings/013_sessions2.3postharvest.pdf?

Okunola A.A. and A.I. Bamgboye, 2011b. Evaluation of milling characteristics of some varieties of paddy rice in south west Nigeria. 9th Nigerian Institution of Agricultural Engineers International Conference, Ilorin, Vol.32, 517 – 519.

West Africa Rice Development Association, (WARDA, 2004). Annual report. 2002-2003. The Africa Rice Center, Bouake', Cote d'Ivoire, http://www.warda.org. (retrieved, 13th August 2013)

- Low level of education.
- Inadequate capital affected the level of production of the respondents,
- Lack of storage facilities,
- Cost of rice processing machines,
- High cost of fuel and
- Contaminations most especially stones

5.0 RECOMMENDATIONS

In order to improve the quality and quantity of rice production in the study area, the following recommendations are made:

- Government should provide storage facilities to rice processors as this would increase production

- Efforts must be made to collaborate with the stake holders and ensure training programmes for skill acquisition (workshops, seminars) are conducted regularly on standard processing techniques to educate rice producers.
- Modern milling machines (multi pass) and destoners at subsidized rates should be made available to the rice processors to improve the quality and quantity of local rice thereby improving the market value.
- Government should collaborate with some research institutes such as National Centre for Agricultural Mechanization (NCAM), Nigerian Institute of Social and Economic Research (NISER) as well as Agricultural Rural and Management Training Institute. (ARMTI) to fabricate affordable rice processing plants locally and establish extension services with engineering component for operation and maintenance.
- Research works on removing stones in locally produced rice should be encouraged.

REFERENCES

Adu E. A, Isiaka A. A, Awagu E. F, Aminu M. D Olayemi F. F, Study On The Level Of Mechanization Of Rice Processing In Kano State, Nigeria 2012 International Journal of Engineering Research & Technology Vol. 1, 10, 1-15. www.ijert.org

Agidi, G. 2001. The Effect of variety and processing parameters on rice (*Oryza sativa* L) quality. Ph.D. Thesis. Dept. of Agricultural Engineering University of Ibadan, Ibadan, Nigeria. xix + 264pp

Agwu, A.E., Adeniran, A.A. (2009). Sources of agricultural information used by arable crop farmers in Isale Osun farm settlement, Osogbo Local Government Area of Osun State. Journal of Agricultural Extension, 13(1), 24-34.

Akande, T., Olokesusi, F., Akanji, B., Akpokodje, G., Adeoye, G. 2003. Final draft report of Nigerian Rice Production. United Nation Environmental Protection. Retrieved Sept 15, 2007, from http://www/.unep.ch/etb/events2003/200319feb /RiceNigeria.pdf

Akpokodje, G. , Lancon F. and Erenstein O. 2001 Nigeria rice economy; state of the art WARDA, Bouake pp 43 – 67.

Badawi, A.T. 2001. A proposal on rice post-harvest losses.Workshop on the Development in rice agronomy and effects on yield and quality.Agriculture Research Centre, Egypt.

Daramola, B. (2005). Government policies and competitiveness of Nigeria rice economy. Paper Presented at the Workshop on Rice Policy and Food Security in Sub – Saharan Africa, WARDA Cotonou. Republic of Benin**.**

FAOSTAT. 2009. Food and Agricultural Organisation data base on crop production. Retrieved October 19, 2011 from http://faostat.fao.org/site/339/default.aspx

GAIN. 2007: Global Agricultural Information Network Senegal Grain and Feed Regional Rice Annual No. SG 7003.

Ibukun, E. O. 2008. Effect of prolong parboiling duration on proximate composition of rice. *Scientific Research and Essays* 3:7. 323 – 325.

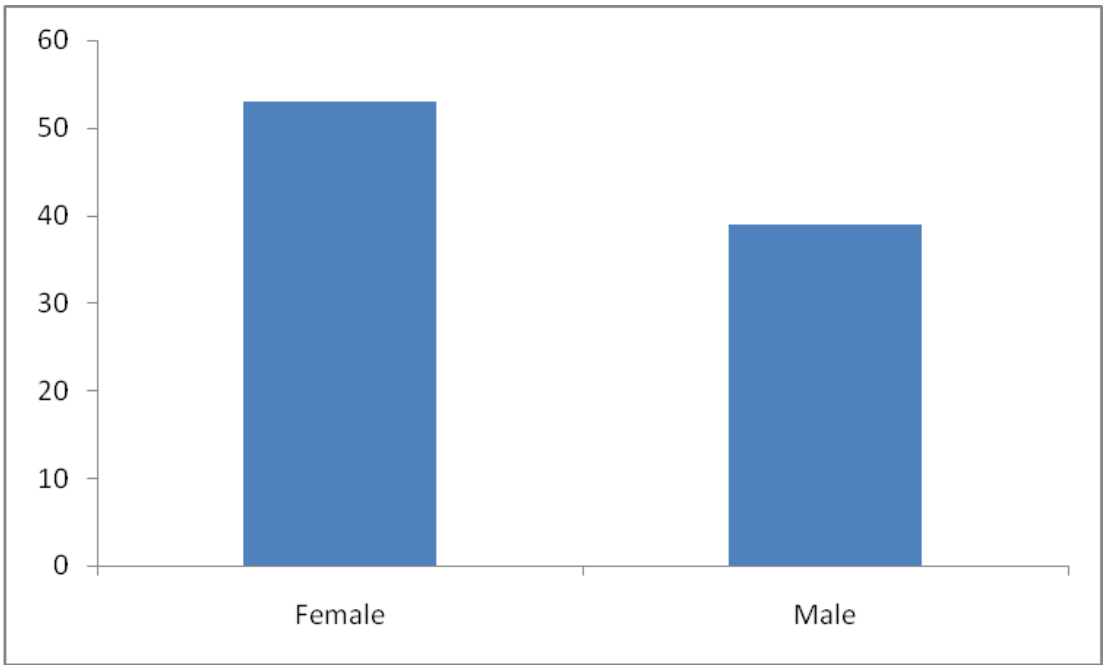


Fig 1: Gender Of Rice Processors

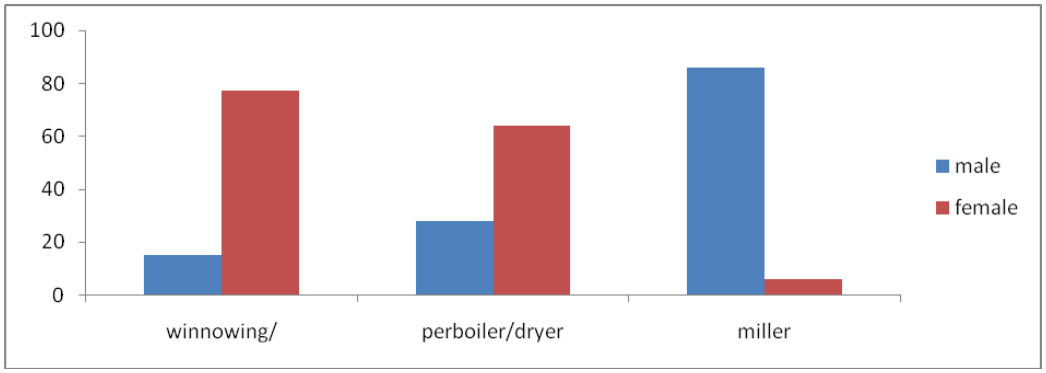


Fig 2: Rice Processing And Gender

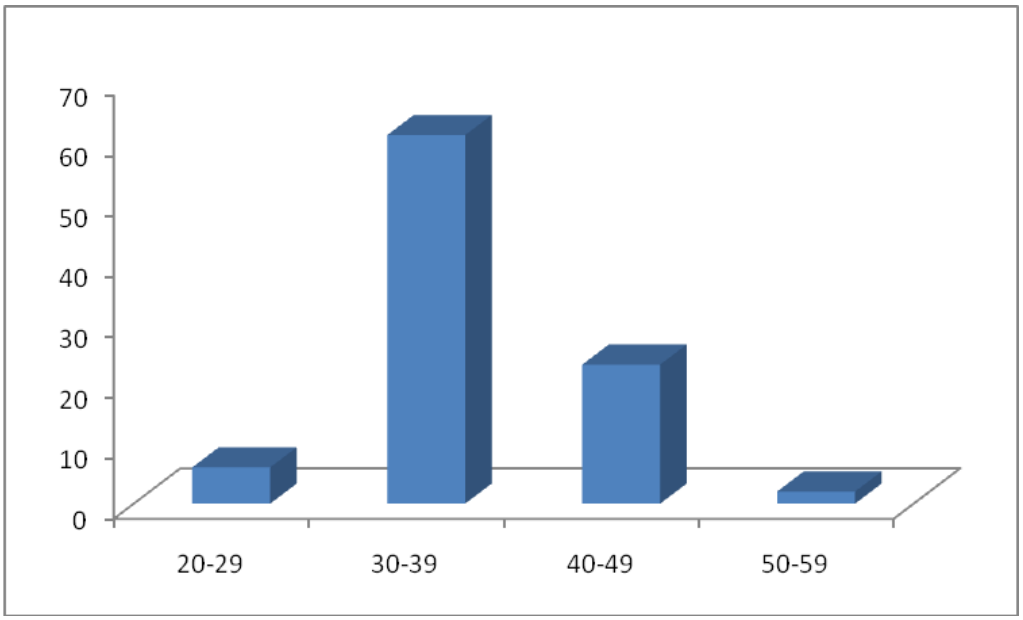


Fig 3: Age Of Rice Processors

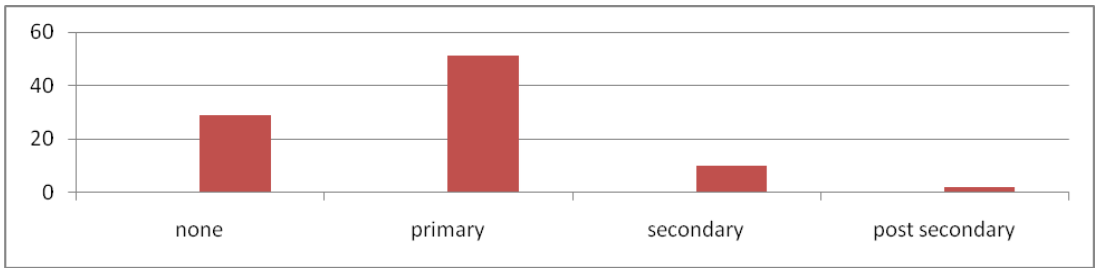


Fig 4: Educational Qualification Of Rice Processors

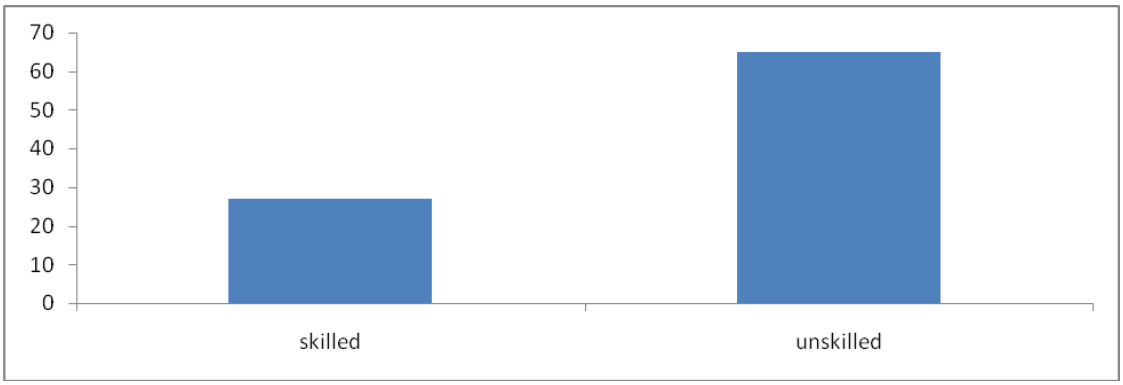


Fig 5: Types Of Labour

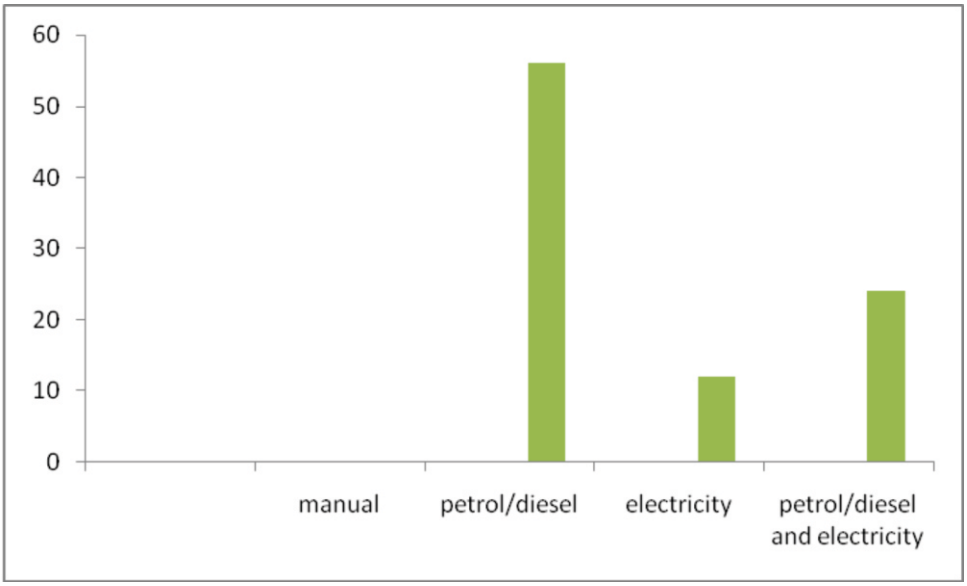


Fig 6: Sources Of Power For Milling

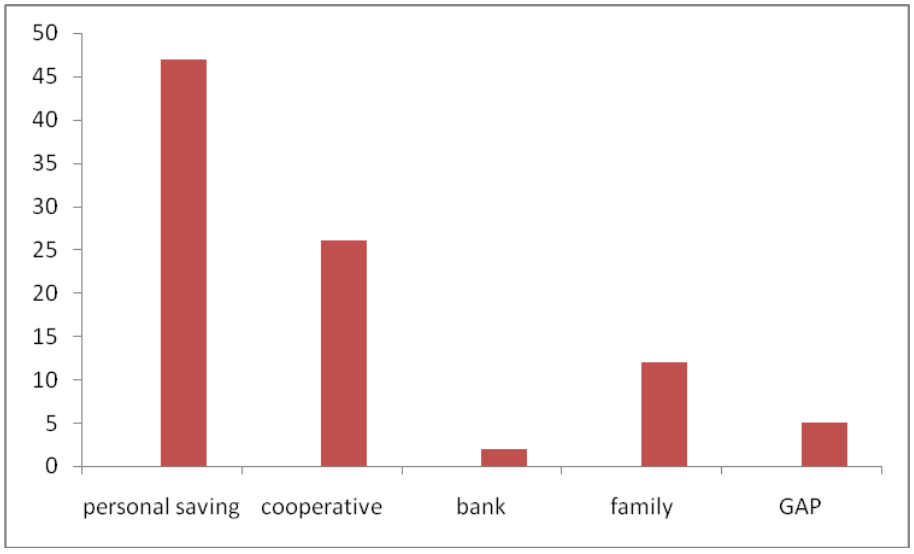


Fig 7: Sources Of Capital Of Rice Processors

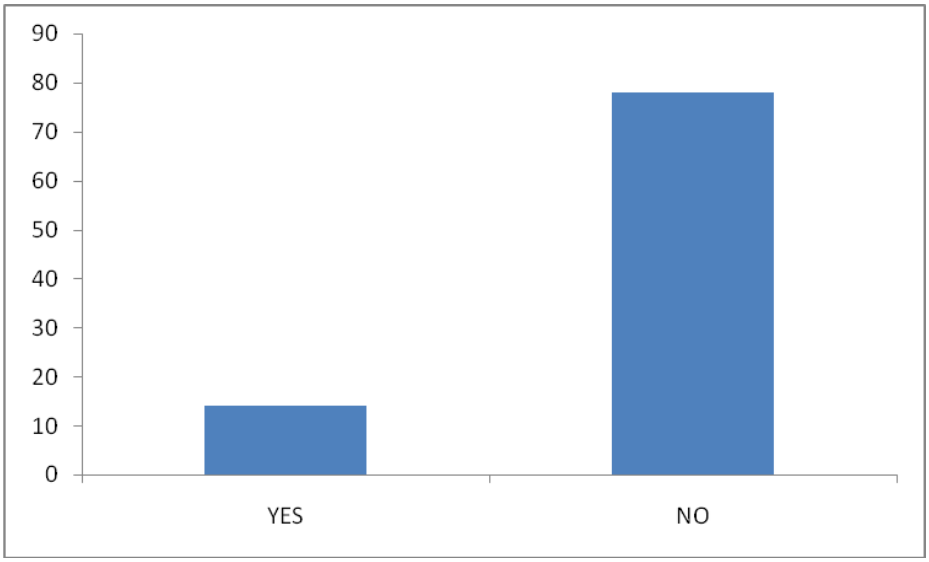


Figure 8: Storage Facilities

PHYSICOMECHANICAL AND CHEMICAL PROPERTIES OF TWO PALM FRUITS VARIETIES

***Fati Astapawa Adamu[1&3] ; Muhammad Hamisu Muhammad[2]; Barbara Ndidi Acquaye[3]**

[1&3]Department of Agricultural and Environmental Engineering, School of Engineering and Engineering Technology, Modibbo Adamawa University of Technology, P.M.B. 2076 Yola, Nigeria.

[2]Mechanical Engineering Programme, School of Engineering and Engineering Technology, Abubakar Tafawa Balewa University, P.M.B. 0248, Bauchi, Nigeria.

Correspodence author: fatiastapawa@yahoo.co.uk

ABSTRACT

Investigation on physical, mechanical and chemical properties of fresh palm fruits varieties will give a conceptual ideas and data on the design of machines to aids the processing of edible part of palm fruits, while the non edible may be processed as cleaning agent. The physical properties investigated includes: sizes, sphericity index, aspect ratio, mass, unit & bulk densities. The mechanical properties investigated includes: cracking force, dynamic angle of repose & coefficient of friction. The chemical properties investigated includes: moisture content, free fatty acid, insoluble impurities, free alkalis and acid value. Two fresh palm fruits *dura* and *tenera* varieties were used for the studies. The mean values of physical properties of palm fruits varieties were : sizes (length,width & thickness) , sphericity, bulk densities, cracking force, coefficient of friction and angle of repose on [ply wood, aluminum mild steel] for *dura* : (30.25 , 19.93,15.41) mm, 70.6 % , 659.40 kg/m^3, 2301N , 0.67, 18. 52^0 and for *tenera*: (35.87, 20.17, 17.11) mm, 64.23 %, 611.04 kg/m^3, 1149 N, 0.5, 21^0, respectively. The mean values for free fatty acid and insoluble impurity for the edible oil are (3.49 & 1. 8) % and the free alkalis and fatty acid for the non edible oil are (0.035 & 0.78) % respectively. There was 5 % significant between the palm fruits varieties.

Keywords: Palm Fruits, Physical, Mechanical, Chemical, Design, Machine

1. INTRODUCTION.

The oil palm, (*Elaeis guineensis*) belongs to the family of Palmae and is a major tropical tree crop in Nigeria. It is grown in the Southern part of the country and the Guinea savannah area of the Middle belt. It originated from the tropical rain forest region of West Africa with its main oil palm belt running through the Southern latitudes of Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon and into the quatorial region of Zaire and Angola between latitudes 10_N and 10_S (Opeke, 1982; Poku, 2002). The wild oil palm groove in Nigeria is estimated at 2.1 million hectares whereas plantation estates and small holdings account for 81,475 and 105,184 ha, respectively (Owolarefe, et al. 2005). Palm oil, the most important product of the oil palm, is the world's main edible oil (Bek- Nielson, 1974). The meal obtained after oil extraction from the kernel is also used as animal feed. High quality palm oil is needed for domestic and industrial applications.

The kernel shell contains no oil, but has local uses which includes biogas, biodiesel, local soap, lubricant etc (Alamu, et al,2007). The oil content of palm fruit depends on the thickness of the mesocarp (for palm oil) and the size of the kernel (Gupta, 2011). Plate 1 shows the structure of the two types of oil palm fruit. Since the *tenera* and

dura varieties of palm fruit are useful in production of palm oil and palm kernel, respectively, it becomes imperative to characterize the fruits with a view to understanding the properties that may affect the design of machines to handle the processing of the fruits. Such physical properties such as size, shape, sphericity, aspect ratio, true density, bulk density and porosity, and mechanical properties such as coefficient of friction angle of repose as well as fracture resistance are very important in the design of processing machines for major agricultural crops. While the chemical properties such as the free fatty acids, moisture content, alkalis, insoluble impurities and acid value may be used to produce local soap. Hence the important of this study cannot be over emphasized.

1.1 Related studies on palm kernels. Even though, a lot of attempts (Bek – Neilson,1974, Gunston 1994, Kimura- Meiko, 2004 & Owolarefe et al. 2005) were made to harness edible and non edible components of palm fruits, little research is made in regard to its chemical properties and palm fruits toxic (Gupta, 2011, Poku, 2002 & Lynn, 1991).

1.1.2 Justification of the studies. Data physical, mechanical and chemical properties of palm fruits will prevent environmental pollution, aid the conceptual designs of machine for the processing of the palm fruits. While the some of the data that will be obtained from non edible palm kernel will be used for industrial purposes , cosmetics like local soaps etc.

2.0 MATERIAL STUDIED

2.1 Materials used for the studies includes

Two fresh palm fruits *dura* and *tenera* , Vernier calipers: it was used to measure the length, width and thickness of the palm fruit. Measuring cylinder: it was used to measure the amount of liquid used. Sensitive weighing balance (0.1g): it was used to weigh the palm fruit. Sample container: Used for keeping each sample gotten. Stop watch: To check time intervals of the laboratory work. Plane paper: The palm fruit was traced on it. Sharp thin pencil: Used for tracing the palm fruit. Ply wood, steel, iron sheet, weighing balance with precession of 0.1, hardness tester (California Bearing Ratio (CBR), Soxhlet apparatus and electronic balance. Beaker fitted with a stirrer: Used to mix samples, Thermometer: Was used to take the temperature reading. Graduated pipette: For titration, Ordinary drum mixer (reactor):

2.2 Area description

Palm fruits seeds were bought from Songhai Delta Amukpe, Delta State of Nigeria, 120 for *tenara* and *dura* was used for the study. The research was conducted in three laboratories (Chemical, Farm Power and Machinery and Biotech), all situated at Modibbo Adama University of Technology, Yola – Adamawa State Nigeria,

2.3 Methods

The research comprises of three methods namely:

1. Study of physical properties: This comprises physical identification of the palm fruits varieties, measurement of length, height, width, sphericity,
2. Study of mechanical properties of palm fruit: This comprises determination of unit and bulk densities of palm fruits varieties, fractional resistance force of palm fruits , coefficient of resistance on plywood, metal and iron , angle of repose ,
3. Study of chemical properties of palm fruits: This comprises chemical properties of edible palm oil (moisture contents, free fatty acids, insoluble impurity and acid value); the chemical properties of non- edible palm oil (free alkalis, moisture contents and fatty acids).

2.3.1 Techniques

The physical properties considered in this study are size, shape, true density, bulk density and porosity.

Determination of size: From the samples, 50 fruits were selected at random for determining the physical characteristics. For each fruit,three linear dimensions were measured, that is (a) length,(b) width, and (c) thickness, using a Vernier caliper (Kanon Instrument, Japan) reading to 0.01 mm. Hence measurement of all size indices were replicated fifty times for both *tenera* and *dura* varieties of palm fruits.

Determination of shape: The fruit shape was expressed in terms of its sphericity index and aspect ratio. For the sphericity index Sc, thedimensions obtained for the 50 palm fruits selected at random were used to compute the index based on the recommendation of Owalarefe et al.(2005) as:

$$Sc = (abc)^{1/3}/a \quad x\ 100 \qquad (1)$$

For the aspect ratio, 50 palm fruits were also selected at random for conducting the experiment. Measurements of all size and shape indices are replicated fifty times. The Vernier caliper was also used for the measurements. The aspect ratio (Ra) was calculated as recommended by Maduako and Faborode (1990) as:

$$Ra = b/a \quad x\ 100 \qquad (2)$$

Determination of fruit mass: The mass of individual fruit for both dura and tenera varieties were determined by using a Mettler Toledo PB 153 electronic balance (Mettler Toledo GmbH, Greifensee, Switzerland) to an accuracy of 0.001 g. Each measurement was replicated 50 times.

Determination of true and bulk density: The true density of the palm fruit was determined by the water displacement technique (Dutta, Nema, & Bhardwaj,1988). Ten randomly selected palm fruits were weighed and lowered into a graduated measuring cylinder containing 30 ml of water. It was ensured that the fruit was submerged during immersion in water. The net volumetric water displacement by each fruit was recorded. The true density qt was then calculated using Eq. (3) below:

$$Pt = m/v \qquad (3)$$

where m is the mass of fruit (in kg), and v is the volume of fruit (in m3). For bulk density measurement, an empty cylindrical container of 444.50 cm3 volume was filled with palm fruits and the bulk weight recorded. This was done in 10 replications. Using Eq. (3) above, the bulk density (qb) was then calculated for each of the replications. Each of these was conducted on the *tenera* and *dura* variety of palm fruits.

Determination of density ratio and porosity: The density ratio Dr is the ratio of true density to bulk density expressed as a percentage as follows:.

$$Dr = pt/pb\ x\ 100 \qquad (4)$$

Porosity (P) was computed (Owolarefe et al. 2005) as

$$P = pt - pb/pt\ x\ 100 \qquad (5)$$

Reported values of all density characteristics are means of 10 replications

2.4. Measurement of the Mechanical Properties of Palm Fruit

Three mechanical properties determined in the study include angle of repose,

fracture resistance and sliding coefficient of friction. The dynamic angle of repose or the emptying angle was determined on four surfaces namely, plywood, aluminium, galvanised steel sheet and mild steel sheet. A regular cylindrical container opened at both ends was placed on each flat surface and filled to the top with palm fruits. The container was then lifted up gradually from the surface. The gradual lifting continued until a conical heap was formed. The emptying angle was calculated from the height and base radius of the heap formed (Maduako & Faborode, 1990). Measurements of all frictional characteristics were replicated 10 times. The coefficient of static friction was found with respect to four structural materials namely, plywood, aluminium, galvanised steel sheet and mild steel sheet using the inclined plane apparatus as described by Dutta et al. (1988). A fruit was placed on the plane and the table was gently raised and the angle of inclination to the horizontal at which the palm fruit started sliding was read off the protractor attached to the apparatus. The tangent of the angle was reported as the coefficient of friction (Dutta et al., 1988). The coefficient of friction was found for both the *dura* and *tenera* varieties of palm fruits and each measurement was replicated 10 times. The fracture resistance, fr of the varieties of palm fruit was tested to know the magnitude of the force that was required to break the fruit when the fruits are either placed longitudinally or transversely. The California Bearing Ratio (CBR) machine was used to determine the cracking force of the material. Each fruit was loaded until it fails as observed by the return of the pointer of the CBR machine gauge and the point of return gives the fracture resistance of the fruit. The palm fruits were placed on a plain paper and traced out before the fracture resistance was determined from the CBR. The projected area was calculated after each palm fruit was traced out on a millimeter graph paper. Reported values of fracture resistance were replicated 10 times.

The resulting pressure, r was computed from the ratio of the fracture resistance (fr) to the projected area (Ap) of palm fruit as

$$\Delta = fr / Ap \qquad (6)$$

2.5 Measurement of Chemical Properties of Palm Fruits

Four chemical properties determined includes the free fatty acids, moisture contents, acid value and insoluble impurities.

2.5.1 Palm oil extraction

The oil in the kernels was extracted by using Soxhlet apparatus, according to the method reported by Yashajahu and Clinton (1978) to have samples of the Palm Kernel Oil (PKO).

2.5.2 Determination of metal content

2.0 g palm kernel oil sample was weighed in a beaker on a balance and 2cm^3 of concentrated sulphuric acid was added to it. The beaker was heated on the hot plate for 10 min to digest the oil sample in the acid. The digested sample was then transferred to an electric furnace and ashed at 550^{0}C for 30 min. After the ashing and cooling of the sample, 6 cm^3 of HCL was used to wash the sample into another beaker. The beaker was further washed with 25 cm^3 of distilled water and resultant solution filtered with a 125mm filter paper as reported by Kimura - Meiko (2004).

2.5.3 Determination of free fatty acid

10g of the sample was weighed into a conical flask; 10ml of ethanol was added. The mixture was heated on a hot plate until the mixture starts to boil. The mixture was removed and titrated against 0.1 sodium hydroxide using phenolphthalein indicators to give a pink colour.

2.6. Multiple T-test

Statistical analysis of palm fruits varieties: T-Test was carried out as described by Obi (2002) on the physical properties of the two varieties of palm fruits.

3.0 RESULTS AND DISCUSSION

A summary of the results of the determined physical and mechanical parameters of the *dura* and *tenara* varieties are shown in Table 1. *Tenera* variety length, width and thickness (35.87,20.17,17.11) mm respectively, are greater than *dura* (30.25, 19.93, 15.41) mm variety respectively. This agrees with Owolarefe, et al. (2005) and Mohsenin, (1978). Owolarefe"s (2005) reported that *tenera* palm fruit mean length, width and thickness were found to be 35.96 mm, 20.15 mm and 17.1 mm, respectively. Mohsenin (1978) and Omobuwajo et al. (1999) have discussed the importance of these and other characteristic axial dimensions in determining aperture size of machines, particularly in separation of materials. These dimensions may be useful in estimating the size of machine components. The sphericity and aspect ratio for *dura* were found to be 70.67% and 67.78%, respectively. The high sphericity of the palm fruit is indicative of the tendency of the shape towards a sphere. Taken along with the high aspect ratio of 67.78% (which relates the fruit width to length), it may be deduced that the palm fruit will rather roll than slide on their flat surfaces. However, the aspect ratio value is being close to the sphericity values may also mean the palm fruit will undergo a combination of rolling and sliding action on their flat surfaces. The *tenera* sphericity and aspect ratio were found to be 64.23% and 56.77%, respectively. The average fruit mass of the *tenera* variety was 8.50 g while the average fruit mass of the *dura* was 7.66 g. The average fruit mass of the *tenera* is higher than the *dura*. This may not be unconnected with the size of the *tenera* as the *dura* is smaller. The bulk density of *dura* and *tenera* are 659.40 kg/m^3 & 611.04 kg / m^3respectively. The bulk density will aid the design of the capacity of hopper that will contain palm fruit.

Also, these properties may be useful in the separation and transportation of the fruit by hydrodynamic means. Results of mechanical properties shows that , the coefficient of static friction of the *dura* palm fruit was 0.58 on plywood, 0.53 on aluminium sheet, 0.56 on a mild steel sheet and 0.56 on a galvanised steel sheet. The coefficient of static function of the *tenera* variety was 0.52 on plywood, 0.52 on aluminium sheet, 0.52 on mild steel sheet and 0.52 on galvanised steel sheet, respectively. There was no significant difference in the coefficient of friction obtained on plywood and aluminium sheet. There was a small difference in the coefficient of friction obtained on mild steel and galvanised steel sheet. Nevertheless, the values obtained for plywood, aluminium and mild steel are very close. The value of the coefficient of static friction for galvanised steel is a little bit higher than that of other surfaces. the disparity of fractural resistance of 1152 N. But in terms of angle of repose and coefficient of resistance there was little significant difference of less 0.3 for the two varieties. The coefficient was higher than that for values for oil bean seeds (Oje and Ugbor, 1991). The results of chemical properties of palm fruits are shown in Table 2.

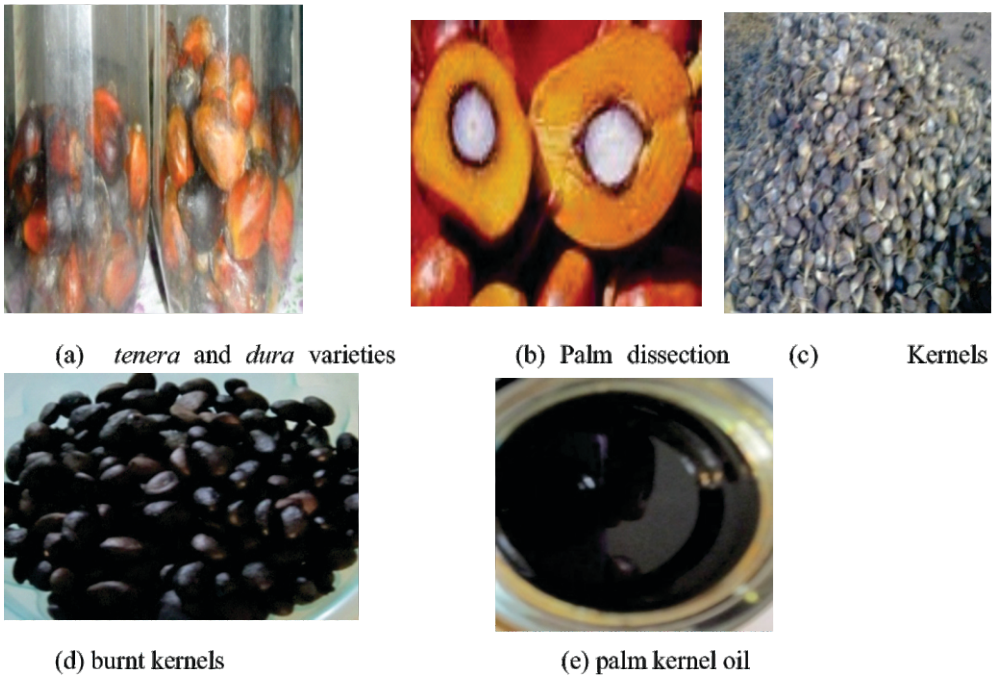
The moisture content of edible and non edible palm oil is 80 % and 23 % respectively. These is obvious because the after oil extraction, the kernel is left with the most hardest and part of the palm kernel. The research is looking forward to harnessed this non edible part which is yet to reach it full potential. The fatty acid and free alkalis for the edible and non edible oil are The acid value gotten as palmitic acid was 0.095

Table1: Average Physical And Mechanical Properties Of Palm Fruits Seeds.

Property	Mean value (±standard deviation *Dura* variety	 *Tenera* variety
Length, mm	30.25 (±5.07)	35.87 (±4.08)
Width, mm	19.93 (±2.64)	20.17 (±3.79)
Thickness, mm	15.41 (±2.25)	17.11 (±1.91)
Sphericity, %	70.67 (±9.27)	64.23 (±6.58)
Aspect ratio, %	67.78 (±15.29)	56.77 (±9.47)
Fruit mass, g	7.66 (±2.04)	8.50 (±2.00)
Bulk density, kg/m^3	659.40 (±21.74)	611.04 (±27.79)
Cracking force, N	2301	1149
Density ratio, %	59.33 (±2.21)	61.45 (±4.01)
Angle of repose, O^0		
	22.05 (±1.51)	
Plywood		18.45 (±1.86)
Aluminum	21.09 (±1.74)	18.44 (±1.98).
Mild steel	19.92 (±2.18)	18.68 (±1.27)
Coefficient of static friction		
	0.58 (±0.05)	
Plywood		0.52 (±0.06)
Aluminum	0.53 (±0.03)	0.52 (±0.04)
Mild steel	0.56 (±0.03)	0.52 (±0.05)

Table2: Average Chemical Properties of Edible and Non Edible Palm Oil

Chemical properties of Edible palm oil	Average values for both ***dura*** & *tenara*
Moisture content (%)	0.80
Free fatty acid (%)	3.49
Insoluble impurity (%)	1.8
Acid value (%)	7.18
Chemical properties of non edible palm oil	Average values for both ***dura*** & *tenara*
Moisture content (%)	0.25
Free alkalis	0.035
Fatty acid ((%)	0.78



(a) *tenera* and *dura* varieties (b) Palm dissection (c) Kernels

(d) burnt kernels (e) palm kernel oil

Plate 1: Palm Kernel Oil Process Stages.

EFFECT OF DRYING METHODS ON SOME PHYSICO-CHEMICAL PROPERTIES OF SOME SELECTED VARIETIES OF CASSAVA STARCH

***A. A. Adesola, D. Lasisi, L. A. Balogun, A.R. Nasirudeen, F.O. Ogunsola, and T.A. Adeyeye**
Department of Agricultural and Bio-Environmental Engineering
Oyo State College of Agriculture, Igboora
*Corresponding author E-mail: dalasisi@yahoo.com Tel: +234 -7062606974

ABSTRACT
This research work investigated the effect of drying methods on some physico-chemical properties of starch of some selected varieties of cassava. Two different drying methods namely: oven drying and sun – drying were considered. Starch from four different varieties of cassava namely TMS 30572, TMS 01/1181, TMS 01/1235 and local variety, Odongbo were also considered. The cassava varieties were obtained from International Institute of Tropical Agriculture, Ibadan (I.I.T.A.) while the local variety, Odongbo was obtained from a local farm in Ibadan. The physico- chemical properties of starch determined were starch yield, viscosity, moisture content, swelling power, free sugar and solubility of starch. After extraction and drying of the starch, the yield produced per each of the varieties were recorded in which TMS 3057 has the highest yield of starch of 1.31kg while 01/1235 has the lowest yield of 0.90 kg. TMS 01/1181 sun dried has the highest moisture content (10.47%) while Odongbo variety oven dried has the lowest moisture content (9.2%). TMS 01/1181 sun-dried has the highest pasting temperature of 73.41^{0}C. TMS 01/1235 has the highest peak viscosity of 553.96 while TMS 30572 has the lowest peak viscosity (373.51). However, it was noticed that the varieties with high peak viscosity mostly above 260 made good quality products (Otegbeye, 2004). Therefore, all the varieties are acceptable for starch industrial purposes. Water binding capacity and paste clarity increased, while swelling power and solubility, peak viscosity; break down viscosity, setback viscosity and peak time decreased significantly with increase in drying temperature ($P < 0.05$). Pasting temperature decreased while final viscosity increased significantly with increase in drying temperature.

Keywords: Drying Methods, Physico-chemical, Cassava Starch, Effect.

1.0 INTRODUCTION

Cassava (Manihot esculenta Crantz) ,is grown mainly in the tropical part of Africa, Brazil, Malagasy, Indonesia, South India, Philippines, Malaya, Thailand, and China.(Ajibola,2000). Nigeria is the largest producer of cassava in Africa. This became evident from statistics of cassava production quantity reported by Food and Agricultural Organization (FAO, 2000). In the tropical part of Africa, it has become the most important crop in terms of both land areas devoted its production and the proportion it contributes to the human diet. Cassava is utilized extensively for human and livestock consumption as well as for other industrial products such as starch. Most of the usage of cassava is in processed forms while only a small quantity is consumed directly. Cassava is a short-lived perennial tropical shrub growing for about 100-350cm tall which is believed to be first domesticated in South America. Its cultivation has spread throughout the humid tropics and sub tropics (Rehm and Espig, 1991). Its total production in Africa has

increased 35 - 80 million tonnes between 1965 and 1995 (Hillocks, 2000). Nigeria being one of Africa countries in cassava production can process this crop into gari, lafun, pupuru, paki, fufu, and cassava gnat for direct human/livestock consumption.

Starch is the one of the most abundant substances in nature, a renewable and almost unlimited resource. Starch is produced from grain or root crops. It is mainly used as food, but is also readily converted chemically, physically and biologically into many useful products to date; starch is used to produce such diverse product food, paper, textiles, adhesives, beverages, confectionery, pharmaceuticals, and building materials. Cassava starch has many remarkable characteristics, including high paste viscosity, high paste clarity and high freeze-thaw stability which are advantageous to many industries.

Cassava is produced primarily by the wet milling of fresh cassava roots. Osunsanmi (1987) described the method as the classical method of extraction of cassava starch, but in some countries such as Thailand, it is produced from drying cassava chips. Starch is the main constituent of cassava. About 25% starch may be obtained from mature, good quantity tubers. About 60% starch may be obtained from dry cassava chips and about 10% dry pulp may be obtained per 100kg of cassava roots (FAO, 2002). Fresh tubers are processed during on-season and dry chips during off- season in some countries. Extraction of starch from fresh cassava root can be divided into five main stages. Preparation (peeling and washing), dewatering, drying and finishing (milling and packaging). For cassava, the process of starch extraction is relatively simple as there only of small amounts of secondary substances, such as protein, in the roots. When cassava roots are harvested or selected for starch extraction, age and quality are critical factors. Cassava roots need to be processed almost immediately after harvest as the roots are highly perishable and enzymatic processes deterioration within days. A first rate quality starch can be obtained from cassava using only water.

The physico-chemical properties of starches depend on the interaction of several factors including granule size, amylose-amylopectin ratio internal organisation within granule and other component such as liquid and phosphate groups. The functionality of a starch in a given application and therefore, its quality is determined principally by the physicochemical properties. These include the water binding capacity, gelatinization, temperature, and swelling power solubility, freeze-thaw solubility, paste clarity, paste viscosity, retro gradation and gel strength (Nwokocha,2002,). Starches need to be dried under conditions that will not have any adverse effect on these properties as that could lead to impaired functionality. The drying conditions are determinant for the phase morphology of protein and starch in cooked pasta, which in turn governs the structural properties of the pasta. In other to control and establish the starch drying conditions that will yield the physicochemical property values needed for a particular application, there is the need to determine the response of the properties to starch drying temperatures. Therefore, these research work aims at investigating the effect of drying temperature on physicochemical properties of cassava starch.

2.0 MATERIALS AND METHODS

Materials:

Three different varieties of cassava roots used for starch, extraction were obtained from International Institute of Agriculture (IITA), Ibadan. The varieties were TMS 30572, TMS01/1235 and TMS 01/1181 while other local variety, of cassava root, Odongbo (TMEI) aged 15 months at harvest were obtained from a farm in Apata, Ibadan.

Starch extraction:

The cassava roots were peeled by hand using knife after which they were thoroughly washed and grated (crushed) in a grating machine to produce pulp. The pulp was then mixed with water to produce slurry. The slurry was sieved with the aid of muslin cloth and 75μm mesh sieve size. At this stage, starch molecule was separated from the fibrous material. The starch milk obtained was allowed to settle after which the supernatant was decanted. The settled starch obtained was rewashed several times using distilled water so as to remove the impurity and protein debris. The cassava starch obtained thereafter was divided into two portions.

One portion was used for proximate composition pH determination and physicochemical characterization. This was done by spreading the starch milk on a tray in thin layer. It was replicated thrice .The drying period covered three days with rest period at night when the surface cracked and on touching it, it crumbled and turned into powder. The following proximate composition was determined using the AACC standard method (AACC, 2000). Moisture content, crude fibre content, protein, ash and fat. Cassava starch pH was determined using pH meter while the amylase content of the starch was determined using the IITA method (IITA,1995) The second portion was used to investigate the effect of drying methods on the physicochemical properties of the starch. Some of the physicochemical properties determined are moisture content, starch water binding capacity, swelling power and solubility, freeze stability and paste clarity. The starch pasting properties obtained were peak viscosity, final viscosity, set back, breakdown, pasting temperature and peak time. The drying method considered were sun drying and oven drying. The moisture content at which starch drying commenced was determined using an air ventilated oven (Gallen Camp oven model 300series). A known weight of cassava was dried in the oven at 102°C for 16hrs. The moisture content of the starch was determined with reference to weight of the starch.

This was done for the starch got from the four varieties of cassava roots considered.

Starch water binding capacity was determined using the method of Medcalf and Gillies(1965) as adapted by Nwokocha (2002) and Jyothi *et al.* (2006).Swelling power and solubility were determined using the method of Tattiyakul *et al.* (2007). Freeze –thaw stability and paste clarity were determined using the method of Singhal and Kulkarni (1990) and Bello-Perez, (2000) respectively.The pasting characteristics of starch were determined using a rapid visco-analyser(RVA) series 4,Newport Scientific Ltd. Sydney, Australia, that employed the 12 profile. The data obtained were subjected to statistical analyses using analyses of variance (ANOVA), Least Square Difference and Duncan multiple range test.

3.0 RESULTS AND DISCUSSION

The proximate composition and pH of starch from different varieties of cassava roots and dried by different methods of drying were shown in Tables 1a and 1b. The highest moisture content was obtained in TME 1 variety in Table 1a while the lowest was obtained in variety TMS 30572. In table 1b, the highest moisture content was obtained in sample oven dried while the lowest was obtained in sample sun dried. In all, the moisture content was found to be within the range of 10 – 20 percentage moisture content recommended for commercial native starches (Soni *et al.*, 1993).

The highest acidity of starch in Table 1a was obtained from sample TME1 with a pH value of 5.05 while the lowest was obtained from TMS 01/1235 with a pH value of 6.15. In Table 1b ,sample oven dried has a higher acidity with a pH value of 5.65 when compared to sample sun-dried with a pH value of 5.72. In the overall, the pH values of all the samples were within the acceptable range for cassava starch (5 - 7) as indicated by

Sanni *et al*. (2005).This could be as a result of effect of variety on the pH. There was no appreciable difference in all the parameters.

Table 1a. Proximate Composition and pH of Varieties of Starch

Parameter	TMS01/1235	TMS01/1181	TME 1	TMS01/1235
Protein (%)	1.48 ± 0.03	1.46 ± 0.02	1.54 ± 0.02	1.42 ± 0.01
Carbohydrate (%)	84.60 ± 0.01	82.50 ± 0.02	83.10 ± 0.01	80.70 ± 0.01
Ash (%)	1.10 ± 0.02	1.03 ± 0.001	1.20 ± 0.01	1.06 ± 0.02
Fat (%)	0.42 ± 0.01	0.45 ± 0.01	0.43 ± 0.01	0.41 ± 0.01
Crude fibre (%)	2.22 ± 0.00	2.38 ± 0.01	2.50 ± 0.01	2.32 ± 0.01
Moisture content	12.15 ± 0.05	12.20 ± 0.01	12.28 ± 0.02	12.12 ± 0.05
pH	6.15 ± 0.01	5.96 ± 0.02	5.05 ± 0.01	6.08 ± 0.01

Table 1b. Proximate Composition and pH of Drying Method For Cassava Starch

Drying method	Oven drying	Sun drying
Protein (%)	1.52 ± 0.03	1.46 ± 0.02
Carbohydrate (%)	83.20 ± 0.01	82.50 ± 0.02
Ash (%)	1.06 ± 0.02	1.03 ± 0.001
Fat (%)	0.46 ± 0.01	0.45 ± 0.01
Crude fibre (%)	2.15 ± 0.00	2.38 ± 0.01
Moisture content	12.10 ± 0.01	12.20 ± 0.01
pH	5.65 ± 0.01	5.72 ± 0.02

The mean value of the physic-chemical properties of cassava starch obtained from different varieties of cassava roots are shown in table 2(a) while the mean values of physic-chemical properties of cassava starch obtained from two different drying methods are indicated in table 2(b). The swelling power was obtained from TME 1 variety of cassava was the highest (13.99) while the lowest swelling power obtained from TME30572 variety. There was significant difference swelling power of the varieties and the swelling power significantly higher oven-dried samples when compared sun-dried samples ($P<0.05$). This might be due to the fact when starch is heated in and excess water system, the granules imbibe water through the amorphous region in a reversible manner and the amount of the water imbibed increase with temperature until the gelatinization temperature is reached and the starch swells irreversibly with a loss of crystalline order.(Aviara *et al*.,2010).

The water binding capacity was significantly highest in TMS01/1181 sample, while it was lowest in TME 1 sample (table 2a).In table 2b, the water binding capacity

significantly higher in oven-dried sample compared with sun-dried samples (P<0.05) (table 2b). Water binding capacity in a measure of the strength of starch inter granular bond. Low water binding capacity is attributable to tight association (Soni et al, 1993), while high water binding capacity is indicative of a loose association of a native starch polymers or low lipid content (Nwokocha and Ogunmola, 2005)

There was a significant difference in solubility of the different varieties of cassava roots and the drying methods (P < 0.05).

Table 2a. Effect of Varieties on Some Physicochemical Properties of Cassava Starch

Varieties	PTemp	MC	Sugar	Starch	WBC	SWP	Solu.CNP
TMS01/1235	69.83^{b}	10.02^{a}	2.25^{c}	84.38^{b}	98.99^{b}	13.25^{b}	12.69^{a}
TMS01/1181	69.49^{b}	10.04^{a}	2.69^{b}	83.66^{c}	99.07^{a}	13.08^{b}	12.39^{b}
TME 1	72.68^{a}	9.72^{b}	2.12^{d}	83.65^{c}	98.54^{d}	13.99^{a}	12.72^{a}
TMS30572	72.28^{a}	10.08^{a}	3.41^{a}	85.46^{a}	98.80^{c}	11.88^{c}	10.65^{c}
LSD	0.59	0.12	0.004	0.009	0.05	0.52	0.19

Table 2b: Effect of Drying Methods on Some Physicochemical Properties of Cassava Starch

Drying Mtd.	P Temp	MC	Sugar	Starch	WBC	SWP	Solu.CNP
Oven drying	70.72^{a}	9.63^{a}	2.69^{c}	84.23^{b}	99.11^{b}	13.35^{b}	12.41^{a}
Sun drying	71.42^{b}	10.30^{a}	2.53^{b}	84.33^{c}	98.59^{a}	12.76^{b}	11.81^{b}
LSD	0.42	0.085	0.003	0.07	0.04	0.37	0.1133

The particles size values were significantly different amount the cassava starch varieties (P < 0.05) also between the oven-dried samples and sun-dried samples (table 3a and 3b). The bigger the size of the sieve the larger the particle size of the starch. Therefore, particle size is affected by the variety of the starch used.

TMS01/1235 significantly has the highest peak viscosity of 557.90 while TMS30572 has the lowest peak viscosity (P<0.05). However, it was noticed that the varieties with high peak viscosity mostly above 260 made good quality product (Otegbeye, 2004). Therefore, all the varieties are acceptable for starch industrial companies.

Table 3a: Effect of Varieties on Particle Size of Cassava Starch

Variety	Part 1	Part .710	Part .500	Base
TMS01/1235	24.36[b]	29.75[c]	28.87[c]	16.55[b]
TMS01/1181	19.32d	29.45[d]	28.29[d]	18.25[a]
TME 1	19.88c	31.13a	29.87[a]	17.27[b]
TMS30572	25.51a	30.95b	29.68[b]	13.11[c]
LSD	0.04	0.09	0.09	0.86

Number in the same column with the same alphabets have no significant difference

Table 3b: Effect of Drying Methods on Particle Size of Cassava Starch

Variety	Part 1	Part .710	Part .500	Base
Oven drying	22.62[a]	33.25[c]	29.11[b]	17.02[a]
Sun drying	22.12[a]	30.38[a]	29.25[b]	15.56[b]
LSD	0.03	0.07	0.05	0.86

Number in the same column with the same alphabets have no significant difference

Table 4: Effect of Drying Methods on Viscosity Of Cassava Starch

MTD	Peak	Through	Brk Down	F Visco	St Back	P Time	P Temp
Oven dry	517.17[a]	167.55[b]	349.46[a]	229.91[a]	62.34[a]	3.65[b]	70.72[b]
Sundry	450.4[b]	169.11[a]	291.74[b]	221.59[b]	62.55a	3.75[a]	71.42[a]
LSD	0.48	0.735	1.38	0.74	0.07	0.08	0.42

Table 4 shows the effect of drying methods on peak viscosity to set back viscosity. However, it was noticed that the varieties with high peak viscosity mostly above 260 made good quality products (Otegbeye, 2004). Therefore, all the varieties and the two drying methods are acceptable for starch industrial purposes.

Starch yield:

The highest yield of starch (0.67kg) was obtained from TMS30572 sun-dried while the lowest yield of 0.44kg was got from TMS01/1235 oven-dried. The significant difference in weight of yield of the same variety and different drying method might be due to the effect of drying method employed, ($P<0.05$). Therefore, starch yield can be regarded as a function of variety and some other agro-ecological factors.

Table 5: Effect of Drying Methods and Varieties on Starch Yield

Varieties	Weight of Tubers(kg)	Weight After Peeling (kg)	Starch Extracted (Kg)	Starch Dried (Kg)	Sundried (kg)	Oven dried (kg)
30572	12	9.2	2.4	1.31	0.67	0.64
01/1235	12	9.0	1.8	0.90	0.46	0.44
01/1181	12	9.5	2.2	1.10	0.54	0.53
TME1	12	8.3	2.25	1.12	0.55	0.52

4.0 CONCLUSION

The yield of cassava starch depends largely on varieties and it can be affected by drying methods. The moisture content of the starch also depends on drying methods and variety used. Oven-drying is more effective in removing moisture than sun-drying method.

The varieties with high peak viscosity mostly above 260 are good quality product

REFERENCES

Aviaria N. A.,Igbeka J. C. and Nwokocha, 2010: Effect of drying temperature on physiochemical properties of cassava starch. International Agrophysics, 24, 219-225.

Nwokocha I. M. and Ogunmola G. B., 2005: Isolation and Charasterization of starch from treculia Africana Dene (African breadfruit) seeds. Nigerian Journal Science 39, 73-79

Osunsanmi A.,1987:African Journal of Biotechnology. Vol.17,pg 2717.

Otegbeye B. O.,2004: Grono Morphology, Physiochemical and Rheological characteristics of Yam species at humo or textural quality of yam. A Ph. D Thesis, University of Ibadan, Nigeria.

Rehn S. and Espig G.,1991: The cultivated plant of the tropics and subtropics. Verlag Josef Margraf, Germany, 243-247.

Sanni L. O., Maziya-Dixon B., Akanya J. N.,Okoro C. I.,Alaya Y., Egwuonwu C. V., Okechukwu R. U. Ezedinma C. Akoroda M.,Lemchi J., Ogbe F., Okoro E., Tarawali G., Mkumbira J., Patino M., Ssemakula G., Dixon A.,2005: Standard for Cassava products and Guideline for Export. I. I. T. A. Press, Ibadan, Nigeria.

Singhan, R. S., P. R. Kulkarni, 1990: some properties of Amaranthus panukulatas (Rajgeera) starch pastes. Starch, 42, 4-5.

Soni P. I., Sharma H., Dum D. and Gharia M. 1993: A Physico-chemical properties of Quercus Leucotrichopora (oak) starch,45, 127-130.

Tattiyakul, J., Pradipasena P. and Asavasaksakul S., 2007: Taro coloscasia esculenta (L) schott amylopectin structure and its effect on starch functional properties, Starch, 59, 342-347

AACC, 2000. Approved methods. St Paul, MI, USA.

Ajibola O.O.,2000. Adding value to the farmers' harvest: Obafemi Awolowo University press limited, Ile-Ife, Nigeria.

Bello-Perez L.A., Contreras-Ramos S.M., Jimenez-Aparicio A., and Peredes-Lopez O., 2000. Acetylation and characterization of banana (Musa Paradisiaca) starch. Acta Cientifca Venezolana, 51, 143-149.

FAO, 2000, FAO corporate Documentary Repository, Proceedings of the Export consultation on Root Crop Statistics.

Hii C.L., Cloke M., 2009. Thin Layer drying kinematics of cocoa and dried product quality. J. Bio-sys. Eng. Elsevier Ltd., pp. 155-161.

Hillocks R.J., 2002. Cassava in Africa. In cassava: Biology, Production and utilization.

Hillocks, J.M. thresh and A.C. Bellolli. Pp 41-54. CAB International, Wallinford.

I.I. T.A.,1995. Simplified procedure for any lose content determination. In: selected Laboratory Methods for Maize Quality Evaluation (Ed. A.U. Okoruruwa). IITA Press, Ibadan, Nigeria.

Jyothi A.N., Moorthy S.N, and Rajasekharan K.N., 2006. Effect of cross linking with epichlorohydrin on the properties of cassava (Manihot esculenta Crantz) starch, 58, 292-299.

Medcalf D.G. and Gilles K.a., 1965. Wheat starch: comparison of physic-chemical properties. Cereal Chem.,42, 558-565.

Nwokocha L.M., 2002. Chemical characterization, modification and industrial utilization of starches from Nigerian food crops. Ph.D. Thesis, University of Ibadan.
Osunsanmi A., 1987. African Journal of Biotechology.V

EFFECT OF FEEDING METHODS ON GROWTH RATE OF CATFISH (*CLARAS GARIEPINUS*)

Ogunlela, A. O. and A. A. Adebayo
Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin Nigeria.

ABSTRACT
Aquaculture, the farming of aquatic organisms is gaining more attention in recent times. Experiments were conducted to evaluate the effect of feeding methods on growth rate and feed conversion ratio of catfish, *Claras gariepinus,* using two methods; manual and automatic _ with 2% daily feed intake rate. Imported feed ("Durante") was used for both methods throughout the experiments. In the automatic feeding, the total average gain in weight per fish (89.50 g) was higher than that of manual (78.50 g). The feeding efficiency of the automatic feeding (20.9%) was higher than that of manual (18.6%) in relation to their feed conversion ratios. A t- test was conducted at 5% significance level and the result indicated a significant difference of in both methods.

Keywords: Feeding Methods, Feed Conversion Ratio, Feeding Efficiency, Catfish.

1.0 INTRODUCTION

Feeding is a major aspect of fish production that determines the total cost. Comparative studies related to feeding methods in different species (Kentouri *et al*., 1993) have shown the high performance of demand feeding on fish weight gain and feed conversion. In addition, the labour cost for feeding is significantly reduced. The cost of feed, often greater than 60% of the total cost of fish production, is the single largest expense in raising catfish (*Claras gariepinus)*.

Studies conducted on other fish species have shown that feed consumption and growth rate generally increase with feeding frequency up to a given limit (Baçınar *et al*., 2007). Factors affecting the poor feed utilization and resulting in high feed conversion ratios (FCRs) include the inappropriate selection of feed type (pellet type and formulation), quality and the feeding method. The quality of feed refers to the nutritional as well as the physical characteristics of the feed that allow it to be consumed and digested by the fish. The feed should contain all the nutrients required by the fish, in the right proportions for good performance (growth and health). The purpose of this study was to evaluate the effects of different feeding methods (automatic and manual) on the growth rate and feeding parameters of catfish (*Claras gariepinus)* reared in a recirculatory aquaculture system (RAS).

2.0 MATERIALS AND METHODS

The study was conducted using a recirculatory aquaculture system (RAS) located behind the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin , Nigeria.

Ilorin (longitude $4^0 35^{\prime}$ E latitude $8^0 30^{\prime}$ N, the capital of Kwara State of Nigeria, has two main seasons: wet (March-October) and dry (November-February). The investigation was conducted from April to June, 2013. 20 kg (66 pieces) of juvenile catfish (C. *gariepinus)* were obtained and stocked in an existing recirculatory system. Two culture

tanks of capacity 750L (0.75m^3) each were used for stocking the fish - with 10kg (33 fishes) placed in each tank. Other materials used included an automatic feeder, fish feed ("Durante"), water, weighing balance and meter rule.

Dry feeds were administered from the first day of the experiment, monitored and adjusted weekly. The experimental fish were fed twice daily, in the morning (8.00a.m) and in the evening (6.00p.m). Normal fish rearing practices were followed and the fish were fed daily with pelleted feed. Every day, 70-80% of water was replaced in the tank - for sanitation.

$$\text{FCR} = \frac{total\ amount\ of\ the\ feed\ given\ (gram)}{total\ gain\ in\ weight\ by\ the\ fish\ (gram)} \quad (1)$$

$$FE = \frac{1}{feed\ conversion\ ratio} \quad (2)$$

2.2 Method 2

In this method, the culture tank of capacity 0.75m^3 was also used for stocking the catfish (*Claras gariepinus)* of 10 kg (33 pieces) with an average weight of 300 g. The growth rate of the fish was estimated by sampling 10 fishes from the rearing tank every week (7 days interval). Based on the growth of the fish, the feed quantity was determined (2% of the average body weight) and supplied to the culture tank using conventional method (manual feeding). The average gain in weight per fish was determined. The feed conversion ratio (FCR) and feeding efficiency (FE) were estimated using equations (1) and (2).

3.0 RESULTS AND DISCUSSION

The study results are shown in Tables 1 and 2.

For the automatic feeding method, the total average of feed consumed per fish during the period of the experiment = 428.0 g.

The total average gain in weight per fish during the period of the experiment = 89.50 g

For the manual feeding method, the total average of feed consumed per fish during the period of the experiment = 421.50 g

The total average gain in weight per fish during the period of the experiment = 78.50 g

3.1 Feed Conversion Ratio (FCR) and Feeding Efficiency (FE)

The FCR for automatic feeding system was calculated from Table 1.

Average feed consumed by the fish = 428.0 g

Average fish produce (gain in weight by the fish) = 89.50 g

$$FCR = \frac{total\ amount\ of\ the\ feed\ given\ (g)}{total\ gain\ in\ weight\ by\ the\ fish\ (g)} = \frac{428}{89.5} = 4.78$$

$$\text{Feeding Efficiency } FE = \frac{1}{feed\ conversion\ ratio} = \frac{1}{4.78} = 20.9\%$$

For manual feeding system, the feed conversion ratio and feed efficiency were calculated from Table 2.

Average feed consumed by the fish = 421.50 g

Average fish produce (gain in weight by the fish) = 78.50 g

$$FCR = \frac{total\ amount\ of\ the\ feed\ given\ (g)}{total\ gain\ in\ weight\ by\ the\ fish\ (g)}$$

$$= \frac{421.50}{78.50} = 5.37$$

$$\text{Feeding Efficiency } FE = \frac{1}{feed\ conversion\ ratio}$$

$$= \frac{1}{5.37} = 18.6\%.$$

Graphs of the growth rates for the automatic and manual feeding systems are shown in Figures 1 and 2, respectively.

3.2 Statistical Analysis

Statistical analysis was performed using t-test to determine differences between treatment means at 5% significance level.

$$\mathbf{t} = \frac{X - \mu}{\sigma/\sqrt{n}} \qquad (3)$$

Where,

X? = mean of the value
μ= population mean
σ = standard deviation
n = number of data points.

The result of the statistical analysis is shown in Table 3.
The investigation revealed that, an average feed of 421.50 g was required to produce 78.50 g of fish in manually-fed tank, while in the automatically-fed tank, an average feed of 428 g was required to produce 89.50 g of fish. Both feed consumption and growth rate appeared to increase with the correct amount of feed dispensed at the appropriate time. The feeding efficiency was higher in the automatic feeding system than in manual, justifying the use of automatic feeder for feed management. Also, from the statistical analysis, the average gain in weight per fish in automatic feeding was higher than in manual.

4.0 CONCLUSIONS

There was significant difference in weight gain in fish fed using manual and automatic methods. Fish fed by automatic device exhibited higher weight gain. The feeding efficiency was higher in the automatic system than in manual.

REFERENCES

Baçınar N., Çakmak E., Çavdar Y. and Aksungur N. (2007). The effect of feeding frequency on growth performance and feed conversion rate of Black sea trout (*Salmo trutta labrax* Pallas.

Baldwin, W. J. 1983. The design and operation of an automatic feed dispenser. Aquaculture,

Hepher B. 1988. Nutrition of Pond Fishes. Cambridge University. Press, Cambridge.

Kentouri, M., P. Divanach, and E. Maignot. 1993. Production, Environment and Quality. Bordeux Aquaculture '92. European Aquaculture '92. Special publication No. 18, Ghent,

Belgium.

Losordo, T. M. and Westers, H. 1998. Aquaculture Water Reuse Systems: Engineering Design and Management. Developments in Aquaculture and Fisheries Sciences, vol. 27. Elsevier, Amsterdam.

Table 1: Growth Rate of Catfish for the Automatic Feeding Method

S/N	Date	Number of Fish	Average weight of fish (g)	Total feed consumed (g)	Average gain in weight (g)
1	16/04/2013	10	300.00	0.00	0.00
2	23/04/2013	10	305.00	42.00	5.00
3	30/04/2013	10	313.50	43.00	8.50
4	7/05/2013	10	323.00	44.50	9.50
5	14/05/2013	10	335.50	46.00	10.5
6	21/05/2013	10	345.50	47.00	10.30
7	28/05/2013	10	355.53	49.00	9.80
8	04/06/2013	10	365.80	51.10	10.5
9	11/06/2013	10	377.20	52.00	11.40
10	18/06/2013	10	389.20	53.40	12.00

Table 2: Growth Rate of Catfish for the Manual Feeding Method

S/N	Date	Number of Fish	Average weight of fish (g)	Total feed consumed (kg)	Average gain in weight (g)
1	16/04/2013	10	300.00	0.00	0.00
2	23/04/2013	10	304.00	42.00	4.00
3	30/04/2013	10	312.50	44.00	8.50
4	7/05/2013	10	320.20	45.00	7.70
5	14/05/2013	10	329.00	46.00	8.80
6	21/05/2013	10	335.00	46.50	8.00
7	28/05/2013	10	344.50	47.00	9.50
8	04/06/2013	10	354.70	49.00	10.20
9	11/06/2013	10	365.50	50.00	10.80
10	18/06/2013	10	376.50	52.00	11.00

Table 3: Result Of Statistical Analysis

Feeding Method	Mean gain in weight per fish (x)	Standard deviation (	t-test value
Automatic feeding	8.95	3.57	1.077
Manual feeding	7.85	3.23	0.973

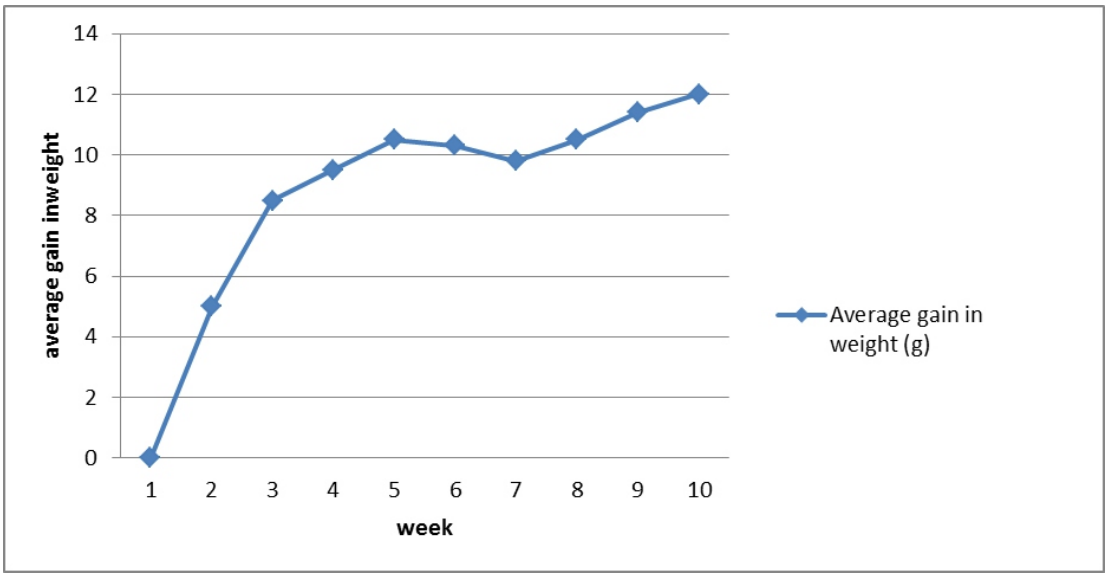


Figure 1: Graph Of Growth Rate For Automatic Feeding System

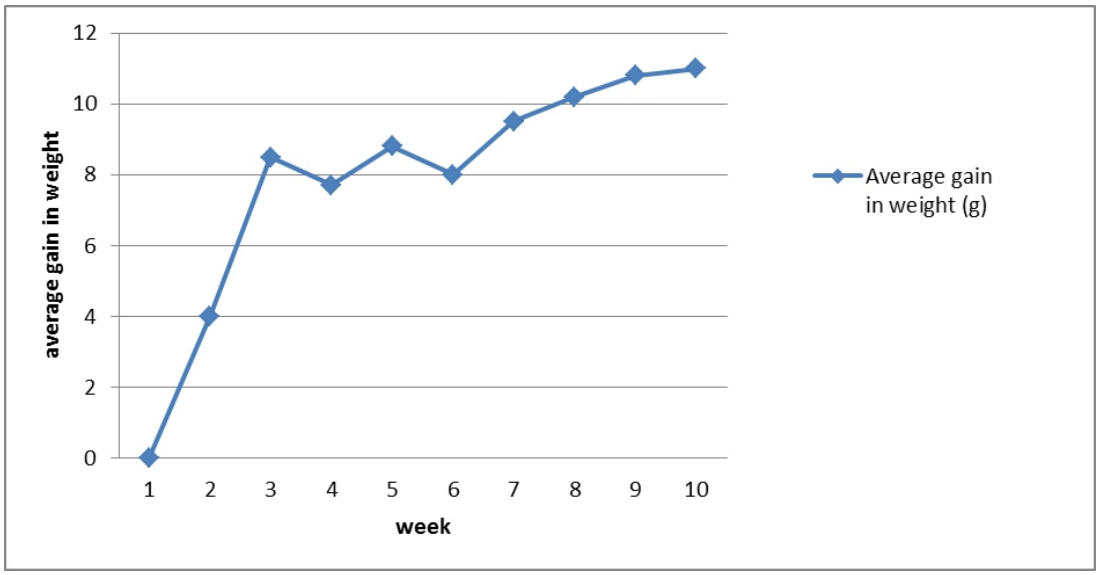


Figure 2: Graph Of Growth Rate For Manual Feeding System

AN INVESTIGATION INTO THE LOCAL TECHNOLOGY OF THE PRODUCTION OF SUGARCANE BASED SWEETENER (MAZARKWAILA) IN NORTHERN NIGERIA

[1]**Mohammed Abubakar and** [2]**R.F.Jahun**
[1]Department of Agricultural Engineering, ABU,Samaru-Zaria
[2]Department of Agricultural Engineering, BUK, Kano

ABSTRACT
A technical investigation of sugarcane based sweetener (Mazarkwaila) processing was conducted in Yakasai village soft sugarcane fields of Kaduna state, Nigeria. Mazarkwaila is a raw sugar produced from chewing or soft sugarcane and used in northern Nigeria as food sweetener since pre-colonial time. A scientific investigation method was adopted and the results showed that the Mazarkwaila processing powered by horses is purely people's oriented and indigenous technology comprising of unit operations as: harvesting, handling, juice extraction, evaporation, homogenizing, moulding and packaging. The sugarcane cultivar used as raw material was Danhausa and has yield of 56.4tons/ha, giving income yield of N 776,925.00 /ha. It is the only post-harvest technology that is on farm that produces ready-to -eat food from farm in Nigeria. The problems of the technology include; use of outdated tools, drudgery on operators and the animals, poor hygiene and improper packaging. Upgrading this technology will create sustainable rural employment and an improvement in food security and quality.

Keywords: Sugar, Chewing Sugarcane, Sweetener, Mazarkwaila .

1.0 INTRODUCTION

Sugar contains calorie and is made from sugarcane (*saccharum officinarum* L.). Sugarcane is one of the crops cultivated in Nigeria for its commercial value and its serves as a source of income for a sizeable population of farmers in many parts of Nigeria (Wayagari, et, al.2003). According to Food and Agricultural Organization (FAO 2008), the production of sugarcane in Nigeria is 1.5million metric tonnes per annum. Other major producers of sugarcane on the globe are Brazil and India (Binbol,et al.2006). However, the current global warming has its effect on the world production of sugarcane. The recent flood in India and the dry spell in Brazil, which are the evidences of global, warming, have decreased the production of sugarcane in those countries (Akintola, 1980). In Nigeria and the other countries, sugarcane is produced not only as direct food and a source of calorie for human beings but also as a major raw material for sugar and other food industries.

The first sugar production company in Nigeria was established at Bacita, Kwara state in 1960. Since then, a few number of other sugar companies have been located across the country (Suleiman, 1996).. Some of these sugar companies import the raw material (centrifugal sugar) from other countries (Agboirs,et al.2002), while some others depend solely on the sugarcane produced in Nigeria. Sugarcane varieties are largely divided into industrial and soft sugarcane. The industrial sugarcane is used mainly for the production of industrial sugar and it has a hard back which makes it difficult to chew by humans. The soft sugarcane is chewed by humans for its sweetness. After chewing and removing sugary juice from the soft sugarcane, the stalk is spewed.

Among other uses of sugarcane is production of food sweeteners. Food sweeteners are used in food production companies such as confectioneries and yoghurt,

to improve on the taste of their produces. Food sweetener made from sugarcane has been found to be good substitute for sweetener from honey comb. One major kind of local sweetener from sugarcane is the *mazarkwaila* (raw sugar). Mazarkwaila is produced in most part of northern Nigeria (Imam, 1994). It is made into small cubes and sold in local markets across the part of the country where it is produced. Mazarkwaila may be chewed for entertainment just like chocolate or used as domestic food sweetener at home when added to pap-*ogi* or *koko(cereal foods)*.

However, as at date, mazarkwila production method and technology remain as they were since the pre-colonial era in Nigeria (Plate1). The techniques of the juice extraction from sugarcane and every other process in mazarkwila production remain archaic and need to be upgraded in line with recent development in science and technology. The tradition of using horses to drive the sugar mill to extract the juice should be discouraged and a more up-to-date power source such as electricity may be used to replace the horses. This would not only improve on the hygiene in the mazakwaila production but would also increase the efficiency of the extraction. Likewise, the process of evaporating and caking the mazarkwail should be redesigned to incorporate modern methods of doing the same things. These would also improve on the hygiene of its production and, perhaps, reduce the cost of production, thus increase the profit margin of the producers.

According to a survey by Suleiman *et al* (2010) on the processing of sugarcane in northern Nigeria, the northwest geopolitical region was found to be the major processor of mazarkwaila and the processing equipment and methods were found to be the same among the processors. In the light of the above therefore, the aim of this study is to conduct a scientific investigation into the local method of mazarkwaila production with the view to applying modern engineering and science knowledge to improve on the process. This study would also make recommendations on how to make the production of mazarkwaila more enviable and wholesome and make the produce more acceptable by patrons.

2.0 MATERIALS AND METHODS

2.1 Study Area

Because of homogeneity in the processing method and equipments among the Mazarkwaila processors, Mazarkwaila processing point of Yakasai village of Soba local government area of Kaduna state located at coordinate (11o 11, N,7o 38, E,686m above sea level) was selected for the study. The point has 50years experience and operates two shifts using two horses, shift1 starts by 7.00am and finishes at 12.00noon and shift2 starts by 3.00pm and finishes at 7.30pm .

The equipment involved in the processing includes: sugarcane mill, harvesting hand tools, horses, earthen stove, evaporator, homogenizing containers and moulds. The sugarcane cultivar used was a local breed called Danhausa.

Instrumentation;

A salter weighing scale (0-150kg) with sensitivity of 50g, vernier calipper, measuring tape, laboratory thermometer, digital moisture meter, measuring cylinder, digital tachometer and a digital camera.

2.2 Methods

Investigation method used by Imam.(1994) was adopted. Preliminary contact was made with the management of the Mazarkwaila processor of the study area, with the view of harmonizing the scientific investigations with their routine production plan so that their capacity utilization is no tempered with. As early as 6.30am the team of investigators was in fadama sugarcane field of the Yakasai village integrating with six

man labour force of the processor. A simultaneous operation began by 7.00am in which the processors are on their processes while the investigators were conducting scientific investigation on the processing process without each others obstruction for the period of two days. Unit operations were identified (figure1) and scientific measurements conducted and replicated five times, mean values were computed and recorded.

2.2.1 Harvesting

Field capacity was measured by measuring an area in the sugarcane field and setting time for a harvester to complete the area and the harvested sugarcanes were weighed with a scale. Weight of harvested sugarcane divide by the time gave the field capacity.

2.22.2 Handling

Manual handling weight was measured using a scale and distance travelled to the processing centre in the farm was measured using tape.

2.2.3 Juice extraction

Throughput capacity was measured by weighing the cane that was fed to machine in an hour, weight per time gave throughput. Quantity of juice extracted was measured using moisture meter, the moisture content of the fresh cane was measured before feeding in to the extraction machine and after. Juice extraction efficiency:

Fresh cane moisture content = 54%
Baggase moisture content = 16%
Extracted moisture = 54-16 = 38%
Extraction efficiency = $^{38}/_{54}$ x 100 = 70%

Physical dimension of the cane was measured using vernier calipper and tape (Imam, 1994). Extraction machine components were measured with the caliper and tape, York length was measured using tape and number of revolution of the horse physically measured.

2.2.4 Evaporation

Juice and massecute boilng temperatures were measured with a laboratory thermometer and their specific gravities were measured using density bottle.

2.2.5 Unit operation

The Msazarkwaila Production Unit Operations is shown in Figure 1.

3.0 RESULTS AND DISCUSSION

The Mazarkwaila processing is purely on farm, where a processing space is provided within the sugarcane field. The cultivar of sugarcane processed was white soft sugarcane (chewing) called Danhausa and processing season ranged October-May annually. The identified Mazarkwaila processing process at the Yakasai point includes unit operations such as: Harvesting, Handling, Juice Extraction, Evaporation, Homogenizing, Moulding and Packaging. The flowchart is shown in figure 1.

3.1 Harvesting Operation

The harvesting method was found to be the same across the Mazarkwaila processors. The canes were first de-trashed, harvested and packed in bundles of 63kg manually at an average rate of 360kg/hr. The sugarcane cultivar was Danhausa having

average yield of 56.4 tons/ha (Suleiman et,al. 2010). Two people were involved in this operation and tools used were; sickle, cutlass, hoe and rope. The by-product of this operation is the trash (sugarcane tops, leaves) which were normally sold to Fulani herders.

3.1.1 Harvesting problems

Although the manual harvest fits the processing method, the two people engaged in this work were not wearing any protective cloth that will protect them from the body itching chemicals of the cane trash. From the workers, this reduces their harvesting speed. The fibrous part of the cane top if inhaled can constitute a health hazard. The cutlass cuts the tops and the cane whereas the sickle cuts the leaves, carrying the two tools and using them inter changeably constitutes a lot of drudgery to the harvesters interns reduces their field capacities.

3.2 Handling

The cleaned bundled cut sugarcanes were transported manually to the juice extraction point located in the sugarcane field. Two people engaged in the handling had to carry 63kg weight of a bundle through a distance of 500m to the juice extraction point. If harvest advances the juice extraction point were normally moved to a closer point within the estimated distance.

3.2.1 Handling problems

The 63kg manual handling in this processing exceeded the International Labour Organization approved manual handling weight of 25kg. The handlers had to meet the juice extraction operation demand; the repetitive trekking of 500m with the bundles can lead to spinal cord injuries.

3.3 Juice Extraction

Juice extraction was achieved by the use of metal rollers powered by a horse. The machine comprises of three rollers, two same sizes and a big one positioned vertically as shown in plate1. An operator insert two canes a big and a small in to the machine and a horse boy ride the horse in to a circular track and power is transmitted from the York connected to the horse then linked to the juice extraction machine rollers. Two horses are used interchangeably at interval of 5hrs.

The extracted sugar juice was collected in a halved metal drum positioned bellow the rollers discharge point. The following machine parameters were measured;

Throughput capacity = 360kg/hr
Mean speed of the horse = 6rpm
Average height of sugarcane = 216cm
Average diameter of sugarcane at node = 3.26cm
Extraction efficiency = 70%

3.3.1 Machine Parameter/Dimension

(I) Clearance between feed rollers = 2.5 cm
(ii) Clearance between discharge rollers = 0.4cm
(iii) Diameter of driven roller (small) = 11.78 cm
(iv) Diameter of driving roller (big) = 20cm
(v) Rotational speed of the driven roller = 6rpm
(vi) Number of teeth of driving gear = 10
(vii) Number of teeth of driven gear = 20
(viii) Distance of horse hitching point to the driving shaft = 4.4m
(ix) Torque (T) of driving gear $= \frac{745x60}{2\pi x6} = 1185\text{Nm}$

πNTD

(x) Power developed by driving roller = 2 $\frac{6x1185}{12}$ = 1640Watts
(v) Torque of driven gear = πNTD = 592Nm
(xi) Power developed by driven roller = 2 = 877.9Watts
(xii) Machine overall height = 76cm

The by-product of this operation is the Baggase, they were sun dried and used in the next unit operation.

3.3.2 Problems of juice extraction

Two men were involved in this operation; one feeds in the sugarcane at kneeling posture (to dodge the horse Yoke) and the other gyrate the horse at a mean speed of 6rpm within the radius of 4.4m. The drudgery incurred here can constitute a serious health hazard. In this process the harvesters and handlers should not lag behind the juice extractors otherwise it is an offence in this factory punishable with a sack. In other words the stresses between the three units operations are connected. The yoking of the horse with a belt reduces neck stress but the circling of the tract for five hours is another health issues in animal draft although bulls do observe these hours but in a linear tract.

3.4 Evaporation of Sugarcane Juice

Open pan evaporation method was used; the equipment consisted of an earthen stove with a half longitudinally sectioned steel drum (plate2). The firing fuel was the baggase recovered from the previous unit operation. One man operates this process; he handled the sugarcane juice from the extractor to the evaporator drum and also supplied the fuel to the stove until massecute is formed. The same man transferred the massecute to next unit operation.

Some thermal properties of this process include;
Juice boiling point = 40-45°C (depends on impurity presence)
Massecute boiling point =65°C
Physical quantities:-
A portion of groundnut oil was added during heating of massecute, in order to improve its viscosity.
Specific gravity of cane juice = 1.05 cc
Density of cane juice = 1050kg/m3
Specific gravity of massecute = 1.2cc
Density of massecute = 1200kg/m3
132kg fresh juice gives 31.5kg of massecute

Juice: Massecute
132: 31.5
1: 0.24

Therefore, 24% of juice gives the massecute in this process and process time does not exceed 1.20hrs.

3.4.1 Problems of evaporation

This process was crude (did not know good manufacturing practice), the hygiene level was low and impurity access was high. Some impurities come to the surface when the juice was boiling and were scooped and sold to women for further processing as sludge.

3.5 Homogenizing

The generated massecute, poured in to a cylindrical metal container was homogenized manually using wooden stick. The stick was rotated in the body of the

massecute until uniform particle size was attained. This was done under a shed.

3.6 Moulding of Massecute in Mazarkwaila Cubes

When the homogenized massecute cools to 40°C, it was the time for cubing. Copper cans were used as mould and the massecute was poured into individual cans as shown in plate3. The cooled massecutes produces the Mazarkwaila cube ready for eating.

3.7 Packaging of Mazarkwaila Cubes

Used peak milk cartons were used in packaging the Mazarkwaila for distribution. Small scale buyers (at farm gate) packaged in polyethylene materials. According to the processors the packaged cubes have a shelf life of up to one year.

3.8 Processing Yield

452kg of juice from one tonne of sugarcane gives 108.5kg of massecute

Then 31.5kg of massecute gives $\frac{108.5}{31.5} \times 60$ cubes of finished Mazarkwaila or 80 set of Mazarkwaila cubes(2cubes give a set) in this processing, therefore;

Number of cube set per tonne = = 275.5

Number of cube set per hectare = 56.4 x 275.5 = 15,538.2

Farm gate price of cube set = ₦ 50

Total production/ha = 15,538.5 x 50 = N 776,925.00

If Nigeria can allocate 1 Million hectare of land for this production, N 776,925.00 Billion can be generated with resultant mass rural employment.

3.9 Labour Budget

A manager (production & marketing)
2 de-trashers/harvester and handlers
1 sugarcane feeder
1 horse boy
1 evaporation pan boy
1 homgenizer/packaging boy

Total labour involved in the processing was 7 people, apart of the manager all the remaining workers were paid with the Mazarkwaila product.

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

On farm processing of chewing sugarcane into Mazarkwaila has been practiced in northern Nigeria for a long time, it serves as a means of preservation and value addition of sugarcane products especially when farmers are confronted with bad sugarcane prices. It is the people's technology, the animals and the people involved were exposed to high level drudgery. Good manufacturing practice was not in place when this technology was developed, contamination potentials can discourage modern man from using the products. Post-harvest extension is something new in Nigeria; the processors do not have contact with government mandated agencies. Since the product from these processors has economic value, up-grading the technology will make the product to be accepted by all. Increase in production capacities will help in creating employment.

If encouraged, the production of mazarkwaila would help to attain government's strive for sugar security, it would also promote increase in the local production of sugarcane by encouraging its cultivation. The mass production and sale of mazarkwaila would definitely create mass employment for rural people and may generate foreign exchange if the products are exported into neighboring countries such as Niger and Chad

Technology. Vol. 5(1-2), pp81-84.

Website visited: http://www.nsdc.gov.ng/index, http://www.faostat.org/, http://www.alvanblanch.org



Plate 1: Sugarcane Juice Extraction Process



Plate 2: Sugarcane Juice Evaporator



Plate 3: Massecute Moulding And Mazarkwaila Cubes

republics etc where mazarkwila may be readily accepted.

4.2 Recommendation

The up-grading of Mazarkwaila production technology is hereby recommended through the following steps:-

i Re-designing of the sugarcane harvest tools for drudgery reduction and increased efficiency.
ii Attachment of handling aids to the handling operation (wheel barrow,etc).
iii Re-designing the juice extractor, to one powered by an engine (prime mover).
iv Improved open pan evaporator made of galvanized iron sheet or aluminum on improved earth stove should be incorporated.
v The juice extractor and the evaporator to the homogenizer should be connected with a pipe network.
vi Smaller mould close to cubes of refined sugar should be introduced and a solar drier should be used to dry the cubes.
vii Carton or plastic packaging should be used to package the product.
viii All the unit operations except harvesting and handling should be housed in the shed.

REFERENCES

Agboirs, S., Wada, A.C. and Ishaq, M.N. (2002). Evaluation and characteristic of Sugarcane Germplasm for their Breeding Values in Nigeria. Journal of Food Technology in Africa. Vol.7, January-March.pp33-35.

Akintola, J.O. (1980). Apreliminary Investigation of the Structure of the Nigerian Sugar Industry. In: M.O.Fawole(Ed). The Sugar Industry, proceedings of a symposium organized by the Unilorin Sugar Reseaech Institute.June 24-25, 1980, pp11-21.

Binbol, N.L., Adebayo, E.H. and Kwon Ndueng. (2006). Influence of Climatic Factor on the Growth and Yield of Sugarcane at Numan, Nigeria. Climate Research . Vol.32, pp247-252.

Chaesman, O.D. (2004). Invironmental Impact of Sugar Production. CABI Biotech, UK Center.

Imam,A.H.(1994). Comparative Study on two different Animal power sources for Stationery Operations. Unpublished MSc. Thesis, Department of Agricultural Engineering, ABU Samaru-Zaria.

North-West National Sugar Development Council enlightenment campaign. (2010). Hausa service of the FRCN Kaduna, 6.0pm- 30/1/2010.

Suleiman M.L.(1996). Traditional Sugar Making-Tools and Process. Proceedings of the commonwealth Training Program on Technology,Tools and Process for Women.P 165-168.

Suleiman M.L, Jahun, R.F. Mohammed,A.(2010) Survey of Method of Processing of sSugarcane in Northan Nigeria. Research and Linkage Program Report. Department of Agricultural Engineering, BUK-Kano.

Wayagari, J.W., Ayoola, G.B., Imolehin,E.D. and Misari,S.M. (2003). Economic Evaluation of Chewing Sugarcane Production in the Central Zone of Nigeria.Sugar

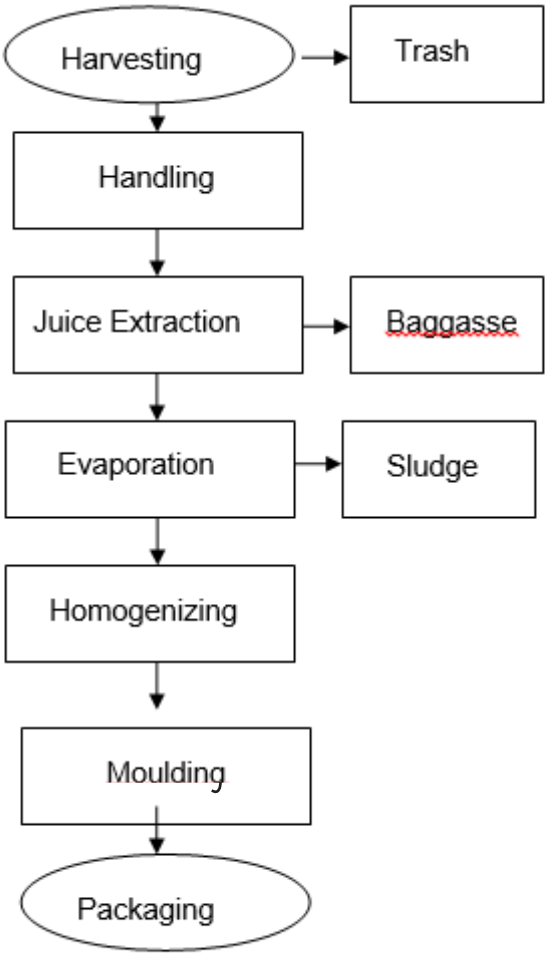


Figure 1.0: Msazarkwaila Production Unit Operations

ENGINEERING PROPERTIES OF THEVETIA PERUVIANA KERNEL FOR THE DEVELOPMENT OF PROCESSING MACHINES FOR BIO-DIESEL PRODUCTION

Nasirudeen A.R., Balogun L.A., Jimo K..A., Akangbe O.E, Lasisi D., Ilori A. O.
Department of Agricultural and Bio-Environmental Engineering, Oyo State College of Agriculture, Igboora, Oyo state
jibolarufai@gmail.com, lawalbalo@yahoo.co.uk, kabyjayengineer@yahoo.com, oluseyiakangbe@yahoo.com, dalasisi@yahoo.com, bjtemilor@yahoo.com
Corresponding Author: jibolarufai@gmail.com, 08063894989

ABSTRACT
Thevetia Peruviana kernel is becoming an alternative industrial raw material to the locally grown *atropha carcus* seed which is not rich in oil production for bio-diesel. Hence, the need to study the Engineering properties of this kernel for the development of the machine for de-hulling and oil extraction. The Engineering properties of T*hevetia peruviana* were investigated using standard method. The shape, size, number of seeds per unit weight, sphericity, geometric mean diameter, true volume, bulk density, porosity, surface area, angle of repose, co-efficient of friction on steel surface. Some experiments were replicated hundred times as others. The result obtained from the study revealed that the minor diameter, intermediate diameter, major diameter, true volume, true density, bulk density, number of seed per unit weight, porosity, surface area, sphericity, geometric mean diameter, percentage of cotyledon to kernel, angle of repose and co-efficient of friction on steel were15,59mm, 17.93mm, 31.34mm, 4.5mm^3,0.90,g/cm^3,0.56g/cm^3, 211, 37.65%, 900.40mm^2, 66%,, 20.60mm, 24.61%, 22.34 and 0.22 respectively. The results obtained from the engineering properties of *Thevetia peruviana* kernels studied can serve as preliminary data required in the development of machines for nut cracking , nut handling and oil extraction processes.

Keywords: *Thevetia peruviana*, Engineering Properties, Bio-Diesel, Oil Extraction

1.0 INTRODUCTION
Thevetia peruviana is an evergreen tropical small tree with a very high resistance to adverse conditions. It is noted to be peculiar to areas like Mexico, Brazil and West Indians. It bears a rounded fruits product which is initially green from emergence to maturity and turned black when ripped for harvesting .Its fruits contains a large seed of brown color.

As reported by Maria et al. (2012) reporting sahoo et al (2009), Thevetia peruviana is a fruit-harvest almost throughout the year. All the part of thevetia peruviana are toxic due to cardenolic compound and cianhiidric acid. It is known as yellow oleander(nerium), gum bush, bush milk, and exile tree in indian, keremuje, kerebuje, kanmiko in Yoruba, Southern Western Nigeria (Ilori et al ,2009). It is as well refers to as kondo flower in yoruba land. This plant has usefulness in different areas to include horticulture, pharmaceutical and power sector among others. It consists of deep green-waxy pericarps fleshy mesocarp and a hard endocarp. Ilori et al(2013) reported that thevetia peruviana is very high in oil with the oil content in the kernel being high as a 62.14%(w/w) while other part of the fruit bears negligible amount of oil. Then this non-edible oil is an excellent source of bio fuel and for this important oil part to be gotten, there need a mechanical machine to express the oil and this give rise to need to study the

engineering properties of the seed.

The extraction of oil from Thevetia peruviana or any other oil seeds can be accomplished through different methods from mechanical to solvent extraction. Diaz-ballote et al (2009) reported that the mechanical extraction of oil from Thevetia peruviana reaching a yield of 40%. Sahoo et al (2009) and Ibiyemi et al, (1995) report solvent extraction of 60% using n-hexane and 62% using petroleum ether as solvent as reported by Jose A. R. U. (2009). Although the extraction of oil from Thevetia peruviana in mechanical extraction is lower than solvent extraction, mechanical method is better in consideration for availability of material to use in each of the processes. Engineering properties of agricultural produce are essential in the design of the component parts of equipment for shelling, drying, cleaning, sorting, grading storage and oil extraction. These various properties have influence in the design of the various parts of any machine for aforementioned operations. Physical and engineering properties are important in many problems associated with the design of machine and analysis of the behaviors of product during agricultural process operations such as handling, planting, cleaning, sorting, drying and storing (Akaaimo, 2006).

Therefore, this study is carried out to determine the engineering properties of Thevetia peruviana as useful in design and construction of machinery for extraction of Thevetia peruviana oil, which is an important oil seed in bio fuel production.

2.0 MATERIALS AND METHODS

The Thevetia peruviana seeds were collected from a school garden in Igboora, Oyo State and the kernel was separated from the fruit using manual threshing method and cleaning was done by hand-picking. Oven drying method was used to determine the moisture content of the representatives samples of the produce (*Thevetia peruviana*).

2.1 Determination of the Engineering Properties

2.1.1 Size and shape

One hundred samples of Thevetia peruviana seeds were selected randomly. The three linear dimension of the seed namely major, intermediate and minor diameters were measured with a vernier caliper reading 0.1mm. the geometric mean diameter of the seeds were determined using Joshi et al (1983) formula.

$$DP=(abc)^{1/3} \quad \text{.....(1)}$$

Where a = longest diameter or major diameter (mm)
b=intermediate diameter (mm)
c=minor diameter (mm)

The sphericity for each seed was determined using Faleye and Atere (2009) equation
Sphericity is the ratio of geometric mean diameter to major diameter

$$S=\frac{(abc)1/3}{a} \quad \text{.....(2)}$$

The true density (particle density) was determined using the water displacement method as described by Oje and Ughor (1991). To accomplish this, a measuring cylinder was filled with water to a certain level. A bunch of seeds of known mass was submerged in the cylinder resulting in rise in water level. The true density was calculated for each of the 10 replications from the relations as follows:

$$e_t=\frac{Ws}{Vw} \quad \text{.....(3)}$$

Where e_t= true density (kg/m3)
Ws=weight of sample (kg)
Vw= volume of displaced water (m3)
The bulk density of the seed was determine by filling an empty 250ml beaker with the seeds from a certain height, leveling the surface and weighed the content(Mohsein 1970). The process was replicated 10 times and bulk density was calculated from the following equation:
?b= *Ws/Vs* ……..(4)
?b=bulk density (kg/m3)
Ws= weight of sample (kg)
Vs= Volume occupied by sample (m3)
The volume of the seeds that filled up the container was calculated using the conventional method of volume of cylinder determination, as given:
$V=\pi r^2 h$ ……..(5)
Where V= volume of occupied m^3
π is constant
r is radius of the inside container
h is the height of the inside container
Porosity was calculated from the values of true and bulk densities using the relationship proposed by Jain and Bail (1997).

$$\varepsilon=\frac{\varrho t-\varrho b}{\varrho t} \quad \text{.....(6)}$$

Where, ε is the porosity
$e_t$is the true density
$e_b$is the bulk density
Number of seeds per unit weight was determined by weighed the certain number of seeds to reach one kilogram and the seeds were carefully counted to determine the number seeds that weighed one kilogram.
The surface area of the seed was determined by the graph method due to unavailability of palanimeter or photographic projector. The surface area was then calculated from the area covered by seed on the graph paper.

Angle of repose was determined using a squarely constructed box as described by Olalusi et al. (2009). The box was filled with seeds and the front panel was quickly removed, which allowed the seed to flow to its natural slope. The angle of repose was calculated from tangent inverse ratio of the height to the base of the pile

$$\text{Ø}_r=\tan^{-1}\frac{height}{base} \quad \text{.....(7)}$$

The Coefficient of static friction was determined using mild steel, plywood, stainless and glass incline plane apparatus as described by Dutta et al. (1998). A seed was placed on the aforementioned surfaces slightly raised to avoid direct contact between the surface and tin. The table was gently tilted and the angle of inclination at whoch the sample just started sliding was read off the protractor attached to the apparatus .The tangent of this angle in degree is reported as coefficient of static, friction for each of the 10 replicates.

$Us=\tan(\text{Ø}_r)$……(8)

Where Us= Coefficient of friction.
Ø_r= Angle of inclination
Percentage of Kernel was determined by opened the nut with the knife and get the kernel as proposed by Maria et al. The mass of the kernel was determined by deducting the mass

of the kernel from the mass the whole nut. The kernel Percentage was determined as:

$$\text{Kernel Percentage } \% = \frac{\text{Mass of Kernel}}{\text{Mass of nut}} x100 \quad \ldots\ldots(9)$$

Roundness of the seeds were determined by tracing their outlines on a graph paper, Ap and Ac were measured according to Alabadan and Gana (2012).

$$R = Ap/Ac \quad \ldots\ldots(10)$$

Where, R is the roundness of the seeds
Ap is the traced area of the seeds obtained
Ac is the traced area of the smallest circumscribing circle

3.0 RESULTS AND DISCUSSION

3.1 Moisture Content

Moisture content (mc) of the Thevetia peruviana was obtained to be11.1%(dry basis) at one month after harvest. This is the moisture content at which the physical properties were taking and considered.

3.2 Size and Shape

The size and shape of Thevetia peruviana is presented in the table 1. The seed had major diameter ranging from 36.91 to 25.57mm and mean major diameter of 31.34mm. The least intermediate diameter is 15.56 and the maximum is 20.41mm while the mean is 17.93mm. The minor diameter ranges from 19.29 to 12.09mm and the mean minor diameter is 15.60mm. It is observed from table 2,that the seed with maximum diameter is not with maximum intermediate and minor diameters. This is an indication of the irregularity in the shape of the seed. These values are higher than that of castor seed of major , intermediate and minor diameter of 16mm,12.2mm and 7.2mm(ojji), 16.3mm, 12.4mm and 7.3mm (evahura) and 10.6mm, 8.2mm and 5.2mm(ashowu) respectively but less than prosopis Africana of 132.47mm, 28.71mm and 19.00mm(Adigun et al, 2000). These parameters would help in designing sieve and clearance in separation and dehulling equipment. The distribution curves for the diameters are shown in figure 1. The curves approach normal distribution curve.

3.3 Geometric Mean Diameter

Geometric mean diameter is presented in table 1.the value ranges from 16.98 - 23.27 mm with mean value of 20.60mm.it is observed from table 2 that maximum geometric mean is obtained from the seed of maximum minor diameter. This implied that geometric mean of irregular dimensioned seed increases with increases in axial dimension of the seed.

3.4 Sphericity and Roundness

The result of sphericity and roundness measured is presented in the table 1. The average sphericity is 65.8% and it is within the range of 59.0% -74.7%. Table 2 shows that the maximum sphericity was obtain at maximum intermediate diameter but minimum major diameter. The value is in accordance with value of Prosopis Africana of 65% (Adigun, 2012). The sphericity would help in designing hopper, chute and other facilities to handle Thevetia peruviana. The spherecity is an indication of sliding or rolling property of a material in different media. Roundness values are 66.7%, 61.1% and 72% for mean,

reported by Alabadan et al.(2012)

3.5 True Volume and Density, Bulk Density and Porosity

The result for true volume, true density and bulk density are presented in table3. The true volume of Thevetia peruviana was at minimum value of 3.48cm^3 and maximum value of 4.86cm^3 with mean value of 4.5 cm^3.The True density has mean, minimum and maximum value of 0.89, 0.73 and 1.02g/cm^3 , respectively. The true density is less than the density of water, which is an indication of its floatation in water. The density helps in separation of seed from other material lesser or higher in density than it. True density can be used to estimate for capacity and crop yield in processing operation and machinery. The bulk density obtained for Thevetia peruviana ranges from 0.522 -0.61g/cm^3 and with mean value of 0.56g/cm^3.

The bulk density can be used to estimate capacity of machine hopper and storage structure. The relationship between density of mass produce and true density is computed as porosity which ranges from 28.5 -46.06 with mean value of 37.35.these values are higher than that of prosopis Africana. The parameter would help in understand the flow of fluid through the mass seed for different processing and storage operations and machinery. The distribution curve of true volume and density skewed to the left while bulk density and porosity are close to the normal.

3.6 Number of Seed Per Unit Weight and % Kernel

The number of Thevetia peruviana per unit weight is presented in table 3 and distribution curve in figure 2. The mean number of seed per unit weight was 211seeds while it has minimum and maximum value of 198 and 220, respectively. This is higher than value for cashew at 8%(mc) 180 and lower than that of neem seed of 4500(Vanangamudi et al, 2007). This helps in estimating weight of known number of seed.

%kernel as shown in the table 3 has mean value of 24.60% and ranges from 19.9 - 30%. The mean is less than % kernel reported by Maria et al,(2012) as 29 %. This would help in estimating the oil yield of oil seed. The distribution curve for NS /UW skewed right while % kernel skewed otherwise.

3.7 Coefficient of Static Friction and Dynamic Angle of Repose

The coefficient of static friction and angle of repose are presented in table 4. The mean value for coefficient of friction was 0.19 on stainless, 0.22 on mild steel, 0.18m on glass and 0.21 on plywood. This is used in the design of hopper and outlet for easy flow of material. The angle of repose for surfaces were 22.59°(stainless steel), 22.34°(mild steel), 23.15°((glass) and 22.41°(plywood). The distribution curve for angle of repose skewed left in case of plywood and glass while approaches normal in mild steel. The angle of repose can be used in designing conveyor belt and in marketing of produce.

4.0 CONCLUSIONS

Engineering properties of Thevetia peruviana seed were determined. These properties are helpful in the design of processing, handling and storage machineries. Inferences made are:

The shape of the Thevetia peruviana seed is oblong. Thevetia peruviana is close to spheroid, meaning that it is rollable and with ability to slide.

The density shows that the Thevetia peruviana seed would float in water

Its porosity shows that the seed is aerial.

REFERENCES

Adigun, Y. J., A. F. Alonge (2000): Some Engineering Properties of Prosopis Africa relevant to Dehulling. Nigerian Journal of Technology, Volume 19. No 152.

Akaaimo, O. I., A. O. Raji (2006): Some Physical and Engineering Properties of Prosopis Africana Seed. Biosystem Engineering, 95(2): 175-205

Alabadan, B. A., I. M. Gana (2002): Determination of Some Physical Properties of Some Selected Nigerian grains. Continental journal of Applied Sciences 7(2): 9 – 18

Diaz Ballotte L., E. T. Vega,T. Suarez-Mendoza, C.Mariel-Dominguez,A. Castillo-Antoche, Thevetia peruviana,: altervnative energetic removable en Mexico, El subcaliforniano-ciencia, Technologicia el innovation para el Desarrollo de Mexico, Ano3, 64 La paz B. C, Mexico 24 de octubre, 2010.

Dutta S. K. , Nema V. K. ,Bardwaj R. K.(1998): Physical Properties of Gram. Journal of Agricultural Engineering Research, 23.

Faleye I., A. O. Atere (2009): determination of Some Physical and Mechanical Properties of Some Cowpea Varieties.Proc of 3rd International Conference of WASAE pp 240.

Frontezak, J. and T. Metzen (1985):The Studies in Slip Angle and Geometric Features of Corn Grain in Moisture Function. proc. 3rd International Conference on Physical Properties of Agricultural materials. 240.

Gupta R. K. ,and S. K. Das (1997): Some Physical Properties of Sunflower Seed Journal of Engineering Research. 34, 222

Ibiyemi, S, A., Bako, S. S. , Ojukuku G. O. and Fadipe V. O. (1995): Thermal stability of Thevetia Peruviana. J. USS Seed Oil Journal AM. Oil Chemistry. SOC; 72(6) , 746

ilori A. T. , A. O Raji, T. O. Dauda (2013): Evaluation of Some Physical and Thermal Properties of Thevetia peruviana (Apocynaceae) Nut AS Affected by Days of Storage. International Journal of Scientific and Engineering Research Volume 4, issue 1

11.ISTA 2009: International rules of seed Testing. A Publication of the International Seed Testing Association.

ASAE, (2003): Moisture Content Measurement on ground Grains and Seeds, American Society of Agricultural and biological engineers(ASABE) pp 178

Jain R. K. and S. Bail (1997): Properties of Pearl Millet.Journal of agricultural Engineering Reasearch 66; 87

Joshi D. C., S K. Das., R K.,. Mukherijee(1993): Physical Properties of Pumpkin seed. Journal of Agricultural Engineering Research.34(3) 221

Mohseinin, N. N.(1970): Physical Properties of Plants Animal Material. Gordon and Breach Publication New York

Maria, J. R. R. , N. Abelardo, C. S. R. Julio, A E. Pablo(2012): Extraction and

characterization of oil from Thevetia Peruviana. Using Supercritical CO2.instituto Technologico de Tepic pp 3

17 Maduako, J. N., M. O., Faborode(1990): Ssome Physical Properties of Cocoa pod in relation to Primary Processing. Ife Journal of Technology 2: 1-7

Oje K., and E. C.(1991): some physical properties of oil Bean Seed. Journal of Agricultural Engineering Reasearch 50: 305-313

Sahoo, N. K. , Subhalaxmi P. Pradham, R. C., S. N.Nai (2009): Physical Properties of Fruit and Kernel Thevetia Peruviana J: a potential biofuel plant. International Agrophysics 23, 199-204

Vanangamudi K. (2007): Advances in Seed science and Technology. Forest Tree Seed Production. volume 4; 25

Table 1: Physical Properties of *Thevetia peruviana*

	Major diameter (mm)	Intermediate diameter (mm)	Minor diameter (mm)	GMD (mm)	Spherecity
Mean	31.34	17.93	15.59	20.60	0.66
Standard Error	0.26	0.11	0.14	0.14	0.00
Standard Deviation	2.61	1.11	1.45	1.44	0.03
Sample Variance	6.79	1.23	2.09	2.09	0.00
Kurtosis	-0.43	-0.73	-0.32	-0.52	1.09
Skewness	-0.27	-0.25	-0.16	-0.24	0.42
Range	11.34	4.88	7.22	6.29	0.16
Minimum	25.57	15.53	12.07	16.98	0.59
Maximum	36.91	20.41	19.29	23.27	0.75
Count	100.00	100.00	100.00	100.00	100.00
Confidence Level(95.0%)	0.52	0.22	0.29	0.29	0.01

Table 2: Seed With Largest Diameter

	Major diameter (mm)	Intermediate diameter (mm)	Minor diameter (mm)	GMD (mm)	SPHERECITY
LARGEST MAJOR	36.91	18.44	17.92	23.02	0.62
LARGEST INTER	33.91	20.41	17.28	22.87	0.67
LARGEST MINOR	35.03	18.65	19.29	23.27	0.66
LARGEST SPHERICITY	26.73	19.02	15.64	19.96	0.75

Table 3: Densities of *Thevetia peruviana*

Statistics	Surface area (mm^2)	Roundness	True volume (cm^3)	True density (g/cm^3)	Bulk density (g/cm^3)	Porosity (%)	NS/UW	%Kernel
Mean	900.40	0.66	4.29	0.90	0.56	37.35	211.30	25.30
Standard Error	11.84	0.01	0.12	0.03	0.01	1.59	2.36	1.01
Standard Dev.	37.45	0.03	0.38	0.08	0.03	5.03	7.45	3.20
Sample Var.	1402.49	0.00	0.15	0.01	0.00	25.28	55.57	10.26
Kurtosis	-0.99	2.70	1.55	1.58	-1.72	0.17	-0.31	-0.75
Skewness	-0.08	0.84	-0.66	-0.66	0.39	-0.05	-0.86	-0.25
Minimum	840.00	0.61	3.48	0.73	0.52	28.50	198.00	19.90
Maximum	956.00	0.72	4.86	1.02	0.61	46.06	220.00	30.00
Count	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Conf. Level(95.0)	26.79	0.02	0.27	0.06	0.02	3.60	5.33	2.29

Table 4: Coefficient of Static Friction for *Thevetia peruviana*

	stainless	*mild steel*	*glass*	*plywood*
Mean	0.19	0.22	0.18	0.21
Standard Error	0.02	0.02	0.02	0.02
Standard Deviation	0.05	0.07	0.05	0.07
Sample Variance	0.00	0.00	0.00	0.00
Kurtosis	-0.69	-1.55	-1.28	-1.58
Skewness	-0.45	0.03	-0.77	0.05
Range	0.17	0.19	0.13	0.19
Minimum	0.10	0.12	0.10	0.12
Maximum	0.27	0.31	0.23	0.31
Count	10.00	10.00	10.00	10.00
Confidence Level(95.0%)	0.04	0.05	0.04	0.05

Table 5: Dynamic Angle of Repose For *Thevetia peruviana*

	Stainless (Aشّ	Mild steel (Aشّ	Glass (Aشّ	Plywood (Aشّ
Mean	22.59	22.34	23.15	22.41
Standard Error	0.66	0.75	1.04	0.67
Median	23.00	22.63	23.25	21.93
Standard Dev.	2.08	2.36	3.28	2.11
Sample Var.	4.33	5.58	10.74	4.47
Kurtosis	1.62	0.43	1.89	0.28
Skewness	-1.22	-0.85	0.50	0.91
Minimum	18.00	17.50	17.50	20.00
Maximum	25.00	25.00	30.00	26.60
Count	10.00	10.00	10.00	10.00
Confidence Level(95.0%)	1.49	1.69	2.34	1.51

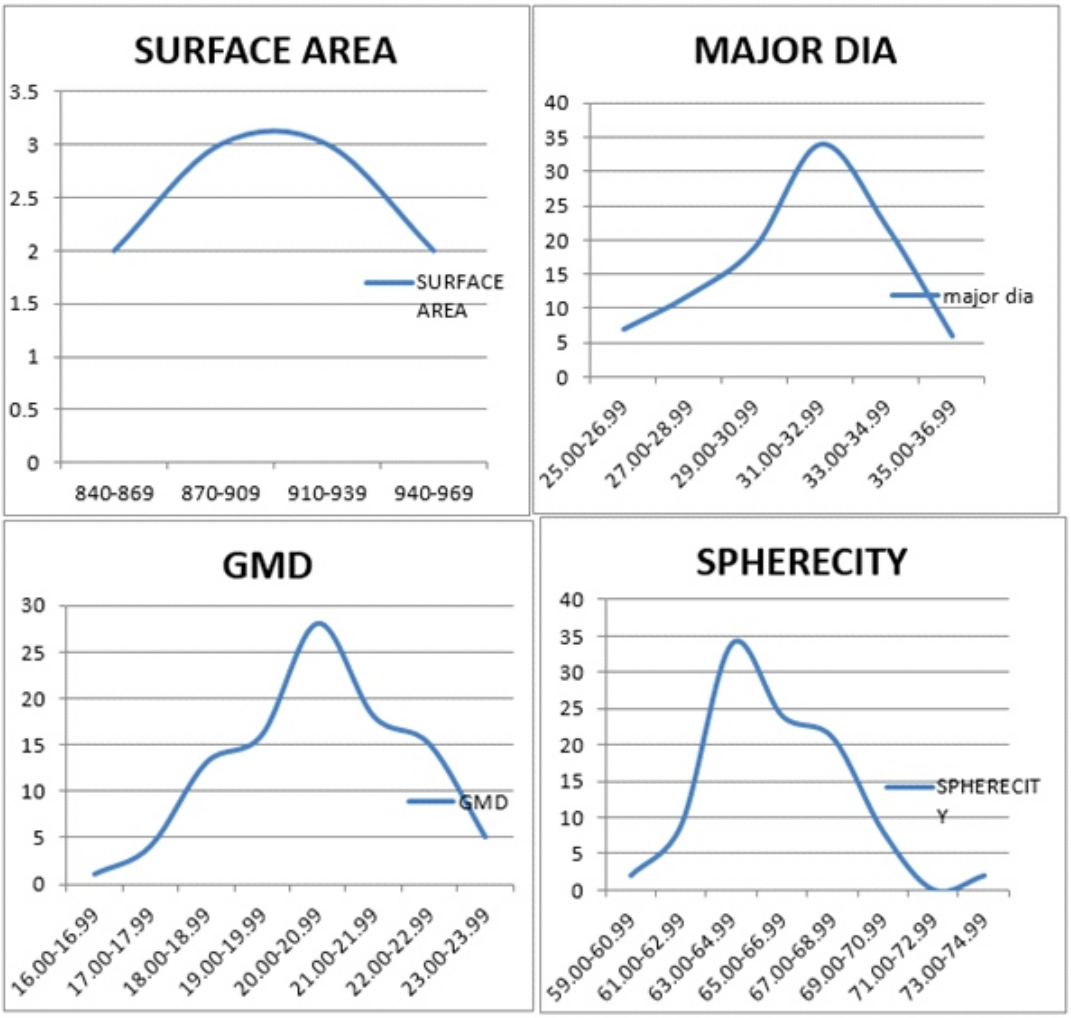


FIGURE 1: DISTRIBUTION CURVE FOR PHYSICAL PROPERTIES OF *THEVETIA PERUVIANA*

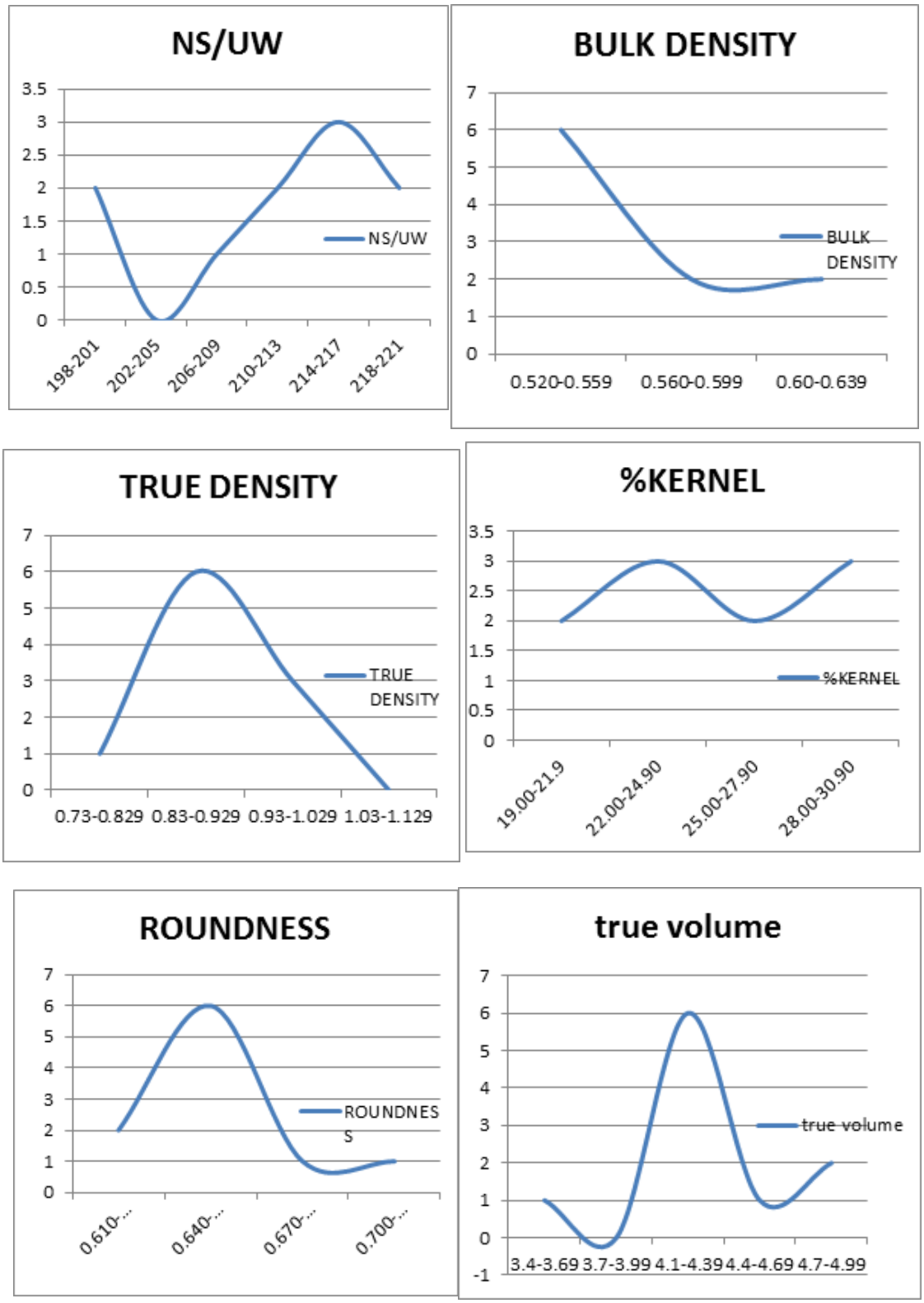


Figure 2: Distribution Curve of Densities of *Thevetia peruviana*

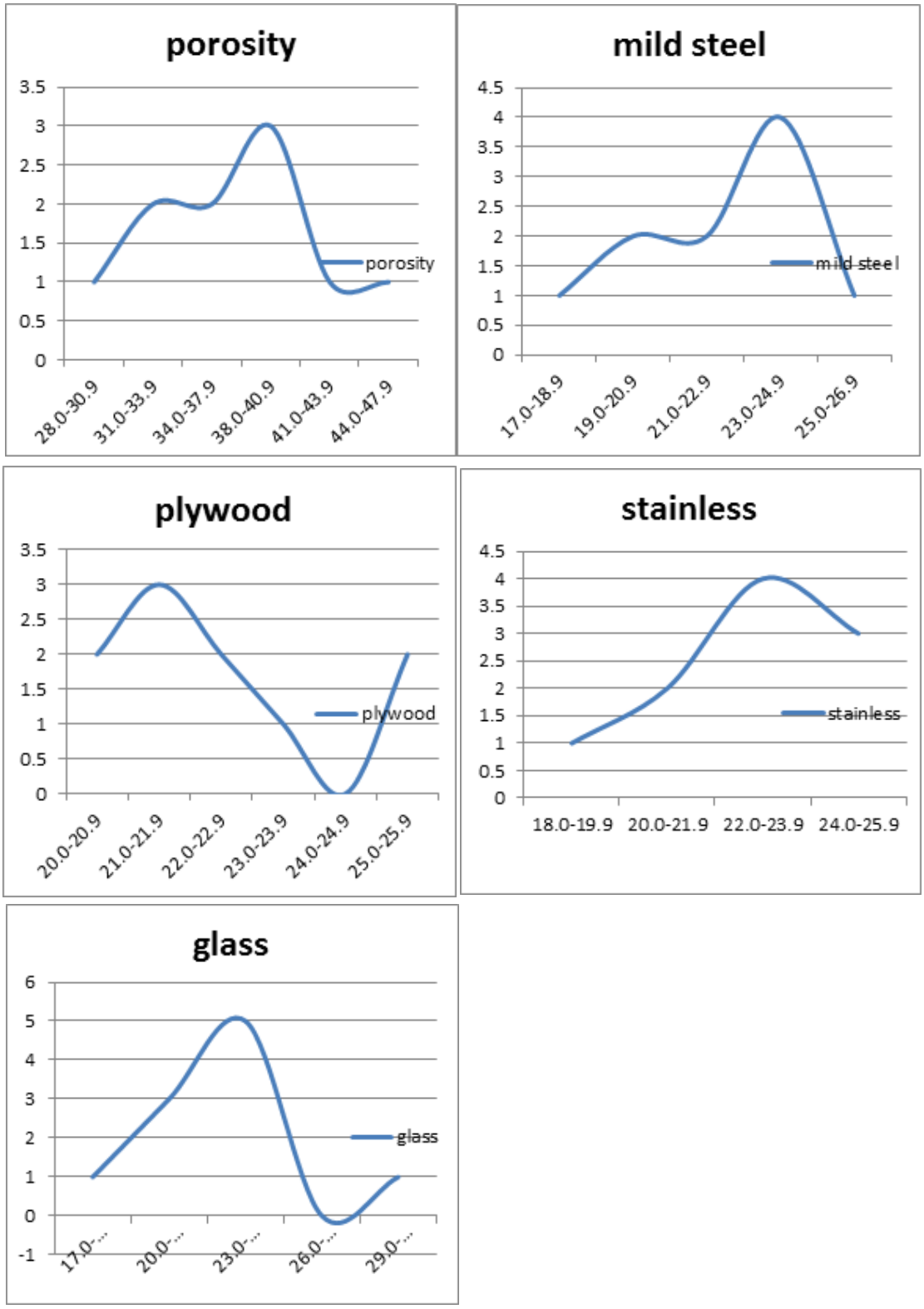


Figure 3: Distribution Curve of Angle of Repose of *Thevetia peruviana*

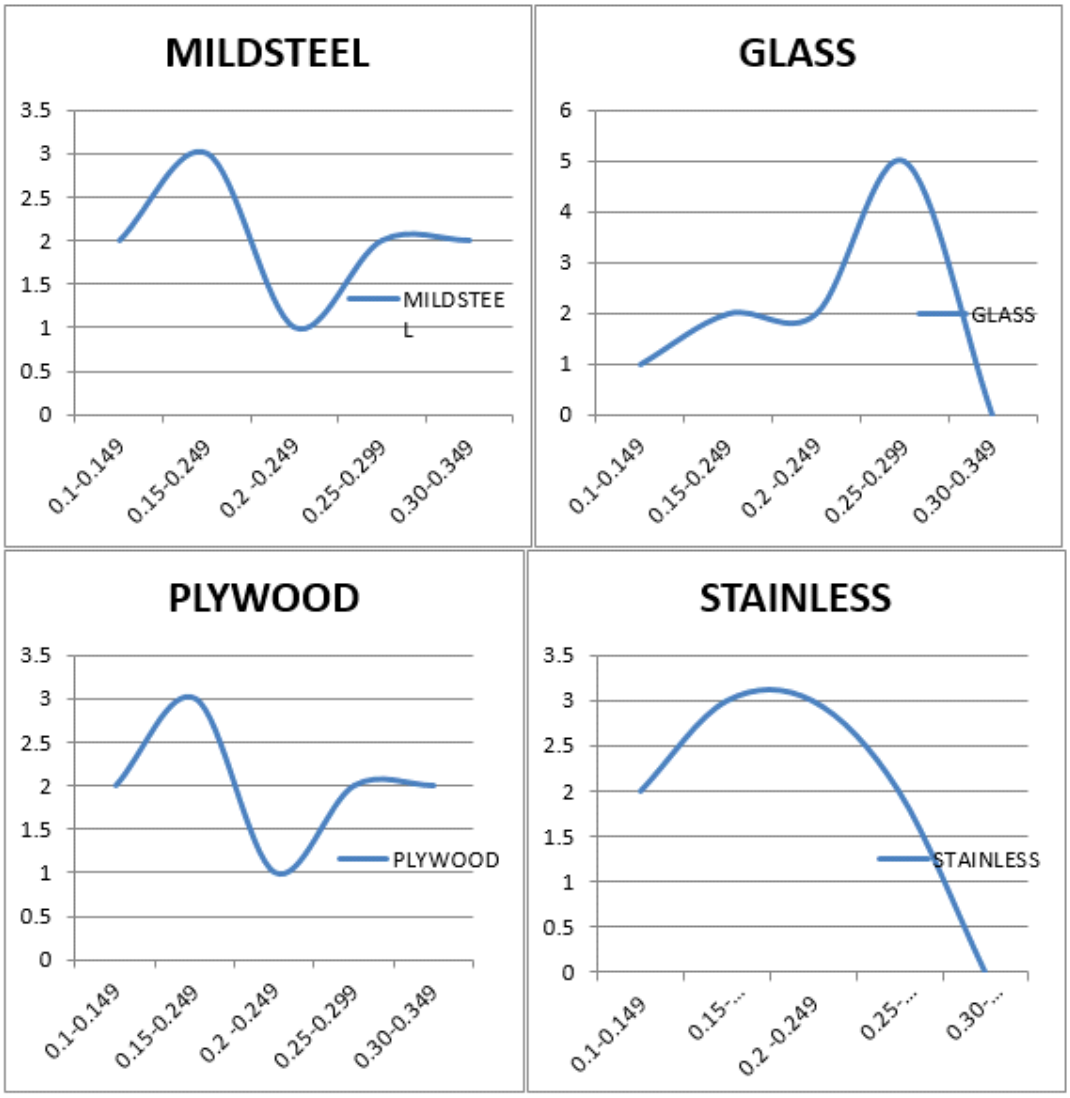


FIGURE 4: DISTRIBUTION CURVE OF COEFFICIEBT OF FRICTION OF *THEVETIA PERUVIANA*

DETERMINATION OF SOME ENGINEERING PROPERTIES OF MORINGA SEEDS, GROWN IN KANO STATE, NIGERIA

[1]Mohammed Abubakar and [2]Faruq, Z.A
[1]Department of Agricultural Engineering, ABU Samaru-Zaria
[2]Department of Agricultural Engineering, BUK, Kano

ABSTRACT
Moringa (oleifera) seeds are used in water treatment, produce edible oil; fresh seed are eaten as pear and are very nutritious. They also have a lot of medicinal values. Moringa (oleifera) tree is grown as farm boundary demarcation crop, orchard farm fence and backyard crop in Kano state. Engineering properties of the seeds, in terms of physical, mechanical and thermal were determined. Seed samples were acquired from Kano state farm center. The seeds were cleaned and divided in to two parts. Half of the samples were hulled manually and the other was left unhulled. Engineering properties were determined for both hulled and un-hulled seed using standard laboratory procedures. The results obtained in terms of mean length, width, thickness, equivalent diameter, sphericity, roundness, solid density, bulk density, porosity, one thousand seed weight, surface area, moisture content, angle of repose, cracking force, coefficient of friction on wood and steel surfaces and Specific heat capacity were respectively: 8.82mm, 7.54mm,6.22mm, 7.43mm, 0.84,74.94%, 675kg/m^3, 487kg/m^3, 27.2%, 209.97g, 2.62cm^2, 15.75%, 16^0, 54.49N, 0.3532, 0.3369, 1.93J/gK for the hulled seeds, and sequentially also 12.88mm, 10.76mm, 9.24mm, 10.86mm, 0.84, 67.22%, 907.9kg/m^3, 129.87kg/m^3, 85.6%, 303.3g, 3.5cm^2, 15.1%, 24^0, 32.52N, 0.4706, 0.6480, 1.06J/gK for the un-hulled seeds. Statistical analysis using paired t-test indicated that, there was no significant difference ($p<0.05$) between the mean values of length, width, thickness equivalent diameter, sphericity, roundness, porosity, surface area, solid density, angle of repose, moisture content, coefficient of static friction on wood, coefficient of static friction on steel and specific heat capacity of the hulled and un-hulled moringa seeds. In other words the mean values of these parameters are said to be statistically the same. Significant difference exist ($P<0.05$) between the means of bulk density and cracking force.

Keywords: Moringa Seed, Engineering Properties, Hull, Un-hull, Kano State.

1.0 INTRODUCTION

Engineering properties of agricultural materials are important, if not essential, in the design of handling, transportation, processing and storage equipment. The properties can be classified as, physical (length, width, thickness, equivalent diameter, sphericity, moisture content, roundness, solid density, bulk density, porosity, surface area, cracking force, angle of repose, and seed weight), mechanical (cracking force, coefficient of static friction on wood and steel), and thermal (specific heat). Recent advances in biotechnology researches had lead to the exploitation of both plant and animal materials for the benefit of man. These challenges lead to the exploration of a wonderful plant called the moringa tree. There are about 13 species of moringa trees in the family Moringaceae, they are native to India, the red sea area and some parts of Africa including Nigeria and Madagascar (Martin, 2000). Moringa oleifera as shown in plate 1 is the most widely and known grown specie in Nigeria (Muyibi (2003).

The moringa tree consists of the stem, leaves, pods and flowers. The leaves are outstanding as a source of vitamin A, vitamin C, vitamin B and lots of minerals. The

calcium content is very high in the plant, thus the leaves are highly nutritious and one of the best plant foods that can be found" (Frank, 2000). Moringa (oleifera) seed contain significant quantities of low molecular-weight, (water-soluble proteins) which carries a positive charge. "When the crushed seeds of moringa are added to raw water, the proteins of the seed produces positive charges acting like magnets and attracting the predominantly negatively charged particles of the water (such as clay, silt, bacteria, and other toxic particles in water) allowing the resulting "flocks" to settle at the bottom or be removed by filtration. As such moringa seeds could potentially provide a renewable, sustainable and biodegradable material for water treatment" (Berth, 2005).. The use of moringa seeds in water treatment could be attractive in developing countries were 25,000 people die from water-borne diseases every day (Muyibi ,2003). Kano State is located geographically at Coordinates $12^0$00'N $8^0$31'E, moringa oleifera is grown as farm boundry demarcation crop, orchard farm fence and backyard crop. The state government developed accelerated moringa production programme that will generate large quantities of moringa seeds. Moringa seeds are used in water treatment, produces edible oil, fresh seed are eaten as pear which is very nutritious and also it has a lot of medicinal values. Despite this enormous benefits derived from moringa seeds, there is inadequate information on the engineering properties of the seeds produced in Kano that will enable the design of its processing equipment.

The development objective of this work includes measurements of some engineering properties of hulled and un-hulled moringa (Oleifera) seed samples found in Kano State, Nigeria that will enhance its production and value addition.

2.0 MATERIALS AND METHODS

2.1 Materials

Seed samples used for these investigations were moringa (oleifera) species which is the most common variety found in northern Nigeria.Kano State is located geographically at Coordinates $12^0$00'N $8^0$31'E,a location which favours the growth of moringa plant. The seed samples were collected at Kano Farm Centre, Kano State. The seeds were cleaned manually where all foreign materials such as stones, chaffs, pre-matured seeds, broken seeds, dust and dirt were removed (Isiaka et al 2006), the cleaned seeds were later divided in to two sets, one set was hulled manually and the other remained un-hulled as shown in plate (2&3).Instrumentation equipment used includes; seed hardness testing machine, copper calorimeter, over-head projector, drafting table, micrometer screw gauge, vernier caliper and oven.

2.2 Methods

The procedure involved the measurements of the physical properties which include: length, width, thickness, equivalent diameter, sphericity, roundness, solid density, bulk density, porosity, 1000 seed weight, moisture content, surface area and angle of repose. The mechanical properties include cracking force and coefficient of static friction on wood and steel surfaces. And then the thermal property includes specific heat capacity.

2.2.1 Dimensions

The dimensions which include length, width and thickness were determined using a vernier calliper and a micrometer screw gauge (Mohsenin, 1978). Five replicates were measured for both hulled and un-hulled seeds.

2.2.2 Solid density

This was determined by pouring kerosene in a measuring cylinder. The volume of the kerosene was recorded, weighed samples of seeds were dropped inside the cylinder and the new volume of the kerosene was recorded. Solid density was computed by the ratio of mass to volume. Three replicates were done for both hulled and un-hulled.

2.2.3 Bulk density

Using cylinder and scale (Isiyaka, 2006). This was done by pouring the seeds in a graduated cylinder and then the excess seeds were removed by a strike off stick. The content of the cylinder was weighed on a digital scale having a sensitivity of 0.01g (Dutta et al, 1988). The experiment was replicated five times for both hulled and un-hulled

2.2.4 Equivalent diameter (De)

This was determined using the equation given by (Gupta and Das, 1997):

$De = (LWT)^{1/3}$

Where:

De = Equivalent Diameter, mm
L = Length, mm
W = Width, mm
T = Thickness, mm

The experiment was replicated five times for both hulled and un-hulled

2.2.5 Sphericity

The sphericity of both the hulled and un-hulled seeds was computed using the equation:

$$Ø = \frac{De}{L} = \frac{(LWT)^{1/3}}{L}$$ (Baryerh and Mangope, 2003).

De = Equivalent diameter
L = Length (mm)
W = Width (mm)
T = Thickness (mm)
Ø = Sphericity

The experiment was replicated five times for both hulled and un-hulled

2.2.6 Moisture content

This was done by the oven dry method (Mohsenin, 1986). Samples of known weight were stored in the oven at a temperature of about 130^0c for 72 hours. The Public energy was supplemented by generator power; moisture content was computed using the equation given by (Mohsenin, 1986):

$$Mwb = \frac{Wm}{Wm+Wd} \times 100 = \frac{Wm}{W} \times 100$$

Where:

Mwb = Moisture content, wet basis (%)
Wm = Weight of moisture in the product (g)
Wd = Weight of bone-dry material (dry mass), (g)
W = Total weight (Wm +Wd), (g)

The experiment was replicated three times for both the hulled and un-hulled seed.

2.2.7 Roundness

Roundness was determined using an over head projector. Five (5) replications were done. The seed was projected on a graph paper such that largest projected area of the seed material in natural rest (AP) was obtained and the area of smallest circumscribing circle (AC) was also obtained. Roundness (Mohsenin, 1986) was computed.

Roundness = AP/AC

The experiment was replicated five times for both the hulled and un-hulled seeds.

2.2.8 One thousand seed weight

One thousand seeds were randomly selected from the bulk seeds and weighed (Adejumo et al, 2005). The seeds were placed on a digital weighing balance and then the machine displayed the weight instantly. Three replications were done for both the hulled and un-hulled seeds.

2.2.9 Porosity

Porosity (P) of the seed was computed from the values of the solid density and bulk density of the seeds by using the relationship given by (Mohsenin, 1978).

$$P = \left(1 - \frac{\rho b}{\rho s}\right) \times 100$$

Where P = Porosity in %

ρb = Bulk density in kg/m^3

ρs = Solid density kg/m^3

Three replications were done for both the hulled and un-hulled seed.

2.3 Surface Area

This was determined using an over head projector, Sample of seeds were projected on a graph paper and a plane sheet which was calibrated on 1cm^2 for each box from which the surface area was calculated by counting the number of boxes (Mohsenin, 1986).

The procedure was replicated five times for both the hulled and un-hulled seed.

2.3.1 Cracking force

Grain hardness testing machine was used to measure cracking force (Mohsenin, 1986) for both the hulled and un-hulled seeds. Samples were placed and then tight on the pan, weights were applied by turning the screw which will press the sample and eventually crack, corresponding breaking force was recorded. Twenty seeds samples for both hulled and un-hulled samples were tested.

2.3.2 Angle of repose

This was determined by putting the seeds inside a wooden frame box of size 15cm×15cm×6cm (Isiaka et al, 2006). The box was placed on a drafting table, where by the table was tilted and the seeds inside the box at 2/3 full began to move, the angle was measured. The experiment was replicated twenty times.

2.3.3 Coefficient of static friction on wood surface

A sample of seeds were placed on a drafting table, the table was tilted to an angle. As the sample began to move the tangent of the angle made by the tilted table was recorded (Mohsenin, 1986; Isiaka et al, 2006). The experiment was replicated five times

2.3.4 Coefficient of static friction on steel surface

Samples of seeds were placed on a drafting table which has a steel surface (Mohsenin, 1986). The table was moved to an angle and the samples began to move, the tangent of the angle made by the tilted table was recorded. The experiment was replicated five times.

2.3.5 Specific heat capacity

Method of mixtures was employed using a calorimeter for measuring the specific heat capacity (Aviara et al, 2004). The copper calorimeter was calibrated and placed inside a flask, a sample of known weight and temperature was dropped into the calorimeter containing water of known weight and temperature. The mixture was stirred continuously using a copper stirrer and the temperature was noted every two seconds until equilibrium temperature is reached and the rate of cooling after equilibrium was recorded at two seconds intervals, specific heat was calculated using the equation given by Aviara et al (2004):

$$C_s \approx \frac{(McCc+MwCw)[Tw-(Te+t'R')]}{Ms[(Te+t'R')-Ts]}$$

Where:

Cc = specific heat of calorimeter (J/gK)
C_s = specific heat of seed (J/gK)
Mc = mass of calorimeter (g)
Cw = specific heat of water (J/gK)
Ms = mass of seed (g)
Mw = mass of water (g)
R' = rate of temperature fall after equilibrium (K/s)
Te = equilibrium temperature of seed and water mixture (K)
Ts = initial temperature of seed (K)
Tw = initial temperature of water (K)
t' = time taken for seed and water to come equilibrium (s)

3.0 RESULTS AND DISCUSSION

The summary of the results were presented in Table 1.0. The mean values of the length, width, thickness, equivalent diameter, one thousand seed weight, porosity, and surface area of the un-hulled seeds are higher than those of the hulled seeds, which could be as result of the mass of the coating present in the un-hulled seeds. Asoegwu et al (2006) determined the mean value of porosity of African oil bean seed of 51.56% using similar method used in this work. Also mean value of solid density for the un-hulled seeds is higher than the hulled seed; this could be as a result of trapped air present in between the seed and the coating of the un-hulled seed. Also mean values of the angle of repose, coefficient of static friction on wood and coefficient of static friction on steel of the un-hulled seeds are greater than that of the hulled seed, which could be as a result of rough (un-sharp) corners of the un-hulled seeds.

The mean values of sphericity for both hulled and un-hulled seed are the same; this could be as result of the fact that both hulled and un-hulled seeds are spherical in nature. Also Asoegwu et al; (2006) determined the mean value of sphericity for African oil bean seed to be 0.523mm. The mean value of roundness for hulled seed is greater than that of un-hulled seed, which could be as a result of the sharpness of the corners of the un-hulled seed. Also mean value of bulk density for the hulled seed is greater than the un-hulled seed, which could be as a result of the absence of seed coating in the hulled seed.

Asoegwu et al (2006) determined the mean value of bulk density for African oil bean seed to be 588 kg/cm^3. The mean value of cracking force for the hulled seed is greater than the un-hulled seed, which could be as result of the fragile nature of the coat on the un-hulled seeds. The mean value of moisture content of the hulled seed is greater than the un-hulled seed, which could be as a result of moisture being less on the dry seed coat. Lastly the mean value of specific heat capacity of the hulled seed is greater than the un-hulled seed, which could be as a result of insulation of the seed coat; the un-hulled seed has seed coating and trapped air between the seed and the coating. Also the range values of specific heat capacity of soy bean which was determined by Aviara et al (2004) using the same method as the one used in this work was 1.78-2.646kJ/kgK.

The results of the statistical analysis using paired t-test indicated that, there was no significant difference ($p<0.05$) between the mean values of length, width, thickness, equivalent diameter, sphericity, roundness, porosity, surface area, solid density, angle of repose, moisture content, coefficient of static friction on wood, coefficient of static friction on steel and specific heat capacity of the hulled and un-hulled moringa seeds. In other words the mean values of these parameters are said to be statistically the same. Whereas significant differences exist ($p<0.05$) between the means of bulk density and cracking force of hulled and un-hulled seeds, it could be said that the two mean values are at par.

4.0 CONCLUSION

Some engineering properties of hulled and un-hulled moringa seeds found in Kano State, Nigeria were determined in terms of physical properties which include: length, width, thickness, equivalent diameter, sphericity, roundness, solid density, bulk density, porosity, one thousand seed weight, moisture content, surface area and angle of repose. Also mechanical properties which include: cracking force and coefficient of static friction on wood and steel surfaces were determined and also thermal property which include specific heat capacity. However, only bulk densities and cracking forces of the hulled and un-hulled samples were found to have significant difference. Otherwise the remaining properties were found to be the same.

REFERENCES

Adejumo O I; A.A. Alfa and A. Mohammed (2005). Physical Property of Kano White Variety of Bambara Groundnut. *Proceedings of the Nigerian institution of Agricultural Engineer, 27:203-210*

Asoegwu S.; S. Ohanyere; O. Kanu and C. Iwueke. Physical Properties of African Oil Bean Seed (Pentaclethra macrophylla). Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 05 006. Vol. VIII. August, 2006.

Aviara, N.A., O.O. Ajibola, S.A. Oni (2004). Effect of Moisture Content and Temperature on the Specific Heat of Soybean TGX 1440-1E. *Proceedings of the 4th International Conference of the Nigeria Institute of Agric. Engineers, Vol. 25, 183-191*

Baryeh, A.E.; Mangope, B.K., (2003). Some Physical Properties of QP-38 variety of Pigeon Pea. *Journal of Food Engineering, 56(1):59-65*

Berth Doer (2005). An Echo Technical note, 2005.

Ciro V., H. J. (1997). Estudio Dinámico de la Café para el Desarrollo de la Cosecha Mecánica por Vibración Thesis B. Sc. (Agricultural Engineering). Universidad Nacional de Colombia, Medellín, Colombia

Martin I. Prist (2000). The Moringa Tree. *An ECHO technical note*

Dutta S K; Nema V k; Bhardwaj R K (1988). Some Physical Properties of Fababeans. Journal of Agricultural Engineering Research 23:53-57

Frank Martin (2000). A book son Survival and Subsistence in the Tropics.

Gupta, R.K., Das, S.K., (1997). Physical Properties of Sunflower Seeds. *Journal of Agricultural Engineering Research, 66:1-8*

Isiaka M.; El-okene A.M.I and Ojedele T.A. 2006. Determination of Physical Properties of Melon Seed. *Proceedings NIAE: 28(322-326)*

Mohsenin, N.N., (1978). Physical Properties of Plant and Animal Materials. Second Edition, Gordon and Breach Science Publishers, New York.

Mohsenin N. N., (1986). Physical Properties of Plant and Animal Materials. (Second Edition.). Gordon and Breach Science Technology. 30(5), 335-338

Muyibi, S.A (2003). A technical note on Moringa seeds. *International Islamic University of Malaysia*

Websites Used
http://www.blackherbals.com (March, 2013).
http://www.google.com (April, 2013).
http://www.moringaseed.com (March, 2013).
http://www.moringatrees.org (March, 2013).

Table 1.0: Summary Results Of Some Engineering Properties Of Moringa Seed.

Parameter	Hulled Seed			Un-hulled Seed		
	Range	Mean	SD	Range	Mean	SD
Length(mm)	8.3-9.2	8.82	0.39	12.1-13.6	12.88	0.47
Width(mm)	6.9-8.1	7.54	0.44	10.5-11.1	10.76	0.25
Thickness(mm)	5.1-6.8	6.22	0.63	9.0-9.8	9.24	0.30
Equivalent Diameter(mm)	7.24-7.56	7.43	0.14	10.52-11.19	10.86	0.23
Sphericity	0.81-0.91	0.84	0.05	0.82-0.87	0.84	0.02
Roundness (%)	68.3-80.4	74.94	4.14	63.3-72.2	67.22	3.85
One Thousand Seed weight(g)	208.9-210.8	209.97	0.79	301.7-304.4	303.3	1.16
Bulk Density (kg/m^3)	474.5-505.8	487	13.55	126.3-134.3	129.87	3.29
Solid Density (kg/m^3)	625-760	675	60.42	833.3-963.6	907.9	54.84
Porosity (%)	19-36.7	27.2	7.3	83.9-86.9	85.6	1.3
Surface Area(cm^2)	2.4-2.8	2.62	0.13	3.3-3.7	3.5	0.14
Moisture Content(%) wb	14.9-17	15.73	0.91	14.4-16.5	15.1	0.99
Angle of Repose(^{O})	15-17	16	0.71	23-25	24	0.71
Cracking Force (N)	30.41-64.75	54.49	7.79	17.66-54	32.52	10.32
Coefficient of static friction on wood	0.2679-0.4452	0.3532	0.0579	0.4663-0.4877	0.4706	0.0087
Coefficient of static friction on steel	0.2679-0.3838	0.3369	0.0397	0.5543-0.8097	0.6480	0.0894
Specific Heat capacity(J/gK)	1.49-2.54	1.93	0.45	0.914-1.25	1.06	0.14



Plate 1: Moringa (oleifera) Tree



Plate 2: Un-hulled Moringa Seeds



Plate 3: Hulled Moringa Seeds

COMPARATIVE STUDY OF EFFECTS OF DRYING METHODS ON THE QUALITY OF COCOA BEANS

***D. Lasisi, L. A. Balogun, A. R. Nasirudeen, F. O. Ogunsola, A. A. Adesola and T. A. Adeyeye**
Department of Agricultural and Bio-Environmental Engineering
Oyo State College of Agriculture, Igboora
*Corresponding author E-mail: dalasisi@yahoo.com Tel: +234 -7062606974

ABSTRACT
The study was conducted in order to determine the effects of drying methods on quality of fermented cocoa beans. Drying was carried out using two different methods namely oven drying and sun drying methods. Samples were dried at five different oven temperatures of 35°C, 40°C, 45°C, 50°C and 55°C while the other samples were sun dried until the moisture content of the samples were reduced to 6 – 8 %. Each sample was replicated twice. Some quality assessments were carried out on the dried cocoa to compare the quality of sun dried samples with the oven dried ones. The quality assessments were acetic acid level, pH, colour, free fatty acid, acid value and grading. The values obtained were used to determine better method of drying cocoa beans. It was found that the samples sun dried were better than the samples oven dried. Free fatty acid (FFA) and acetic acid levels significantly increased ($P < 0.05$) with increase in drying temperature while the pH level decreases significantly ($P < 0.05$) with increase in drying temperature.

Keywords: Forced-Air, Continuous Drying, Sun Drying, Cocoa Beans, Quality.

1.0 INTRODUCTION

Cocoa (*Theobroma cacao*) is one of the economic tree crops grown in Nigeria. It is one of the twenty species that constitute the genius *theobroma*, a member of the family *sterculiaecae*. (Are and Gwyne-Jones, 1974). It originated from Amazonian region of Brazil and grown in tropical countries like Nigeria, Ghana, Ivory Coast, Brazil, Malaysia, Venezuela and Indonesia (Beckett, 1994). The cocoa pod which is botanically a berry, attains a height of 129 to 159 mm and diameter of 72 to 83 mm when fully ripe (Maduako, 1989). It normally contains 20 to 40 seeds surrounded by a mucilagenous pulp when the pod is ripe. By weight, cocoa pod is composed of about 74.4% husk, 22.5% wet beans and 3.1% placenta. Cocoa is a perennial cash crop with three important varieties viz. criollio, foresterio and trinitario. Cocoa beans is mainly consumed as chocolate and widely used in beverages, cosmetics, pharmaceuticals and health benefits such as anti-carcinogenic, anti-ulcer, anti-inflammatory, anti-microbial and analgesic (Porter,2006; Taubert et al., 2007). Processing of cocoa beans involves the harvesting of cocoa pods, breaking of the harvested pods, fermentation of wet mass of cocoa beans obtained from broken pods, drying of fermented cocoa beans to moisture content of about 6 to 8% and storage of the dried beans till the time of use. Figure 1 shows a flow chart of the preparation processes.

Out of these steps of processing cocoa pods into beans, the two major steps are fermentation and drying. Fermentation of cocoa beans involves keeping a mass of cocoa beans well insulated while at the same time air is allowed to pass through. This process is carried out to develop the chocolate flavour and aroma in the beans. During fermentation, the pulp surrounding the bean is removed and the sugar in the pulp is converted into acetic acid. The different methods of fermentation are box, basket and heap and tray

fermentation. The duration of fermentation varies from 4 to 7 days depending on the method of fermentation employed. Fermentation is the initial step needed in the development of various flavour precursors in the beans (Hii et al., 2009). After fermentation, the moisture content of the beans is about 55% and this must be reduced to 6 to 8% for safe storage (Opeke, 1987). The drying process apart from reducing moisture content of the beans, aids in the completion of the chemical reactions that were started during the fermentation process and in the development of the chocolate brown colour of well fermented beans (Wood and Lass, 1986).

Drying of cocoa beans on most farms is carried out naturally by making use of the sun rays while few large farms use artificial dryers to achieve the drying operations. Sun drying is carried out by spreading the beans on mats raised off the ground or on concrete floors during the period of sunshine. Beans dried on ground level are easily contaminated by insects or domestic animals and they tend to become dusty. Sun drying is effective where the rainfall is not excessive and the hours of sunshine is sufficiently high. The length of time it takes to dry in the sun depends on weather conditions. During rainy or wet conditions, drying period of up to 22 days may be needed and during dry season, drying may last for 7 days. The long duration of drying using this method may cause possible damage of beans due to mould development. Off-flavour odour is obtained from products manufactured from mouldy beans. Forced-air artificial drying involves the use of heat other than radiant heat to reduce the moisture content of cocoa beans. Heated air is commonly used to dry cocoa beans artificially. Artificial drying is also necessary where fermented beans are produced in the wet season. Artificial drying also saves time due to the fact that drying time for the beans to reach safe storage moisture content is reduced when compared to sun drying. This research work, therefore, aims at investigating the comparative effects of forced-air artificial continuous thin layer oven drying and sun drying at various levels of temperature, moisture contents, relative humidity and time of drying on the quality of cocoa beans and determining the method of drying that would give the best quality of the cocoa beans.

2.0 MATERIALS AND METHODS

2.1 Sample Preparation

Fresh cocoa pods were obtained from Obafemi Awolowo University Teaching and Research Farm, Ile-Ife. The harvested cocoa pods were broken and the cocoa beans were processed for fermentation for five days using heap-basket fermentation method.

2.1 Initial Moisture Content

One hundred grams (100 g) of cocoa beans was placed in the sample container and placed inside an air-ventilated oven (Gallen Kamp Oven Model 300 Series) and the oven was set at a temperature of 103°C for 16 hours as recommended by International Standard Organization (ISO) Table of Standard 2291 – 1972 (E) and AOAC (1984). The moisture content (MC) of the beans was then determined with reference to wet weight of the beans using equation:

$$M.C.(wet\ basis) = \frac{wi-wd}{wi} \times 100\% \quad \text{(Hii et al., 2009)} \ldots\ldots\ldots\ldots (1)$$

Where w_i and w_d refers to initial and dry weight of the beans respectively.

2.2 Forced-air Artificial Continuous Thin Layer Oven Drying

Triplicate samples of fermented cocoa beans, each weighing 100 g were placed in the sample container and then placed in the oven with the oven temperature set at 35°C

with known initial moisture content. Hygrometer was used to measure the wet and dry bulb temperatures of the surrounding. Using psychometric chart, the relative humidity of the surrounding and oven were known. At every 3 hours, each sample weight was known and recorded and the corresponding moisture content determined. This experiment was continued until the moisture contents of the samples were reduced to 6 - 8 %. The experiment was repeated with oven temperatures set at 40°C, 45°C, 50°C and 55°C each time. The equilibrium moisture content (E.M.C.) for each drying temperature was determined by drying until no further change in weight of the beans was observed.

2.3 Sun Drying

A sample of cocoa beans was spread on a concrete floor in the sun. Thermometer was used to measure the peak temperature of drying every day. The sample was sun dried between 9.00 a.m. and 6.00 p.m. every day. At the end of the drying period every day, some quantities of the sample were taken and placed in the oven for 16 hours with the oven temperature set at 103 ^{0}C to determine the moisture content in the sample until the moisture content was reduced to 6 – 8 %.

2.4 Procedures for quality assessment of dried cocoa beans

The quality of the dried cocoa beans was assessed based on the acetic acid value, pH, and free fatty acid (FFA) level and grading. The acetic acid content was determined according to Association of Official Analytical Chemists (AOAC, 1984). A forty gramme of ground sample of cocoa beans was mixed with de-ionized water in a conical flask. The mixture was distilled and allowed to cool. Phenolphthalein of two drops was used as indicator. The solution was then titrated against 0.5 M potassium hydroxide (KOH) until the colour changed. The concentration of acetic acid in the solution was then determined. The pH of the beans was determined according to Duncan et al. (1989).10 g of ground sample of cocoa beans was homogenized with 200 ml of distilled water. The mixture was filtered and pH of the solution was measured using a digital pH meter. The free fatty acid content was determined according to AOAC (1984). One gramme of ground cocoa beans was poured into a conical flask (250 ml). 50 ml of 0.5 M ethanoic potassium hydroxide was added to each of the samples. Heat was applied to dissolve the solution and allowed to cool. Two drops of phenolphthalein indicator was added and the solution was treated with 0.5 M HCl until the colour changed. The percentage FFA was determined as the percentage molar equivalent of the KOH titre to the mass of cocoa beans sample. Samples of dried cocoa beans were taken to cocoa graders in Ile-Ife for grading. Three hundred cocoa beans were randomly selected and cut with a knife. Fully fermented (FF) beans, total mould (TM), Slatee, damp and other defects (OD) were separated. Specifications for grading cocoa beans were given below. For grade I, total mould (TM) should not be more than 1 to $1^2/_3$; Slatee(s) – 1 to 3%; other defects (OD) – 1 to 3%. For grade II - total mould (TM) - 2 to 3% Slatee(S) – $3^1/_4$ to 4%; other defects (OD) – $3^1/_3$ to 4% while no grade falls below grade II in quality.

3.0 RESULTS AND DISCUSSION

3.1 Initial Moisture Content

The initial moisture content of the fermented cocoa beans at the point of commencement of the experiment was 53.7 % for all the samples.

3.2 Forced-Air Artificial Continuous Thin Layer Oven Drying

The sample with 55°C drying temperature dried appreciably fastest taking 18 hours while the sample with 35°C drying temperature was the slowest taking 39 hours to dry to moisture content of about 8 %. This shows that the higher the oven temperature the

less the drying time. The relative humidity of the oven temperatures of 35°C, 40°C, 45°C, 50°C and 55°C are 42 %, 36 %, 27 %, 19 % and 16 % respectively. This also indicates that the relative humidity decreases with increase in drying temperature. The equilibrium moisture content (EMC) for the samples were 6.97, 6.85, 6.75, 6.70 6.62 for 35°C, 40°C, 45°C, 50°C and 55°C respectively.

3.3 Quality Assessment of Dried Cocoa Beans

The physico-chemical characteristics of the dried beans using forced-air artificial continuous drying system are shown in Table 1. Test results showed that the cocoa beans dried under 55°C oven temperature had the highest free fatty acid and acetic acid of 1.69 and 6.70 while the samples dried at 35°C oven temperature had the lowest free fatty acid and acetic acid of 1.38 and 3.70 mg/g respectively. This showed that free fatty acid and acetic acid level increase with increase in drying temperature. The pH level of dried cocoa beans (6.7) was lowest at 35°C drying temperature while it was highest (4.5) at 55°C drying temperature (Table 1). This showed that pH also increases with increase in drying temperature. All the samples fall under grade I. Cracks were recorded in the testa of the samples of cocoa beans under 50 and 55°C drying temperature. This may be attributed to high drying rate which did not allow for the completion of the needed oxidative reaction and acid diffusion process. There was no flavour difference in all the samples of dried beans. In terms of ratings, sun drying samples attained first position (Table 2) in three out of the five physico-chemical characteristics of cocoa beans used in quality assessment which shows that 45°C is the oven drying temperature that is best for drying cocoa beans artificially within 33 hours (1 – 2 days).

4.0 CONCLUSION

It can be established from this research work that cocoa beans could be dried by forced-air artificial continuous oven drying and at the same time be of high quality. It can also be concluded that 45°C drying temperature is the best for drying cocoa beans artificially to safe storage moisture content of 8% wet basis.

REFERENCES

AOAC (1984). Official Methods of Analysis. Association of Analytical Chemists, 4th Edition, Washington D.C., USA.

Are L.A. and Gwyne-Jones D.R.G. (1974). Cocoa in West Africa. Oxford University Press Ltd, Ibadan, pp. 101 – 114.

Beckett S.I. (1994). Industrial Chocolate Manufacture and Use. (2nd Ed.). Blackley Academic and Professional, Glasglow, UK.

\Duncan R.J., Godfrey E.G., Yap T.N., Pettipher G.L., Tharu-marajah T. (1989). Improvement of Malaysian cocoa bean flavour by modification of harvesting, fermentation and drying method. The Planter (Malaysia), pp.57 – 65.

Hii C.L., Law C.L., Cloke M., Suzannah M. (2009). Thin layer drying kinematics of cocoa and dried product quality. J. Bio-sys. Eng., Elsevier Ltd, pp. 153 – 161.

Maduako J.N. (1984). Thin-layer drying of yellow dent corn. Trans. of the ASAE, Michigan, 27(2): 581- 585.

Opeke L.K. (1987). Tropical tree crops. John Wiley and Sons, Chihester, pp. 67 – 213.
Porter L.L. (2006). Benefits of cocoa polyphenols. Manufacturing Confectioner, 86(6): 49 – 53.
Taubert D., Roesen R., Schomig E. (2007). Effect of cocoa and tea intake on blood pressure: a meta-analysis. Arch Intern. Med., 167(7): 626 – 634.

Wood G.A.R. and Lass R.A. (1986). Cocoa. Tropical Agricultural Series. Longman's Scientific and Technical. Co-published with John Wiley and Sons, Inc. New York, pp. 445 – 503,544.

Table 1: Quality Assessment Of of Dried Cocoa Beans

OvenTemp. (ºC)	pH	Acetic acid (mg/g)	FFA (mg/g)	Colour	Grade	Testa
35	6.7	3,70	1.38	Dark brown	1	No crack
40	6.1	4.10	1.46	Light brown	1	No crack
45	5.8	5.20	1.52	Light brown	1	No crack
50	4.9	5.90	1.61	Dark brown	1	Crack
55	4.5	6.70	1.69	Dark brown	1	Crack
Sun drying	6.9	3,75	1.40	Light brown	1	No crack

Table 2: Ratings of Dried Cocoa Beans

Quality assessment	1st	2nd	3rd	4th	5th	6th
pH	Sun drying	35ºC	40ºC	45ºC	50ºC	55ºC
Acetic acid	Sun drying	45ºC	40ºC	50ºC	55ºC	35ºC
Free fatty acid	35ºC	40ºC	Sun drying	45ºC	50ºC	55ºC
Colour	Sun drying	45ºC	40ºC	50ºC	55ºC	35ºC
Grade	Sun drying	45ºC	35ºC	40ºC	50ºC	55ºC

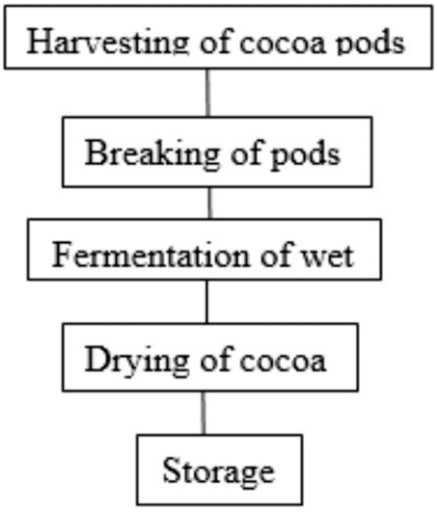


Figure 1: Flow Chart For Processing Cocoa Beans From Cocoa Pod

DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF A CABINET DRYER

Oladimeji A.O, Abisuwa F.T, Olajide O.G, Akintade A.A, and Fasoyin S.A
Department of Agricultural and Bio-Environmental Engineering technology, Rufus Giwa Polytechnic, Owo. Ondo State, Nigeria.

ABSTRACT
The importance of drying has long been recognised in the food industries as most agricultural products have to be dried either as a prerequisite or essential operation for processing. This has been necessitating the need for the use of appropriate type of dryer for drying agricultural crops like yam. Therefore, a cabinet dryer was designed, fabricated and evaluated. The dryer consists of the drying chamber, heating element, instrumentation and control system, chimney, trays, blower and the frame. All the materials used were locally sourced. The cost of producing one unit of the cabinet dryer as at the time of fabrication was estimated to be twenty one thousand eight hundred naira (?21,800). The performance of the machine was evaluated using yam slices at 32% mean moisture content at drying temperature of 40°C, 50°C and 60°C and at 60, 120 and 180 minutes drying time. The result showed that the drying rate linearly increased with increase in temperature with coefficient of determination r2 close to 1(from 0.9313 to 0.9562) at all the drying time and the drying time also decreases with increase in temperature with coefficient of determination r2 close to 1(0.9121). The dryer was found suitable and therefore recommended for the use of farmers and processors.

Keywords: Cabinet Dryer, Drying, Drying Rate, Temperature, Yam

1.0 INTRODUCTION
Yam is the common name for some plant species in genus Dioscorea (family dioscoreaceae) that form edible tubers. These are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America, the Caribbean and Oceania. Yam (Wikipedia, the free encyclopaedia). The important of yam which is one of the primary sources of many foods for most Nigerians cannot be over emphasised as foods such as pounded yam, Elubo and raw cooked yam etc. are all made from yam.
According to This day News Paper, it was estimated everywhere in the country that 30percent of the harvested tubers are lost as waste due to none processing and preservation. It stressed further that the traditional processing method is out modelled and laborious, but grossly inefficient for mass production to satisfy the teeming population and local demand and make room for export market to earn score foreign exchange that is badly needed at this time in the country. Yam flour (Elubo) is a cherished delicacy among Africans and other parts of the world. Its processing increases its shelf life, add value to the tuber (from where it is processed) before being eaten or exported to exported to enhance it economic value, reduces waste and cuts down the cost of transporting the product to longer distance compare with the heavy wet tubers that are unprocessed. The fact that yam can be processed and preserved help to stabilised its prices during off harvest season. As a result of the large scale production of yam in Nigeria and the percentage being wasted cum problems of traditional processing of yam, cabinet dryer that can dry yam products such as cassava and yam slices for making elubo, and pando yam respectively became very important.

Drying is the removal of moisture from product to a predetermined level suitable

for storage. Lawson (2009). Drying also referred to as a thermophysical and physio-chemical operation by which the excess moisture of products are been removed. Sahay and Singh, (1994).

Drying is one of the oldest methods of preserving food. This is the principal reason for drying, though it can also occur in conjunction with other processing techniques. Ale (2010). Michael and Ojha. (2003), also reported that moisture removal is an essential prerequisite for long term storage of food product under normal temperature and humidity conditions of the wear house. Same report was given by Sahay and Singh (1994). Earl, (1983) claimed that drying are controlled by two factors, (1) the transfer of heat to provide the necessary latent heat of vaporization and (2) the movement of water vapour through the food materials and then away from it to effect the separation of water from foodstuff. There has been a change in the mode of drying and baking. This necessitates for different form of equipment performing same task. This varies from the use of sun to the use of sophisticated mechanical equipment like various forms of power dryers of which cabinet dryer is one. Drying of agricultural products was in the practice of spreading of the produce on the rock surface. The products are dried by the heat generated from the rock and moisture is lost to the atmosphere (Ojah and Michael, 1987). David, E and Whitfield (2000) reported that traditional sun drying methods often yield poor quality since the produce is not protected against dust, rain, wind, insect, rodents and domestic animals while drying. However our visit to some food processing areas in southwest Nigeria revealed that most traditional methods of drying food items such as yam slices, gari, cassava chips for making pupuru and other grains are laborious and not hygienic enough for consumption as a result of soiling, contamination by faeces of animals and birds etc. Therefore, in order to remove the drudgery and hygienic problems associate with the traditional drying technique, there is need to develop and fabricate an improved cabinet dryer that would meet the current challenges in the food processing sector.

2.0 MATERIALS AND METHODS

2.1 Description and Operation of the Dryer

The cabinet dryer consist of the frame, drying chamber, instrumentation and control chamber and heat distribution chamber. The frame is made of 850mm by 560mm square pipe with cross- sectional area of 850mm by 560mm by 460mm. The inner and outer part of frame was covered with galvanised metal sheet. In between the two walls is a particle beard of 30mm thickness used as lagging material to prevent heat loss to surroundings during the operation of the machine.

The entire chamber of the machine is divided into two: the drying chamber and the heat distribution chamber. The drying chamber is 500mmby 600mm by 400mm and is further divided into three parts with the aid of 6 rectangular pipe of 400mm in length that are arranged at opposite of each other so that 3 perforated galvanised drying sheet can seat on them. The heat and heat distribution chamber of 500mm by 400mm by 200mm in area consist of electric fan 1000rpm electric heating element of 1500W. The heating element is placed below the cast cabinet in the machine chamber and an insulated perforated galvanised sheet is used as its housing to prevent shock and to allow transfer of heat from the heating chamber to the drying chamber. Below the heating element in the heating chamber is the electric fan that is used to drive and distribute hot air evenly cross the drying chamber. The upper part of the drying chamber consists of five perforated holes of 25mm in diameter each used as chimney for the escape of moisture during drying. The instrumentation and control unit is made of galvanised metal sheet folded to form a box of 410mm by 460mm by 200mm, and it consist of heat resistance wire, sensing element, power indicator, thermostat, timer and regulator all of which control the electric fan and

the heating element to achieve the desired temperature for a specific period of a time in the drying chamber during drying.

The yam slices can be dried after arranging it inside the cabinet in the dryer by connecting the socket outlet of the dryer to power source, regulating the instrumentation and control system to the required temperature and the period needed for drying, then the machine will run automatically until the materials inside it is dried up. The sensing element which runs from the instrumentation and control system to the drying chamber is used to determine the drying temperature during drying and when that temperature is achieved it will send signal to the control chamber so that thermostat will disconnect heating element from receiving further power as such, the inner temperature will be maintained until there is a drop of temperature in the drying chamber, then sensing element will also determine that and send signal to thermostat so that it will reconnect the heating element to produce more heat to maintain the temperature needed at that particular time.

2.1 Design Concept and Considerations

In design of the dryer for effective and reliable performance of its various components, the following were carefully put into consideration:

1. Selection of material that are resistance to heat, water proofs, corrosion, durable, non-toxic, non-absorbance so as to eliminate the possibility of melting of some parts e.g. wire and contaminating the food material in it and to withstand the repeated maintenance activities that will be carried out on the machine.
2. Provision of chimney that allows free escape of vapour from the drying chamber so as to prevent accumulation of vapour in the drying chamber during drying.
3. The inner and outer walls of the machine were painted with silver paints and fully lagged to prevent loss of heat by conduction, convention and radiation.
4. Provision of instrumentation and control unit that control and regulate the machine automatically so as to reduce drudgery during operation.
5. Use of locally available materials to reduce overall lost thereby making the machine affordable by local food processors.
6. Provision of heat distribution device (fan) that ensures even distribution of hot air in the drying chamber thus ensures even drying of materials during drying.

2.2 Design Calculation

2.2.1 The Drying chamber

The design of the chamber was based on the volume requirement of the chamber to accommodate 20kg per load of yam slices with adequate space for turning and circulation of heat across the yam slices in the cabinets.

2.2.2 The heat chamber

The design of the heat chamber was based on the quantity of heat energy needed to dry 20kg of slice yam. This was determined with the expression given by Okeke et al (2009).

$$Q = MC?? \quad \text{---------- (I)}$$

Where

Q = quantity of heat required (kJ)
M = mass of yam slices being dried (kg)
C = specific heat capacity of yam slices (kJ/kg.k)
?? = change in temperature of slice yam (k)
The heating element to be used was selected based on the needed power, p.

$$P = Q/t \text{---------- (ii)}$$

Where t is time of drying.

The calculated power = 1.38 k (a). Assuming 8% heat loss during processing, a heating element of 1.5kw was selected.

2.2.3 Insulation thickness

The material selected for lagging the whole embodiment of the dryer is particle board as it is readily available and cheap.

The required insulation thickness was determined by using the correlating equation for conduction and convection heat transfer by Frank et al (1985).

$$Q = A(T_c - T_{ambient}) / (1/h_{ambient} + X_1/K_1 + X_{ms}/K_{ms} + X_2/K_2 + 1/h_{air}) \text{ ---------- (iii)}$$

Where

Q = quantity of heat produce (W),

A = surface area of the smoking chamber (m^2)

T_c = operating temperature of smoker (k)

$T_{ambient}$ = Temperature of the surrounding air (k)

$h_{ambient}$ = Convention heat transfer co efficient of the surrounding air (W/m^2k)

h_{air} = Convention heat transfer co efficient of the air inside the drying chamber (Wm^2k)

X_1 = Thickness of the insulator (m)

X_2 = Thickness of the smoker outer wall (m),

K_1 and K_2 are the thermal conductivities of the inner walls of the dryer and kins are the thermal conductivities of the insulator.

$K_1 = K_2$ =15.6w/m.k and kins =0.30w/m.k. The calculated insulation thickness =26.7ml, therefore, particle board of mm thickness was selected for lagging the dryer.

2.3 Evaluation Test

Good quality yams tubers were bought and peeled, the peeled yam were then sliced, washed soaked for about 24 hours. After this period the soaked yam slices were removed from water and it`s moisture content was determined to be 32% mean moisture content. The yam slices were then divided into nine equal samples. The first portion was loaded inside the cabinet of the dryer and dried at 40 °c for 60 minutes. The next two samples were dried at same 40 °c for 120 and 180 minutes drying time respectively. Samples 4, 5 and 6 were dried at 50 °c for 60, 120 and 180 drying time respectively while the last three samples were dried at 60 °c drying temperature for 60, 120 and 180 minutes drying time respectively. A sensing element was used to monitor the temperature. After drying, the dried yam slices were immediately cooled to the ambient temperature and kept for evaluation.

2.4 Sensory Evaluation

The nine samples of yam slices dried at different temperatures and periods were evaluated for dryness, appearance and acceptability. The evaluation of the product`s quality were carried out by experienced sensory judges that composed of nine staffs of Department of Agricultural and Bio-Environmental Engineering Technology and Food Science and Technology of Rufus Giwa Polytechnic, Owo. Some of the dried yam slices were grinded to critically evaluate the products. Analysis of variance (ANOVA) was used and statistical significance was set at $P<0.5$ using Duncan's multiple range test (Harris's, 1985).

3. RESULT AND CONCLUSION

Figure I shows the relationship between the drying rate and the drying temperature, while figure II shows the relationship between drying time and drying

temperature. However it was observed that the first three samples which were dried at 40°c for 60, 120 and 180 minutes drying time were not well dried whereas the next six samples which were dried at 50°c for 60, 120, and 180 minutes drying time respectively and 60°c for 60, 120, and 180 minutes drying time respectively were well dried but the 6th, 7th and 8th samples all met consumers satisfaction and the 9th samples was slightly over dried as the colour tend to change to dark brown.

4. CONCLUSION

A cabinet dryer was designed, fabricated and evaluated at Rufus Giwa Polytechnic, Owo. The dryer is cheap, easy to operate and maintain. It proved viable for the drying of yam slices with overall acceptability that compares favourably with product from traditional drying methods in terms of quality, general acceptability and drying rate. The dryer will help to reduce problems that are associated with traditional drying methods like soiling, contamination etc. as reported by Arogba S.S et al (1998). The dryer is therefore recommended for both small and medium scale processors.

REFERENCES

David, E. and Whitfield, V. 2000. Solar Dryer Systems and the Internet: important resource to improve food preparation. Proceedings of International conference on solar cooking. Kimberly – South Africa. 26th-29th November, 2000.

Frank, P. Incropera and David, P.De Witt. 1985. Introduction to heath transfer. John Wiley and sons Inc. New York.

Lawson, O.S. 2009. Lecture note on crop storage (PHT 313). Department of Agricultural and Bio-Environmental Engineering Technology. Rufus Giwa Polytechnic Owo.

Michael, A.M. and T.P Ojha. 2003. Principles of Agricultural Engineering. Vol.1 and Vol II. Jain Brothers, New Delhi
(http://www.tnps.gov.insyllabus/dgagricultural.engineeringpdf)

Okeke, P.N, Okene, F.N. and Akande, S.F. 2009. Senior Secondary Physics. Revised Edition. Macmillan Nigerian Publisher Limited. Lagos. 342pp.

Early, R.L and Early, M.D…. Food processing. Copyright © 1983. Published by NZIFST (Inc) Unit Operation in food processing. The web edition.
(http://www.nzifst.org.nz/unitoperations)

Arogba S.S, Ugwu, F.M, Abu, J.D Plant food for Human Nutrition 1998, volume 53, issue 2, pp113-120.

This day Live. 23rd July 2013. Setting up yam flour plant for export. (www.thisdaylive.com>HOME>NEWS)

Yam (vegetable) Wikipedia the free encyclopaedia. (en.wikipedia.org/wiki/yam-vegetable)

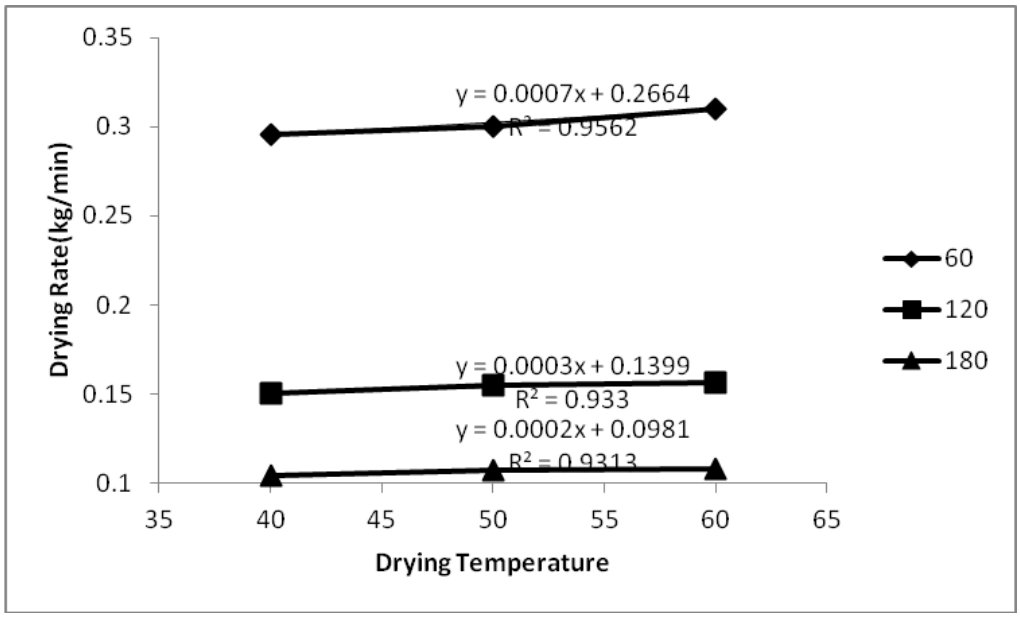


Figure1: Drying Rate Versus Drying Temperature

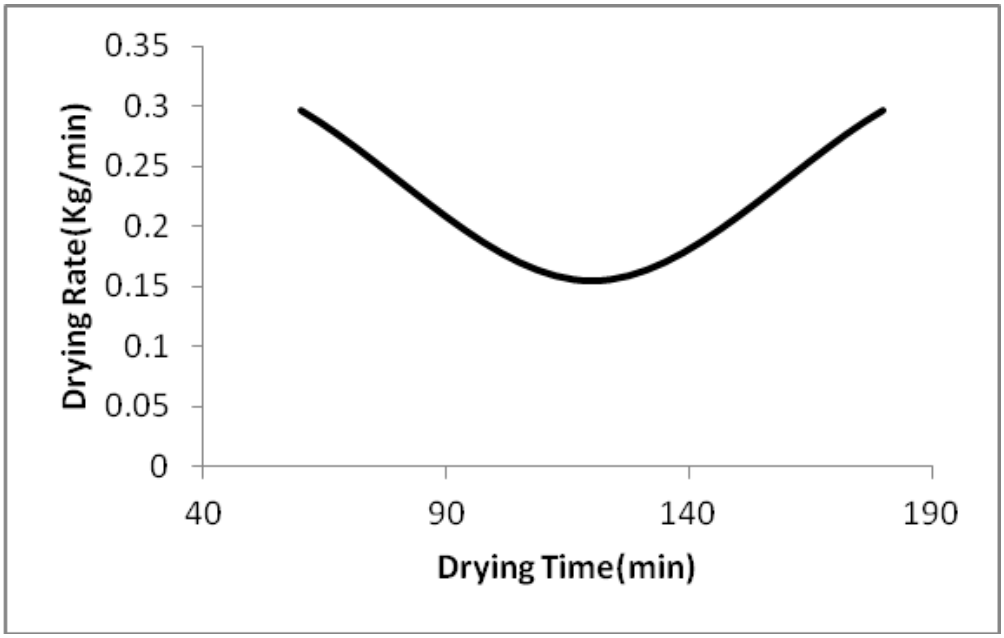


Fig. 2: Drying Rate Versus Drying Time

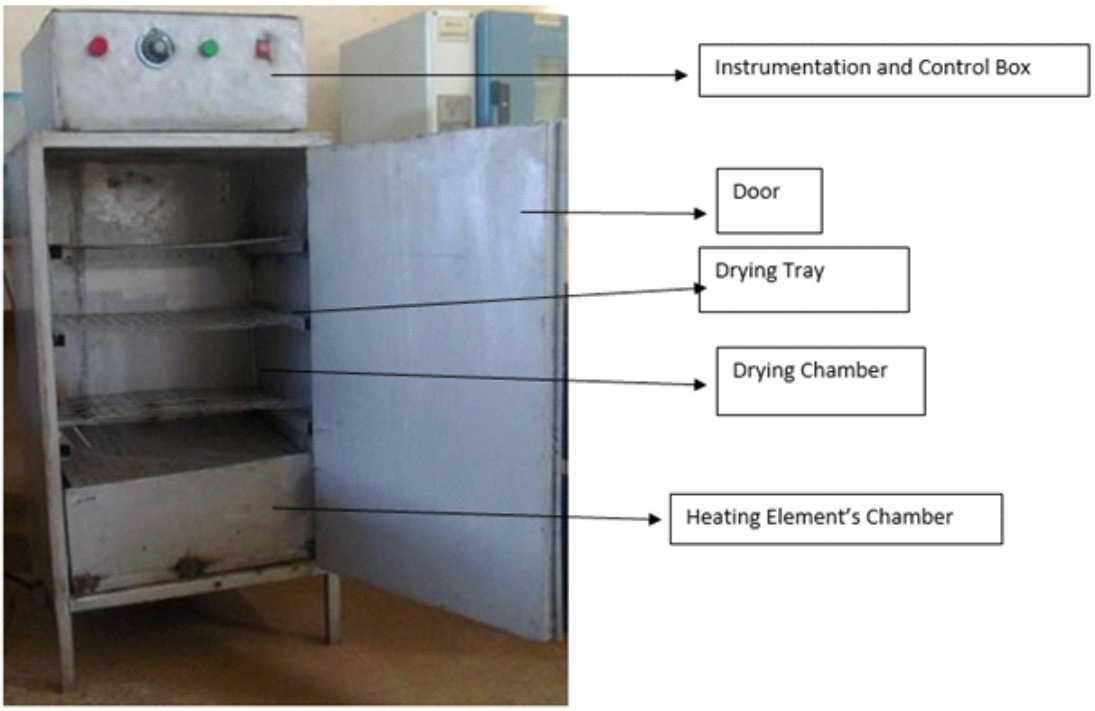


Figure 3: Pictorial View of the Dryer

DEVELOPMENT OF SOFTWARE FOR MONITORING PERFORMANCE EVAPORATIVE COOLING SYSTEM FOR STORAGE OF FRUITS AND VEGETABLES

[a] W. A. Olosunde, [b] A. K. Aremu and [a] D. I. Onwude
[a] Department of Agricultural and Food Engineering, Faculty of Engineering, University of Uyo, Uyo, Nigeria.
[b] Department of Agricultural and Environmental Engineering, Faculty of Technology, University of Ibadan, Ibadan, Nigeria.

ABSTRACT
Evaporative cooling occurs when warm and unsaturated air is blown across a wet surface. Software was developed as a research tool for designing of the evaporative cooling system. The software incorporates information for the effect of cooling pad length, cooling pad height, cooling pad thickness, air velocity, water flow rate, water temperature, water to air mass flow rate and number of cooling pad segment on the performance efficiency of the cooling system. The software rapidly produced model data which was subjected to further analysis for verification and validation. The modeled and experimental data of saturated efficiency against four (4) most important parameters statistically, using paired sample t-test of equal variance assumption and univariate linear model. The results showed that there was no significant difference between the software generated data and the experimental data of Saturated efficiency on Pad thickness –mm (*p=0.635)*, Air Velocity -m/s (*p=0.140)*, Water Flow Rate -L/min (*p=0.341)* and Water Temperature ^{0}C (*p=0.567)* at α= 0.05 significant level and 95% confidence interval.

Keywords: Evaporative Cooling system, Crop Storage, MATLAB, Simulation, SPSS, T-test

1.0 INTRODUCTION

In view of its simplicity and relative efficiency, evaporative cooling offers a lot of potential, which can be exploited and used for the preservation of fruits and vegetables. Evaporative cooling is an aid to conventional air conditioning and refrigeration systems applied to save energy across the tropical, subtropical and temperate regions (Fang, 1994). Mathews et al. (1994) provided a detailed description of evaporative cooling. A mathematical model for direct evaporative cooling air conditioning system was developed by Camargo et al. (2003). Kachhwaha and Suhas (2010) analysed heat and mass transfer study in a direct evaporative cooler. From their work it is observed that much attention has been focused on the modeling, design and construction of simple direct evaporative cooling system.

Evaporative cooling occurs when warm and unsaturated air is blown across a wet surface. The sensible heat of the air is converted to latent heat to change the water from liquid to vapour. Thus the air is cooled by loosing its sensible heat and is humidified due to added vapour into the air stream (Herderson and Perry, 1976; Kays, 1979; FAO, 1986).

Designing pad and fan cooling systems requires a fundamental knowledge of moist air properties, (psychrometrics), air velocity through the pad, water flow rate on to the pad and evaporative pad operational characteristics (Dzivama and Igbeka, 2000). Two Microsoft Windows based digital psychrometric chart tools had been developed, these are entitled 'psyc' which was written in Visual C++ (Fang, et al., 2001), and

written in MATLAB (Wang, et al., 2001). These programs are very useful as teaching and research tools.

The objective of this work is to develop MATLAB based software that design an entire Adiabatic Cooling System, considering the heat and mass balance exchange inside the storage chamber, and psychrometrics variables. This new software system was developed for pad and fan system used in storage chamber for the storage of fruits and vegetables.

2.0 MATERIALS AND METHODS

The material that was used is micro-computer. The software was developed using the strong graphical user interface and powerful toolboxes provided by MATLAB. The software was developed using M-file programming Script.

2.1 Mathematical Formulations

The mathematical model used in this work although based on different other mathematical theories and evaluation was designed/developed in such a way that the variable data were kept dynamic to allow users input, with the aim of optimizing these data for an efficient performance of the evaporative cooling system.
Van der Walt and Hemp (1989) describe the steady-state heat balance and temperature on a wet thermometer. The equation is:

$$h_c (Tdb-Twb) + F_{ev} h_r (MRT-Twb) = h_c ? 0.7 (e_s-e)/P$$

where:

Tdb is the dry bulb temperature, ^oC,
Twb is the wet bulb temperature, ^oC
h_c is the convective heat transfer coefficient, $W/(m^2.K)$,
Fev is the view factor for bulb (typically 0.8, Van der Walt and Hemp, 1989) with respect to its surrounding radiation field. The view factor should be combined with the emissivity of the bulb, which is typically about 0.95 (ASHRAE, 1997), with the combined view and emissivity factor being 0.74.
MRT is the mean radiant temperature, ^oC.

2.1.1 Saturation efficiency (SE)

Saturation efficiency (SE) as an important criterion to judge the evaporative cooling system is calculated as a temperature difference ratio using the formula (ASHRAE, 1992 and Wang, 1993):

$$SE = (Tdb - Tc) / (Tdb - Twb)$$

Where:
Tc is the storage chamber temperature, ^oC

2.1.2 Storage chamber model

In modeling and simulating the evaporative cooling system to attain an optimum cooling temperature for fruits and vegetables and design of the system itself, some data were made dynamic to fit the users environmental conditions in other to simulate these data to the programme to obtain an efficient cooling temperature. This includes the storage chamber length, storage chamber width, storage chamber height, cooling pad length, cooling pad height, and cooling pad thickness.

The following are the sources of heat loads of the cooler determined:

(i) Heat gain by conduction, through the walls, roof and floor of the cooler:
The heat transfer by conduction into the store was calculated by multiplying the area of the various components of the cooler such as walls, floor and roof by their appropriate conductivity value, reciprocal of insulation thickness and by the difference between the outside and inside air temperature (Eqn. 2.1). The total was obtained by the addition of these various products.

$$Q = KA\frac{dT}{dt} \qquad 2.1$$

Where:

Q = heat transfer by conduction, W
A = total area of the various components, m^2
dT = difference between outside and inside temperature, ^oC
dt = insulation thickness.

(ii) Respiration heat load of the produce:
The heat of respiration is the energy released by the product as it respires. This heat decreases during the initial cooling of produce and stabilizes after the required storage temperature is achieved. Respiration heat can be expressed as:

$$Q_r = M_P \times P_r \qquad 2.2$$

Where:

Q_r = respiration heat, W/hr.
M_P = mass of produce, kg.
P_r = rate of respiration heat production W/kg hr.

(iii) Field heat of the produce:
This is the heat picked up by the produce on the field. It is directly proportional to the mass of the produce and the storage temperature. This is expressed as:

$$Q_f = (M_P C_P)\Delta T/t_c \qquad 2.3$$

Where:

Q_f = field heat picked up by produce, W
C_P = specific heat capacity of produce, KJ/kg^oC
t_c = cooling time in seconds, for fruits it is equal to 12hrs
ΔT = change in temperature (Rastasvoski, 1981).

(iv) Infiltration of air:
This heat is estimated to be from 10 - 20% of the total heat load from the other sources (Rastvoski, 1981, FAO, 1986). Thus taking an average of 15%, we have;

$$Q_L = (Q_c + Q_f + Q_r) \times 15/100 = (Q_c + Q_f + Q_r) \times 0.15 \qquad 2.4$$

Where:

Q_L = heat transfer through cracks and opening of cooler door.

2.1.3 Heat and mass balance for the pad-end model

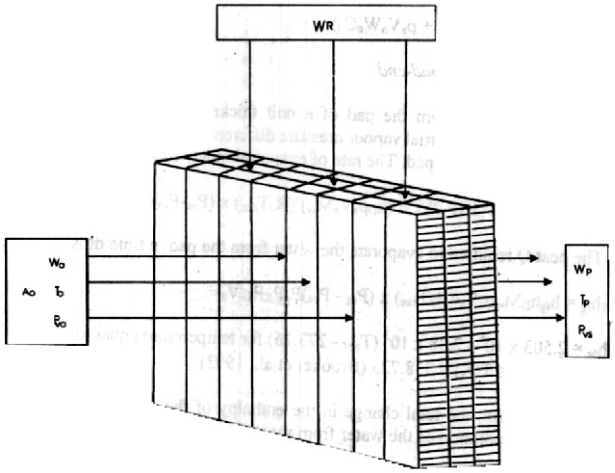


Fig. 1 Pad-end Model (Dzivama, 2000)

$$M_a = (\rho_a V + \rho_a V_a W_0) P_A P_p dt \quad 2.5$$

The enthalpy of the moist h_a flowing through the pad at any time dt is given as

$$h_a = \frac{(\rho_a V_a C_a + \rho_a V_i W_0 C_v) T_0 P_p P_A P_T}{V} \quad 2.6$$

The change in the enthalpy of the air as it passes through the pad thickness due to the void spaces or porosity of the pad in time dt is equal to:

$$h_c = (\rho_a V_a C_a + \rho_a V_a W_0 C_v) \times \left({}^{dT}/_{dP_T}\right) \times ({}^{P_p P_A P_T}/_{V_a}) \quad 2.7$$

The change in the enthalpy of the air per unit pad thickness is due to the convective heat transfer from the air to the pad and is required for the evaporation of the water from the pad. This can be represented by the Newton's law of cooling in time dt as;

$$q = h^1(T_{0(db)} - T_p) P_p P_A {}^{P_T}/_{V_a} \quad 2.8$$

The change in the sensible heat q is equal to the change in the enthalpy h_c of the air after passing through the pad. Therefore, equating equations 2.7 and 2.8 we have:

$${}^{dT}/_{dP_T} = \frac{h^1(T_{0(db)} - T_p)}{\rho_a V_a C_a + \rho_a V_a W_0 C_v} \quad 2.9$$

The equation developed for the pad-end by Dzivama and Igbeka (2000) was used in the model to predict the performance efficiency of the evaporative cooler. In addition, an equation was developed to describe the relationship between storage chamber temperature and the most important parameters.

$$Tc = 3160.7P_T^2 - 399.79P_T + -4\ V_a^4 + 26.933\ V_a^3 - 62.2\ V_a^2 + 56.643\ V_a + 0.2542W_R^4 - 2.8167\ W_R^3 + 11.14\ W_R^2 - 17.796\ W_R + 63.0394 \quad 2.10$$

Where

M_a = Mass of Air
ρ_a = Density of Air
T_o = Inlet air temperature
$T_o(wb)$ = Wet-bulb temperature of the region
W_o = Humidity ratio of air

Partial vapour pressure of air, Pva
Vapour pressure of saturated air at the wet-bulb
Temperature of the region, Pvs
Atmospheric pressure, P_{atm}
Specific heat capacity of water vapour, Cv
Specific heat capacity of air, Ca
Universal gas constant, Ro
Latent heat of vaporisation, h_{fg}
Density of air Pa
Molecular weight of water
Ratio of the convective heat and mass transfer,
$h_1/h_D=(sr/pr)^{2/3}$,
Pad thickness, P_T"
Pad porosity, Pp
Pad surface area, P_A
Air velocity, Va
Water flow rate, W_R

The heat and mass exchange was simulated considering the permanent conditions inside the storage chamber. The process at the pad-end involves heat and mass transfer process, which could be approximated by the wet-bulb thermometer analysis, presented by Brooker et al. (1992) and Van der Walt and Hemp (1989). These could be expressed by mathematical formulae, linking the measurable input parameters to obtain the measurable output parameters. The output parameters are temperature, relative humidity and saturation efficiency of the air leaving the pad after the evaporative cooling process.

2.1.4 Experimental setup

For verification of above model, a solar powered evaporative cooling system was constructed using a ply wood (Fig. 2). The evaporative cooler consists of pad end, suction fan, storage cabin, water pump, overhead tank, collection tank and pipes. The pad is installed on one side of the cabin, and the suction fan on the other side opposite the pad end. An overhead tank is installed on the top of the cooler from which water drips on to the pad through a lateral pipe laid on top of the pad. There is a collection tank at the bottom of the cooler to collect excess water from the pad. The pump re-circulates the excess water back to the overhead tank. The framework is of five different thickness of 20, 40, 60 80 and 100mm of size 600 x 1130mm corresponding to one side of the storage cabin.



Fig 2 Full View Of The Evaporative Cooling System

2.1.5 Analysis

A two-sample *t*-test assuming equal variances using a pooled estimate of the variance was performed to test the hypothesis that the resulting mean of modeled data and experimental data of Pad Thickness, Air Velocity, Water Flow rate and Water Temperature on Saturated Efficiency were equal.

3.0 RESULTS AND DISCUSSIONS

3.1 Effect of Pad Thickness on Saturation Efficiency

Fig. 3 shows the effect of cooling pad thickness on the inside temperature. Cooling pad thickness of 0.02m - 0.11m was used to run the software. The saturation efficiency increases as the thickness of the cooling pad increases (0.02m – 0.065m) and saturation efficiency starts to decrease as the cooling pad thickness is increased further from 0.065m – 0.11m. This change occurs since increase in thickness of the pad increases the residence time of the air within the pad for the air-water contact is longer. This means

that the air could evaporate more water because of longer distance of travel and residence time. However, with further increase in the pad thickness, air would be more saturated as it travels through the pad and this will reduce the capacity of the air to evaporate and absorb more water from the pad. Therefore, the efficiency decline with higher pad thickness.

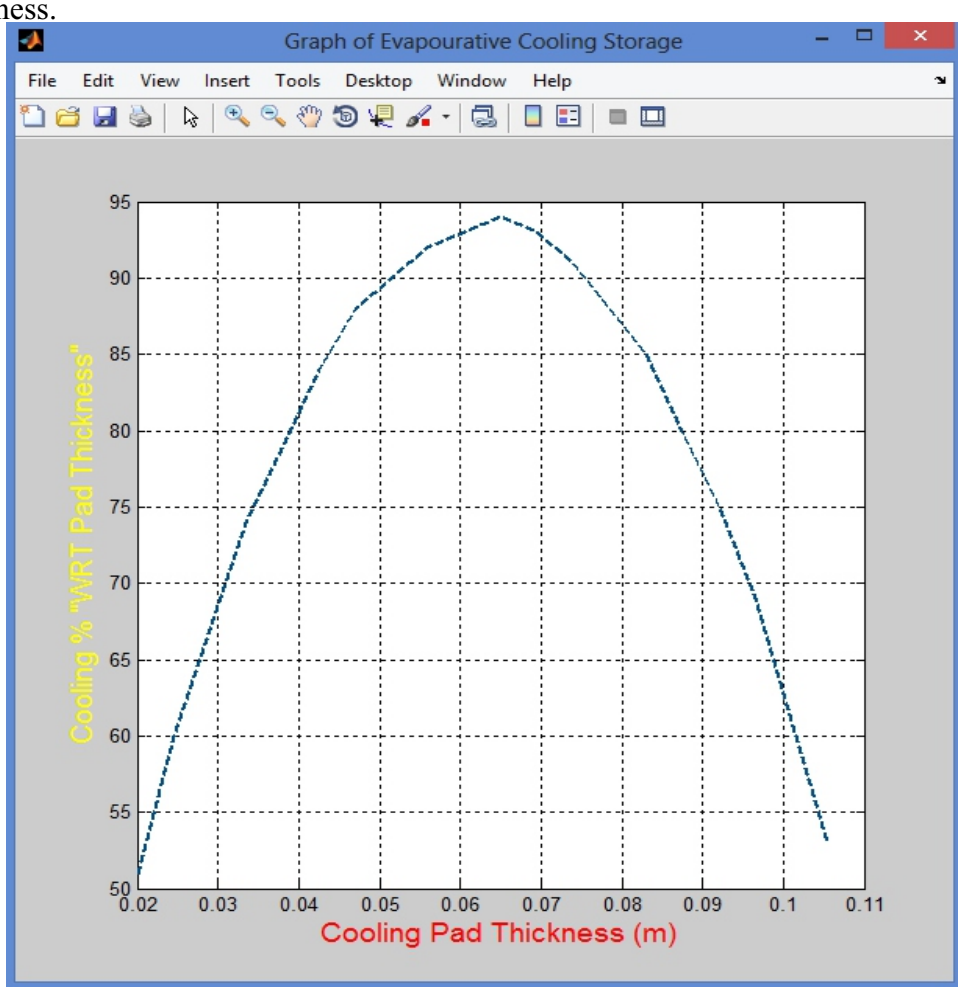


Fig 3. Effect of Pad Thickness on the Saturation Efficiency

3.2 Effect of Inlet Water Temperature on Saturation Efficiency

The effect of water temperature on saturation efficiency is presented in Fig.4. At an inlet water temperature of between 16°C and 19°C there is a sudden increase in the saturation efficiency, a further increase in inlet water temperature beyond 19°C shows a sudden drop in the efficiency as shown in Fig. 13. The sudden increase is due to the inlet water temperature lower than the wet bulb temperature, this clearly indicate that the performance of evaporative cooling is higher when the inlet water temperature is close to the wet bulb temperature.

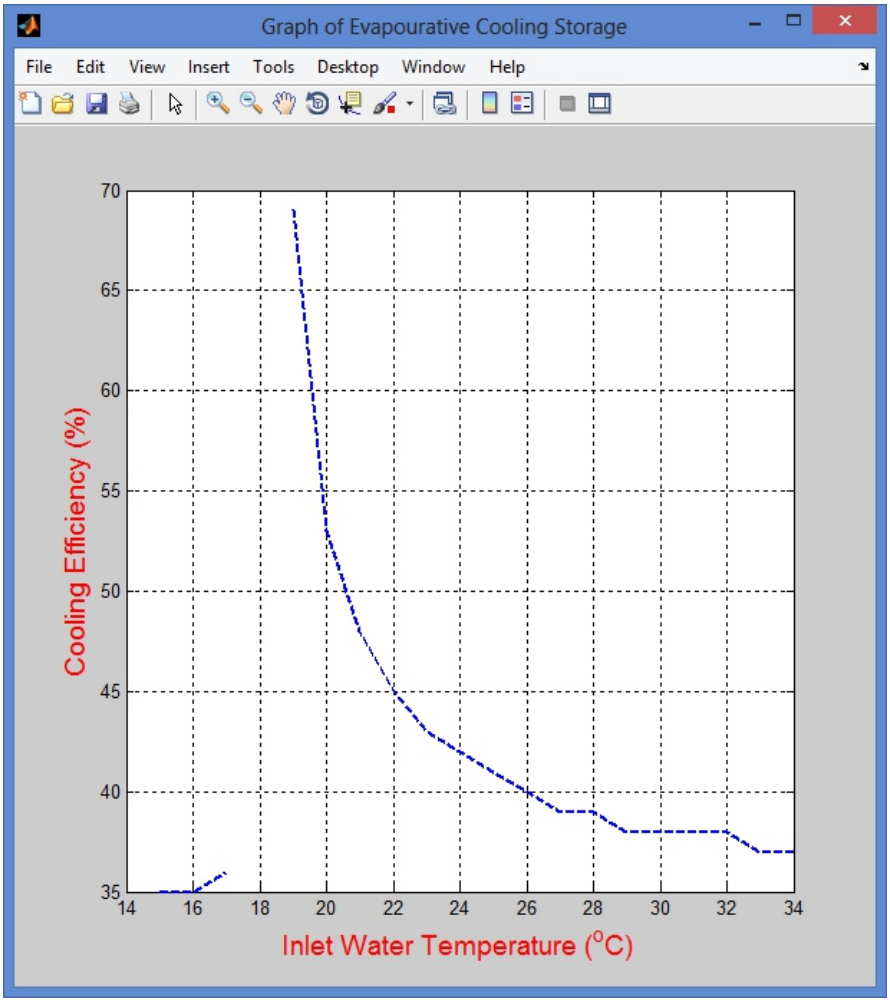


Fig. 4 Effect of Inlet Water Temperature on the Saturation Efficiency

3.3 Effect of Air Velocity on Saturation Efficiency

As the air velocity is increased from 0.5m/s to 1.4m/s, the saturation efficiency increases. Between air velocity of 1.4m/s to 1.55m/s, the efficiency remains constant; a further increase in the air velocity from 1.55 to 1.7m/s increases the saturation efficiency to an optimum value. The optimum value remains constant from 1.7m/s to 1.8m/s after which a further increase in air velocity reduces the efficiency significantly as shown in Fig. 5. The initial high rate of increase in saturation efficiency with increase in air velocity could be due to turbulent nature of airflow at high velocity within the pad. This means that the air could evaporate more water and increase the efficiency. Air moving at low velocity is not turbulent and could only evaporate the water on its path. This reduces the amount of water that could be evaporated and hence the efficiency of the cooling system

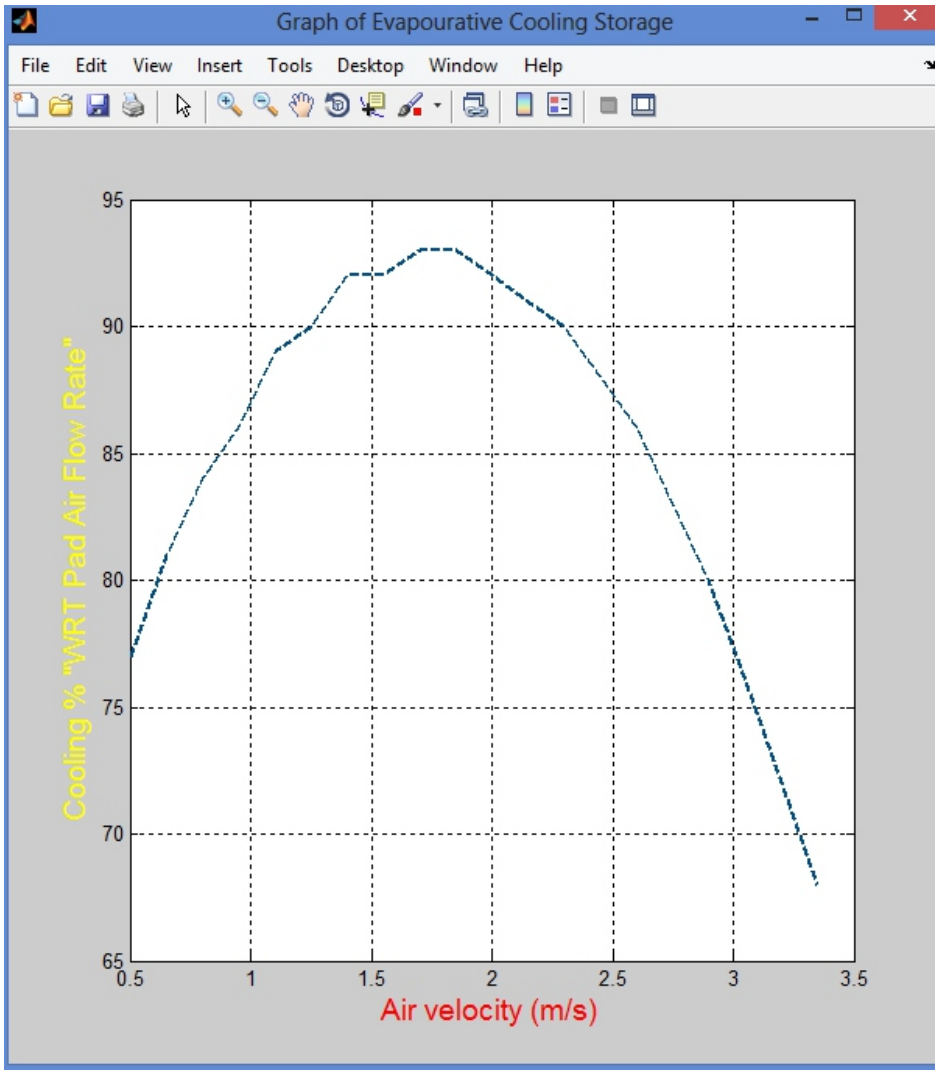


Fig. 5. Effect of air velocity on the saturation efficiency

3.4 Effect of Water Flow Rate on Saturation Efficiency

Fig. 6 shows the effect of water flow rate on the saturation efficiency. The saturation efficiency increases with increase in water flow rate from 0.5L/min to 1.5L/min after which it remains constant between 1.5L/min to 1.7L/min before it reaches optimum efficiency from 1.9L/min to 2.3L/min. The increase in the saturation efficiency with increase in water flow rate is due to the fact that low water flow rate leaves dry spot where unsaturated air could pass through the pad directly without evaporating water; thus increasing the storage chamber temperature and reducing the efficiency.

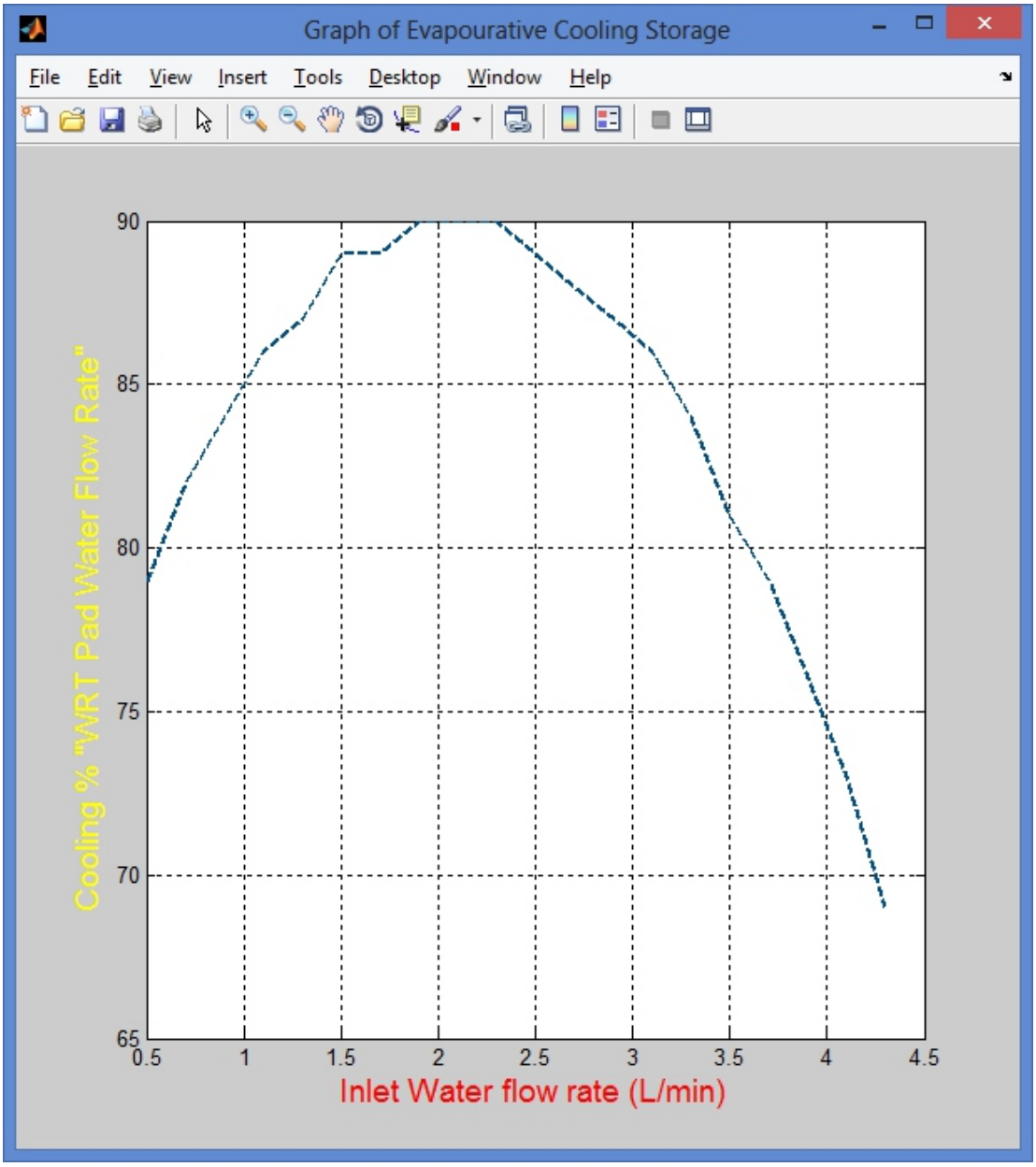


Fig. 6 Effect of inlet water flow rate on the saturation efficiency

4. Comparison between the Modelled Data and Experimental Data of the four parameters on Saturated Efficiency

The hypotheses for this test are H_0: $\mu_1 = \mu_2$ versus *Ha*: μ_1 ? μ_2 or, in words, the following:
Null hypothesis (H_0): There is no significant difference between the experimental data and simulated data of the effects of Pad Thickness, Air Velocity, Water Flow rate and Water Temperature on Saturated Efficiency both are the same.

Alternative hypothesis (Ha): There is significant difference between the experimental data and simulated data of the effects of Pad Thickness, Air Velocity, Water Flow rate and Water Temperature on Saturated Efficiency both are the same.

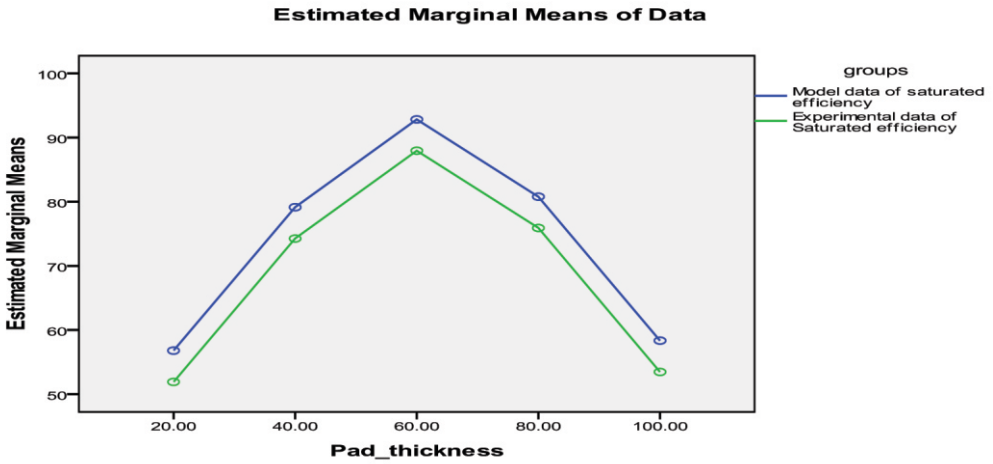


Fig 7.0 Comparison Between Modelled Data and Experimental Data of Saturated Efficiency Against Pad Thickness

The mean effect of Pad thickness on saturated efficiency for both the experimental results and the simulation result were not significantly different, ***t*(5) = 0.494, *p* = 0.635 . (*p>0.05)***

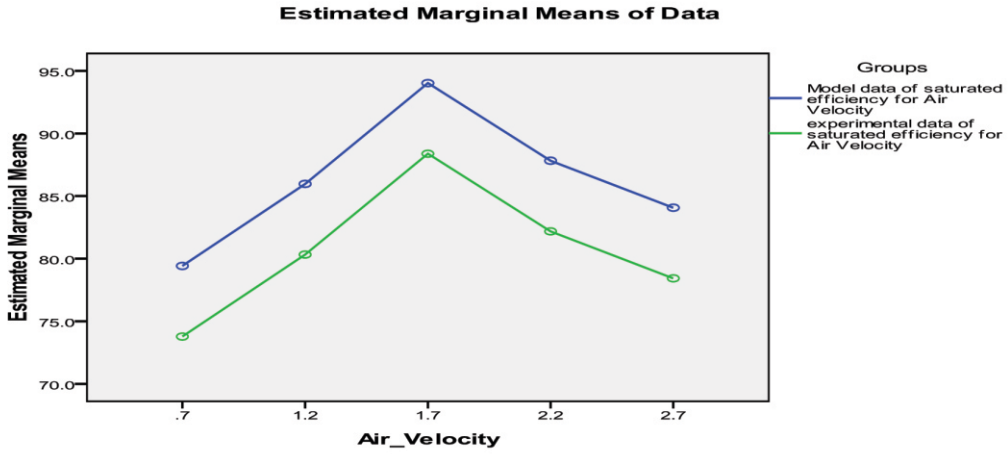


Fig 8.0 Comparison Between Modelled Data and Experimental Data of Saturated Efficiency Against Air Velocity

The mean effect of Air Velocity on saturated efficiency for both the experimental results and the simulation result were not significantly different, ***t*(5) = 1.639, *p* = 0.140 . (*p>0.05)***

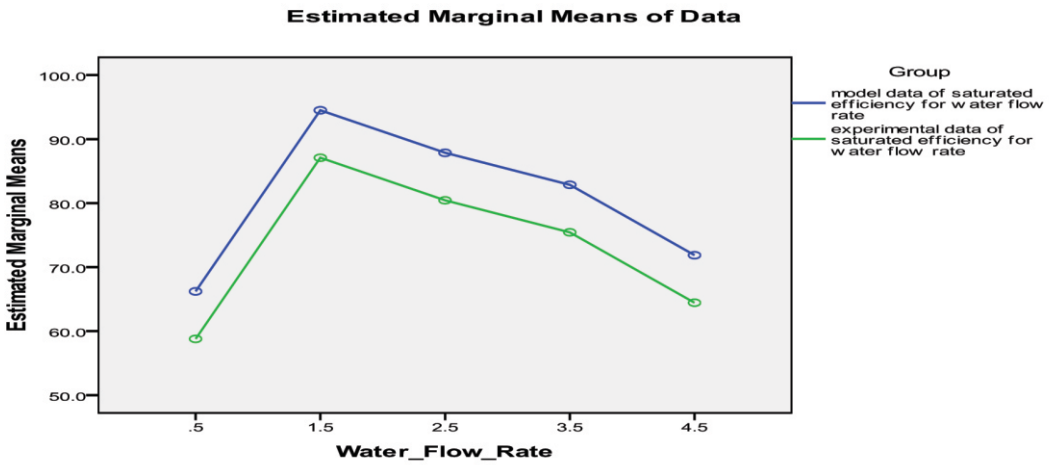


Fig 9.0 Comparison Between Modelled Data and Experimental Data of Saturated Efficiency Against Water Flow Rate

The mean effect of Water Flow Rate on saturated efficiency for both the experimental results and the simulation result were not significantly different, ***t*(5) = 1.013, *p* = 0.341 . (*p>0.05)***

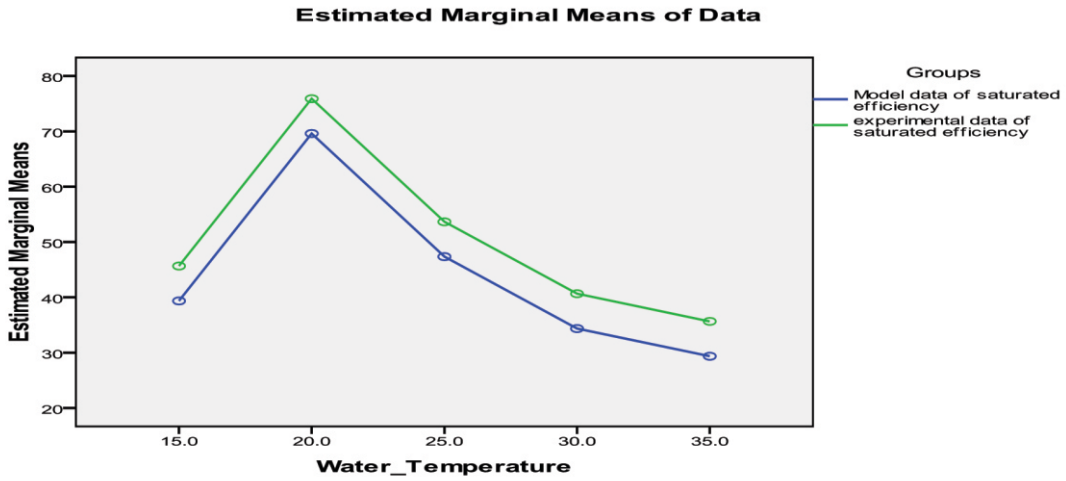


Fig 10.0 Comparison Between Modelled Data and Experimental Data of Saturated Efficiency Against Water Temperature

The mean effect of Water Temperature on saturated efficiency for both the experimental results and the simulation result were not significantly different, ***t*(5) = -0.597, *p* = 0.567 . (*p>0.05)***Table 5.0 Independent Samples Test of Pad Thickness against Modeled and Experimental data of saturated efficiency

Table 5.0 Independent Samples Test of Pad Thickness Against Modeled and Experimental Data of Saturated Efficiency

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data	Equal variances assumed	.230	.644	.494	8	.635	4.880	9.879	-17.901	27.661
	Equal variances not assumed			.494	7.829	.635	4.880	9.879	-17.988	27.748

Table 6.0 Independent Samples Test of Air Velocity Against Modeled and Experimental Data of Saturated Efficiency

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data	Equal variances assumed	.261	.624	1.639	8	.140	5.6400	3.4417	-2.2965	13.5765
	Equal variances not assumed			1.639	7.415	.143	5.6400	3.4417	-2.4069	13.6869

Table 7.0 Independent Samples Test Of Water Flow Rate Against Modeled And Experimental Data Of Saturated Efficiency

		Levene's Test for Equality of Variances		t-test for Equality of Means					
								95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data	Equal variances assumed	.020	.891	1.013	8	.341	7.4200	7.3258	-9.4733	24.3133
	Equal variances not assumed			1.013	7.994	.341	7.4200	7.3258	-9.4755	24.3155

Table 8.0 Independent Samples Test Of Water Temperature Against Modeled And Experimental Data Of Saturated Efficiency

		Levene's Test for Equality of Variances		t-test for Equality of Means					
								95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data	Equal variances assumed	.357	.567	-.597	8	.567	-6.300	10.549	-30.627	18.027
	Equal variances not assumed			-.597	7.625	.568	-6.300	10.549	-30.837	18.237

CONCLUSION

The developed programme came simple and efficient, with few windows for input of necessary data, showing enough information to optimise design of evaporative cooling system for the storage of fruits and vegetables. The results of the comparison between modeled data and experimental data showed that there was no significant difference between the software generated data and the experimental data of Saturated efficiency on Pad thickness –mm (*p=0.635)*, Air Velocity -m/s (*p=0.140)*, Water Flow Rate -L/min (*p=0.341)* and Water Temperature ^{0}C (*p=0.567)* at α= 0.05 significant level and 95% confidence interval.

Hence, the software provides the capability of identifying the working condition on the figures showing the effect of cooling pad thickness, water flow rate, inlet water temperature, air velocity, number of cooling segment and water to air flow rate on storage chamber temperature, storage chamber humidity ratio and saturation efficiency.

REFERENCES

ASHRAE, 1992. Evaporative air cooling. In Equipment Handbook Ch. 19, Atlanta, GA: American Society of Heating, Refrigeration and Air-conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329.

American Society of Heating, Refrigeration and Air-conditioning Engineers: ASHRAE Fundamentals (SI edition), pp. 14.26. ASHRAE, Atlanta, GA (1997).

Brooker, D.B.; Bakker-Arkema, F.W. and Hall, W.H. (1992). Drying of cereal grains. AVI publishing. Co. West Port, Connecticut, USA.

Carmargo J. R., Ebinuma C. D. and Cardoso S. 2003. A Mathemtical Model for Direct Evaporative Cooling Air Conditioning System. Engenharia Termica, no 4, pp. 30-34.

Dzivama A.U. (2000). Performance evaluation of an active cooling system for the storage of fruits and vegetables. Ph.D. Thesis, Department of Agricultural Engineering, University of Ibadan, Ibadan.

Fang W., Fon D. S., Jian Z. H. and Wang D. C. 2001. Re-development of Psychrometric software using Visual C++ and MATLAB. Proceedings of the International forum for vegetable production. Amen, China.

Fang W. 1994. Design and usage of pad and fan system. Journal of Agricultural Machinery Engineering. 3(4): 57-70. (in Chinese).

FAO (1986). Farm Structures in Tropical Climates. Food and Agricultural Organization of the United Nations.

Henderson S .M. and Perry R. L. 1976. Agricultural process engineering, 3rd edition. AVI Publishing. Co. Westport, Connecticut, USA.

Kachhwah S. S. and Suhas P. 2010. Heat and mass transfer study in a direct evaporative cooler. Journal of Scientific and Industrial Research Vol. 69, pp. 705-710.

Kays M. 1979. Convective heat and mass transfer. McGraw-Hill Book Co., India.

Mathews E. H. Kleingeld M. and Grober L. J. 1994. Integrated simulation of buildings and evaporative cooling system, Build Envirn, 29 pp. 197-206.

Rastavorski, A. (1981). Heat balance in potato store centre for agricultural publication and documentation. Wageningen, 210.

Wang, S.K. 1993. Evaporative cooling and evaporative coolers. Handbook for air conditioning and refrigeration. Ch. 13.

Wang D. C., Fang W. and Fon D. S. 2001. Development of a digital psychrometric calculator using MATLAB. Acta Horticulturae 578: pp. 339-344.

Van der Walt, N. T., and Hemp, R., 1989. Thermometry and Temperature measurements in Environmental Engineering in South African Mines. Chp 17. The Mine Ventilation Society of South Africa.

DESIGN AND CONSTRUCTION OF DOMESTIC SOLAR WATER HEATER

Abdulsalam M., M. L. Suleiman, I. B. Dalha and D. O. Emmanuel
Agricultural Engineering Department, Ahmadu Bello University, Zaria.
Correspondent: daniyasalam@yahoo.co.uk
08036052632

ABSRACT
The weather condition of the northern region of Nigeria emphasis the need for judicious utilization of this natural source of energy, solar. The solar water heater was designed and developed in the department of agricultural engineering, Ahmadu Bello University, Zaria. In the design the capacity of the heater, the insulating material to reduce the heat losses, the conveyance and collectors pipes, storage tank and the heat capacity were analysed. Materials used for the construction are readily available and can be afforded by the rural household. The result obtained from the test shows that the amount of heat flux received daily is sufficient to heat water (180 litres for family of 3 members) for domestic activities such as bathing, laundry and dairy farm activities. The maximum heat flux 1944.07 W/m^2 was recorded at temperature of 38.5 ^oC at 1:00 pm. The performance evaluation indicated that the optimal thermal efficiency of the heater was 65 %.

1.0 INTRODUCTION
The prices of petroleum products and other fossil fuel are consistently not stable in Nigeria and the cost of these essential commodities on the rural communities is on the high side. On an uncertain path, many businesses especially those in the agriculture industries need to start looking into the possibilities alternatives, more reliable and less expensive to sustain their business activities.

An active solar system is one having an assembly of collectors, storage device, and transfer fluid which converts solar energy into thermal energy and in which energy in addition to solar input is used to accomplish the transfer of thermal energy (Hunt, 1982). In active solar water heating systems, electric pumps, valves, and controllers are used to circulate water or other heat-transfer fluids through the collectors.

Passive Solar Water Heating System transfers heat by means of natural circulation by convection (i.e. they do not require pumps to function). They naturally modulate the circulation flow-rate in phase with the radiation level. Here, the warmer, less dense water rises to the top of system, displacing the colder water to the lowest point. Passive solar water heaters also known as thermosyphon systems are generally more reliable, easier to maintain, and possibly longer lasting than active systems. They can be built with inherent freeze resistance so they can be used in areas that are subject to extended periods of freezing temperatures and where maintenance facilities may be lacking such as the rural areas (John, 2003). An account given by the United States Department of Energy (USDOE) shows that the active systems are usually more expensive than passive systems but are also more efficient. Active systems are usually easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors.

Solar water heaters can also be classified as open loop (direct) or closed loop (indirect). An open-loop system circulates water through the collector. A closed loop system uses a heat transfer fluid to collect heat and a heat exchanger to transfer the heat to the storage tank. Both direct and indirect water heating can be by either natural circulation

forced circulation (Garg, 1987).

In a natural circulation solar water heater, there is a separate collector and storage tank and the storage tank is placed at a certain height (30 – 60cm) relative to the top of the collector to prevent the reverse circulation during off-sunshine hours. As the sun heats the collector, the hot water inside rises by natural convection and the colder storage tank water leaving from its bottom flows into the collectors by gravity. Thus the circulation loop is automatically established whenever there is sufficient insolation, and circulation automatically stops during insufficient insolation when the upward buoyancy force is unable to overcome the fluid friction losses inside the pipes (John, 2003). Like the name implies, forced circulation systems require a pump to forcefully circulate the heat-transfer fluid. The systems may be either direct type or indirect type. In a direct system, the water is directly circulated between the solar hot water storage tank and the collector. In an indirect system, a fluid (usually an anti-freeze, air, distilled water, or an organic heat-transfer fluid) other than the service water is circulated in the solar collector. Here, heat exchangers are used in or outside the hot water storage tank (John, 2003).

Polyvinyl (PV) modules and batch heaters have been adapted also for water heating. Batch heaters are also known as breadbox or integral collector storage systems. They are simple passive systems consisting of one or more storage tanks placed in an insulated box that has a glazed side facing the sun (USDOE, 1996). Polyvinyl- solar water heating (PV-SWH) system uses PV modules for collecting solar energy as electrical energy and in turn utilizing it for water heating.

The basic elements of most common solar water heaters are the flat-plate collector, heat transfer fluid, and the storage tank. Other components such as heat exchanger, pumps, pipe network, valves, auxiliary energy source, and control systems can be included depending on the intended design, operation, and application of the system.

A conventional flat-plate collector is made up of a flat absorbing plate, normally metallic upon which solar radiation falls, and is absorbed, changing to heat energy. The absorber plate is usually black in colour for optimum collection and its area is the same as the area intercepting the radiation. Attached to the collector absorb plate are tubes, channels, or passages which circulate the heat transfer fluid.

In most developing countries, 60% of the population lives in rural areas. Recently, there is increased emphasis on rural development, and this undoubtedly will require a phenomenal increase in the use of energy. A distance departure must be made from the techniques of exclusive dependence on firewood or charcoal, animal waste as the main sources of energy supply in the rural areas. The use of renewable energy source in its various forms, particularly the solar energy should be encouraged in the developing countries in domestic water heating, cooking and drying of agricultural products.

Based on these the need to develop a simple, efficient and affordable domestic solar water heater to be used not only by rural but even urban communities cannot be over emphasised. The specific objectives of this research are to design and construct a domestic solar water heater and evaluate the performance of the water heater.

2.0 METHODOLOGY

2.1 Material Selection

The materials used for the construction were carefully selected based on their thermal properties that suit the objectives of this research. The materials used are locally available and they are grouped below based on the major components of the water heater;

(a) A coated flat plate (sheet metal) which absorbs solar radiation and

transfers it into thermal energy.

(b) An storage tank which brings water into the system
(c) Cover to reduce upward thermal losses of the collector.
(d) Bottom insulation to reduce thermal losses.
(e) Metal tubes (galvanized steel pipes) and channels for circulating water to collect thermal energy.
(f) Wooden frame (plywood) to house the collector assembly
(g) Wooden frame on which the collector assembly is mounted.

2.2 Method

2.2.1 Design consideration and calculations

The solar water heater was designed for a family of three (3), requiring 180litres of hot water at 40^0C daily. The family of three (3) was chosen as the starting point, the result obtained from this would in future be worked upon in order to construct the heater that would be useful for families with a larger number

Assume metal pipe length, L_P=1.8288m (6ft)

Pipe diameter, D_P = 0.0127m ($^1/_2 inch$)

Volume of water carried by this length of pipe, V_P is

$$\mathbf{V_P = \pi r^2 L_P = \pi (D_P/2)^2 L_P} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(2.0)}$$

Where, r is the radius of the pipe

$$\therefore V_P = \pi\left(\frac{0.0127}{2}\right)^2 \times (1.8288)$$

$$V_P = 2.3167 \times 10^{-4} m^3$$

At any point in time of the day, at least 5litres (0.005m^3) of water should be available in the heater.

$$\therefore NO.ofpipesrequired = \frac{0.005\ m^3}{2.3167 \times 10^{-4} m^3}$$

$$= 21.582$$

$$\cong 21 pipes$$

2.2.2 Dimensions of the Pippings

Equivalent length, L_{EQ} = Length of pipe, L_P + 2(diameter of lateral pipe, D_{LP})

Diameter of lateral pipe, D_{LP} = 250mm

$$\therefore L_{EQ} = L_P + 2(D_{LP})$$

$$L_{EQ} = 1828.8 + 2(250)$$

$$L_{EQ} = 2328.8mm$$

Equivalent width, W_{EQ} = ($22D_P$ + clearance in between pipes (20mm))

W_{EQ} =699.4mm

2.2.3 Dimensions of the wooden case

Length =2728.8mm (L_{EQ} + clearance (400mm))

Width = 899.4mm (W_{EQ} + clearance (200mm))

Depth = 500mm

2.2.5 Angle of Inclination of the Flat Plate Collector, θ

$\theta = 15^0 + latitude\ of\ the\ region$ ..... (2.1) (Agbo, S.N. and Oparaku, O.U. 2006)

In this case, the latitude of Samaru. Zaria is used which is $11^0 11N$ (IAR, 1999).

$$\theta = 15^0 + 11^0$$
$$\therefore \theta = 26^0$$

2.2.4 Dimensions of the plate collector

Length of the metal plate sheet, L_{MPS} = Length of the wooden case

Width of the metal plate sheet, W_{MPS} = Width of the wooden case

2.2.6 Storage Tank Design

The tank is designed to carry a total volume of 180litres which is the amount required daily by the family of three (3). The tank is further given a freeboard (clearance) of two (2) litres.

The tank used here is a cylindrical type and it is chosen and not constructed, this is because it is relatively cheap when compared with the cost of constructing a tank using sheet metal. The type used is that used by the diesel company for transporting their product

2.2.7 Temperature calculation in the collector pipes

Part of the solar energy reaching the collector has been absorbed or scattered in the atmosphere, while the actual solar energy reaching the collector surface per unit area is referred to as "irradiance" Solar radiation as mentioned earlier of all wavelengths can readily be converted to thermal energy by using a black surface to absorb the radiant energy. This is the main reason why the outside of the collector pipes are painted black.

The setup is such that the pipes are arranged parallel, the average radiation by conduction passes through the transparent cover and then to the water inside the pipes through conduction.

The general heat transfer equation is used in calculating the temperature of the collector surface from literature; the relation is given as;

$$\frac{q_x}{A} = \propto_{sun} = \propto_{lowertemp} . \sigma\left(T_1^{\,4} - T_P^{\,4}\right) \quad \text{..... (2.2)}$$

(Holmann, 1981)

Where, $q_x = Heat\ flux\ {}^{W}/_{m^2}$

A = Surface area, m^2

$\propto_{sun} = solar\ radiation, for\ black\ body = 0.96$

$T_1 = Outside\ temperature\ of\ the\ tank$

$\propto_{lowtemp.} = 0.95$

$\sigma = Boltzman's\ constant = 56.7 \times 10^{-12}$

$T_p = Plenum\ Temperature = 51.5^0 C\ (324.5K)$

The average recorded incident radiation for samaru-Zaria is 937.60W/m^2

2.2.8 Received Heat in the System

Thermal energy is stored in the storage tank as sensible heat where the heat capacity of water is used. The amount of sensible heat stored, H_S in a given volume is expressed as:

$$H_S = V\rho C\Delta T \text{..... (2.3)}$$

Where,

H_S = sensible heat (KJ)

V = the storage volume (m^3),

$$Q = mc\frac{\Delta T}{\Delta t} \quad \text{..... (2.4)}$$

Where, Q = rate of heat absorption (Kg/hr)

M = mass of water (kg)

C = specific heat capacity of water (kJ/kgK^{-1})

ΔT= temperature change in K

Table 3.1. The Solar Heater Tank Water Readings Recorded On The 24th September, 2012.

TIME	TEMPERATURE (℃)	CHANGE IN TEMPERATURE, (℃)	HEAT ABSORPTION, Q (KJ/hr)	SENSIBLE HEAT STORED H_S (KJ)	Q_x (W/m^2)
7am	28.89				957.09
8am	32.78	3.89	18.91	0.78	1085.65
9am	34.44	1.66	8.07	0.33	1288.48
10am	42.78	8.34	40.53	1.67	1710.28
11am	44.44	1.96	9.53	0.39	1934.6
12pm	48.89	4.05	19.68	0.81	1944.07
1pm	41.67	-7.22	35.09	1.44	1859.86
2pm	40	-1.67	8.12	0.33	1755.42
3pm	37.22	-2.78	13.51	0.56	1688.15
4pm	35	-2.22	10.79	0.44	1623.02

Table 4.3the Solar Heater Tank Water Readings As On The 25th September 2012

TIME	TEMPERATURE (℃)	CHANGE IN TEMPERATURE, ΔT (℃)	HEAT ABSORPTION, Q (KJ/hr)	SENSIBLE HEAT STORED, Hs(KJ)	Q_x (W/m^2)
7am	33.33				957.09
8am	34.44	1.11	5.39	0.22	1085.65
9am	60	25.56	124.42	5.11	1306.57
10am	43.33	-16.67	81.02	3.33	1824.47
11am	51.11	7.78	37.81	1.56	2161.11
12pm	48.33	-2.78	13.51	0.56	1907.7
1pm	43.33	-5	24.3	1	1847.94
2pm	38.89	-4.44	21.58	0.89	1721.54
3pm	36.67	-2.22	10.79	0.44	1677.26
4pm	35	-1.67	8.12	0.33	1633.64

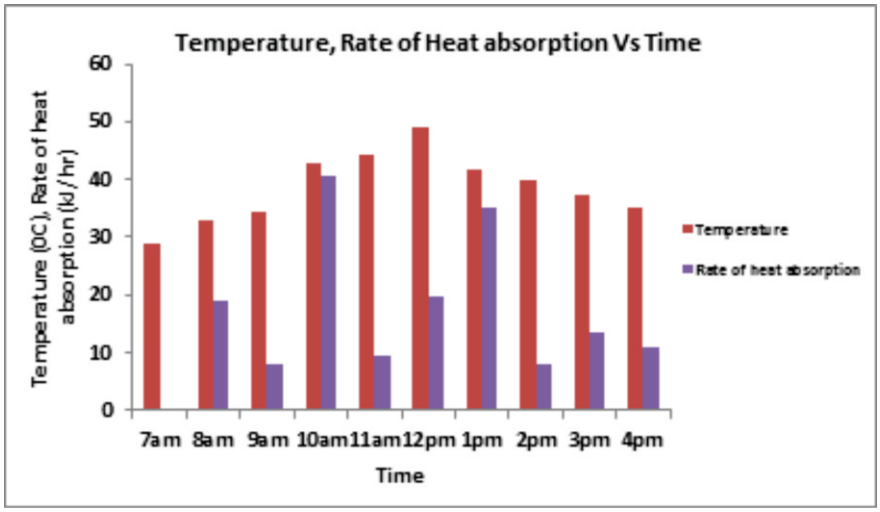


Fig. 2.1(a) Graph Of Temperature And Rate Of Heat Absorption Against Time For The Readings On 24th September 2012

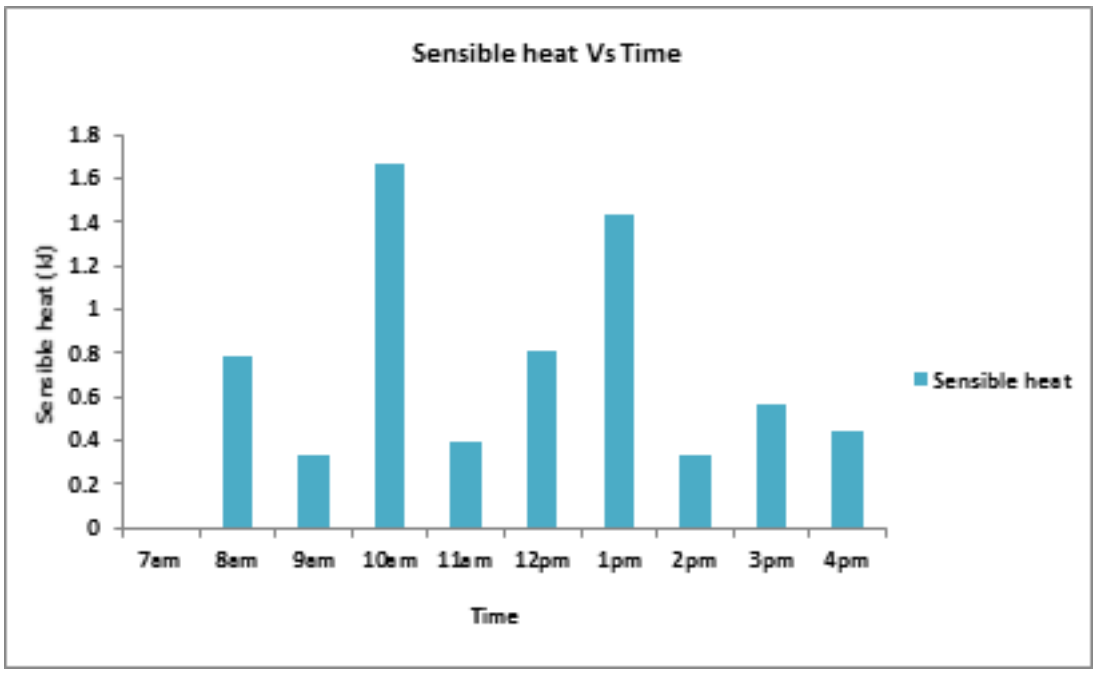


Fig. 2.1(b) Graph Of Sensible Heat Against Time For The Readings On 24th September 2012

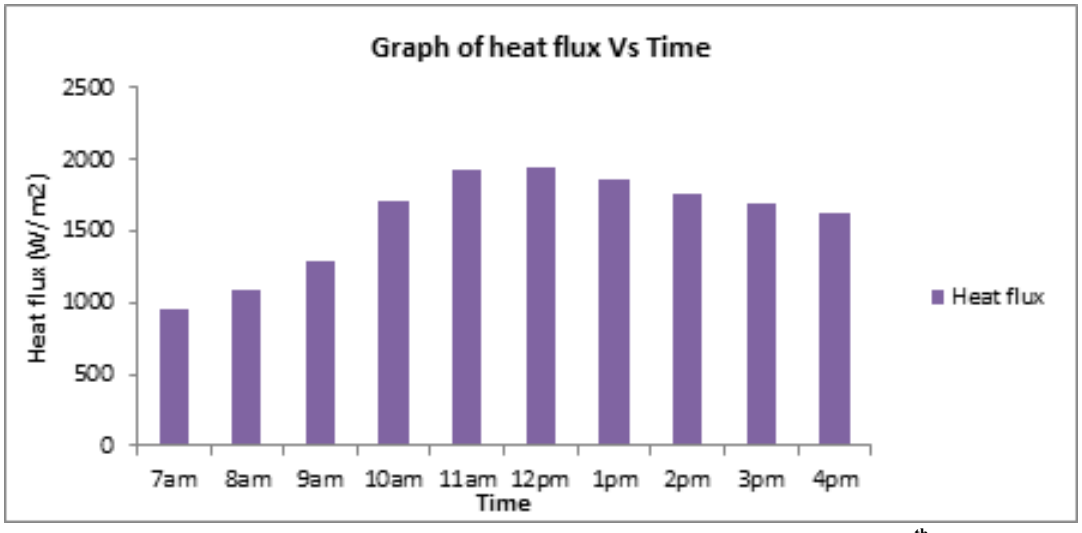


Fig.2.2 Graph Of Heat Flux Against Time For The Readings On 24th September 2012

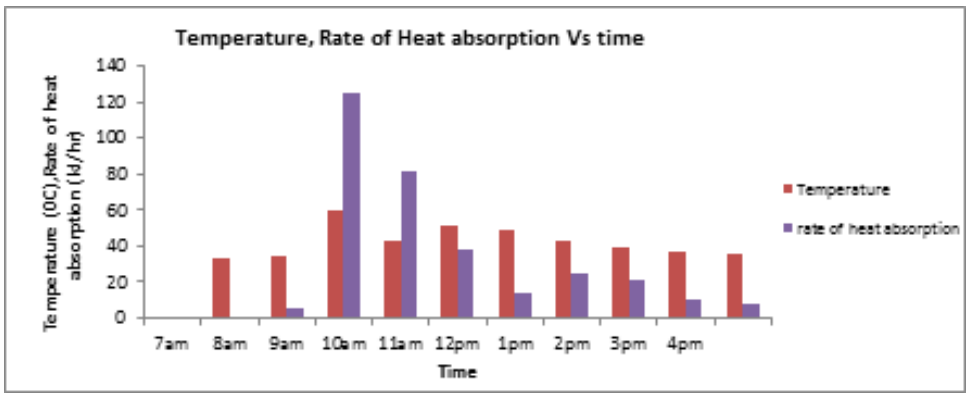


Fig.3.1 (a) Graph Of Temperature And Rate Of Heat Absorption Against Time For The Readings On 25th September 2012

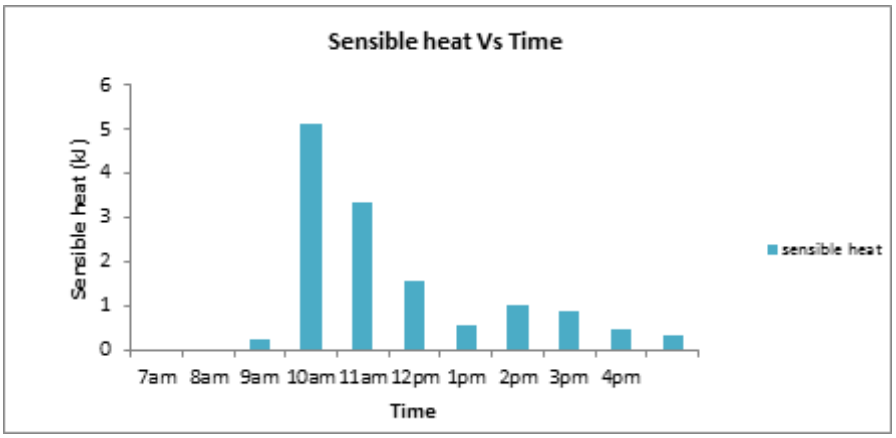


Fig. 3.1(b) Graph Of Sensible Heat Against Time For The Readings On 25th September 2012

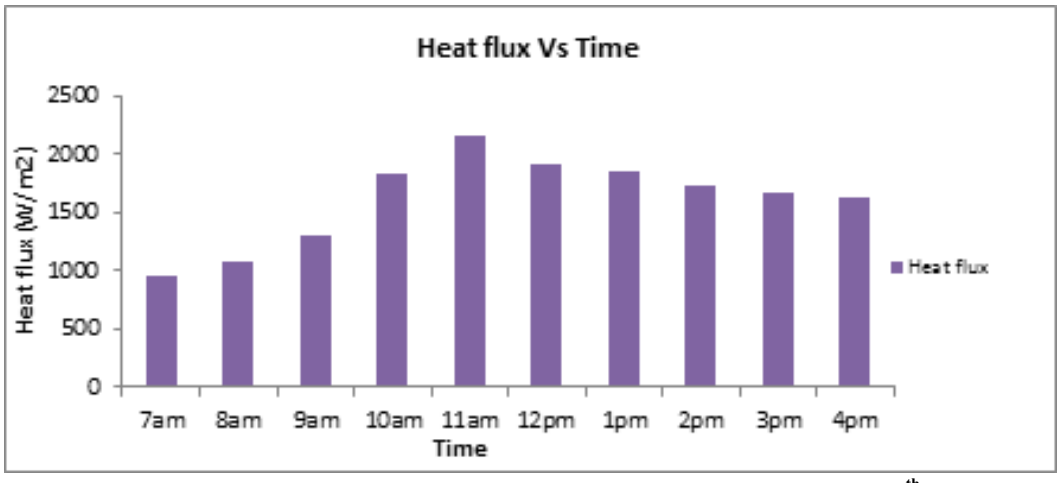


Fig 3.2 Graph Of Heat Flux Against Time For The Readings On 25th September 2012



Fig. 1.0 Pictorial View Of The Solar Water Heater

DETERMINATION OF SELECTED PHYSICAL AND MECHANICAL PROPERTIES OF CEREALS AND LEGUMES AND THEIR EFFECT WITH MOISTURE CONTENT

Isa, J. and Oladele, S.O.
Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State.
E- mail: johnisa4u@yahoo.com. Phone No: +234 803 497 1788

ABSTRACT
The importance of cereals and legumes to mankind cannot be over-emphasized. However, physical and mechanical properties of cereals and legumes are necessary for designing the facility of storage, handling and processing of such agricultural products. Physical and mechanical properties of four seeds, comprising two cereals and two legumes namely maize, rice, cowpea and soybeans respectively, were determined as a function of moisture content using standard techniques. The physical properties determined were seed volume, seed density, sphericity, surface area, seed mass while the mechanical properties determined were rupture force and rupture energy.
The average length, width, thickness, seed mass, and volume of the seeds increased with soaking time until the seeds became saturated while density decreased with soaking time. With increase in moisture content, the mean density of the seeds were found to decrease, from1.13 to 0.6 gcm^{-3} for maize; 1.2 to 0.6 gcm^{-3} for rice; 0.98 to 0.67 gcm^{-3} for cowpea and 0.95 to 0.52 gcm^{-3} for soya beans. The mean volume increased from 0.3 to 0.7 cm^3 for maize; 0.02 to 0.05 cm^3 for rice; 0.4 to 0.9 cm^3 for cowpea and 0.2 to 0.6 cm^3 for soya beans. Rupture energy of the seeds generally increased in magnitude with an increase in moisture content, while rupture force decreased under compression. The outcome of this research is expected to contribute specifically to the designs of equipment for the handling, conveying, separation, drying, aeration, storing and processing of rice, maize, cowpea, and soybeans.

Keywords: Physical Properties, Mechanical Properties, Moisture Content, Cereals, Legumes.

1.0 INTRODUCTION

Cereals are grasses, members of the monocot family , also known as Gramineae, cultivated for their edible cereal (botanically, a type of fruit called a caryopsis).http://en.wikipedia. Cereals are staple crops grown in greater quantities and provide more food energy worldwide than any other type of crop. In their natural form, they are rich source of vitamins, minerals, carbohydrates, fats, oils, and protein. Rice, millet, sorghum, wheat and maize are examples of this plant family. *FAOSTAT* (2006).

Cereals are also used to produce animal feed, oils, starch, flour, sugar, syrup, processed foods, malt, alcoholic beverages, gluten and renewable energy. Pomeranz and Munck (1981). Approximately 50% of the world's calories are provided by rice, wheat and maize, but in many parts of Africa and Asia, people rely mainly on cereals such as sorghum or millet. Maize, sorghum and barley are important sources of livestock feed and barley and rice are used in the brewing industry(Chopra and Prakash, 2002).Worldwide production of maize is 785 million tons, with the largest producer, the United States, producing 42%. Africa produces 6.5%, Nigeria being the largest African producer with nearly 8 million tons (IITA, 2009).

Another very important plant family is the legume. Legume - a class of vegetables that includes beans, peas and lentils are among the most versatile and nutritious foods available. Legumes are typically low in fat, contain no cholesterol, and are high in foliate, potassium, iron and magnesium. They also contain beneficial fats and soluble and insoluble fibre. A good source of protein, legumes can be a healthy substitute for meat, which has more fat and cholesterol (http://www.mayoclinic.com)

The design of equipment for the handling, separation, conveying, drying, storing, aerating and processing of cereals and legumes requires an in-depth knowledge of their physical properties (Sahay and Singh, 1994). The size and shape, for instance, are needed in the electrostatic separation from undesirable material and in the development of sizing and grading machinery (Mohsenin, 1980). Properties of any crop are greatly influenced by its moisture content. Bulk density, true density, and porosity can be useful in sizing cereal hoppers and storage facilities; they affect the rate of heat and mass transfer of moisture during aeration and drying processes. Cereal grains densities have been of interest in breakage susceptibility and hardness studies.

For this study, selected cereals and legumes physical and mechanical properties were investigated. It is aimed at determining the physical properties of the selected seeds during water absorption; determining the mechanical properties of the seeds; and providing data required for the processing, mechanization and production of the seeds.

2.0 MATERIALS AND METHODS

The selected cereals and legumes, namely Rice, Maize, Cowpea and Soybeans, were bought in a local market in Akure, Ondo State and taken to the Agricultural Engineering Laboratory of the Federal University of Technology, Akure. The seeds were cleaned manually and pneumatically, to remove all foreign matters, broken and immature seeds. Afterwards, the following parameters were determined: weight, mass, dimensions, sphericity, moisture content, density, volume, rupture force and rupture energy.

2.1 Size and Shape Determination

For each crop, seeds were selected and the dimensions of their major, intermediate and minor diameter were measured using a micrometre screw gauge. During measurement, care was taken in handling the micrometre screw gauge to avoid undue pressure being exerted on the seeds and error due to parallax. The dimensions of the diameters were determined and then recorded.

2.2 Weight and Volume Determination

A precision electronic balance reading up to 0.01 g with an accuracy of ± 0.2 mg was used to obtain the mass of the seeds. The volume of the each seed was obtained by displacement method. The seeds were dropped into a 100ml measuring cylinder which was filled with known volume of water. Following the Archimedes principle, the seeds displaced certain volume of water which is equal to its volume. The seeds were initially weighed on a scale to obtain their average mass.

2.3 Density Determination

Seed density by definition is mass per unit volume. It is usually expressed in g/cm^3. The samples were weighed, then, the measuring cylinder was filled with water to a known level, after which the weighed sample were dropped into the measuring cylinder containing the water. The equivalent sample volume was determined by reading the final level of water.

2.4 Moisture Content Determination

The initial moisture content of the seeds was determined using the gravimetric method. A known mass of seeds were put in the oven at a regulated temperature of 105^0c until it assumes a constant mass. The value of the new mass accounted for the moisture loss. The differences in the mass were used to calculate the moisture content using the equation below:

$$Density = \frac{Mass\,(g)}{Volume\,(cm^3)} \quad (1)$$

2.5 Surface Area Determination

The surface area of the seeds was determined using the relationship given by Sceenara jarah *et al.* (1989).

$$\text{Moisture content dry basis} = \frac{\text{Wet seed mass (g)} - \text{dry seed mass (g)}}{\text{dry seed mass (g)}} x\ 100\% \quad (2)$$

$$A_s = \pi D_p{}^2 \quad (3)$$

where:

A_s = Surface area (cm^2)

D_m = Geometric mean diameter = $\sqrt[3]{D1 \times D2 \times D3}$ (cm)

D_1 = Major diameter (cm)

D_2 = Intermediate diameter (cm)

D_3 = Minor diameter (cm)

2.6 Mechanical Properties Determination

Compression tests were performed on the cereal and legumes using a Universal Testing Machine (Instron). Testing Conditions for the lnstron Machine were chart speed – 50 rpm/mm; Crosshead speed – 1.5 mm/min.

2.6.1 Compression Test

The procedure was to put the seed on desired section and selecting speed of loading and then applying force until the cereal is fractured. Each seed was placed between the compression plates of the tensonometer. The seed was compressed at a constant deformation rate. The applied forces at bio-yield and oil points and their corresponding deformations for each seed sample were read directly from the force-deformation curve. The mechanical properties of the seeds were expressed in terms of rupture force and rupture energy. The rupture force was determined as the force on the digital display when the seed under compression makes a clicking sound. Each process was completed whenever the break point of the positioned seed is reached.

3.0 RESULTS AND DISCUSSION

In line with the objectives of this study, physical and mechanical properties that were determined include; physical dimension, weight, seed density, moisture content, rupture force, rupture energy.

3.1 Size and Sphericity

The mean dimension of the samples at different moisture content varies. All dimensions were increased with an increase in moisture content until it was saturated. The increasing trend in axial dimensions, with gain in moisture content, was due to filling of capillaries and voids upon absorption of moisture and subsequent swelling. The sphericity of the seeds decreased with increase in moisture content .The seeds volume also increased with the moisture level increment.

3.2 Seed Densities

The values of the bulk density for different moisture levels varied from 0.96 to 0.667 g/cm^3 for cowpea; 0.95 to 0.48 g/cm^3 for soybeans; 1.20 to 0.60 g/cm^3 for rice; and 1.17 to 0.60 g/cm^3 for maize. A similar decreasing trend in bulk density has been reported by Gupta and Das (1997) for sunflower seed. Parde *et al.* (2003) also reported that the standard bulk density of Koto buckwheat increased significantly from 603.90 to 612.90 kgm^{-3} with an increase in moisture content from 14.8 to 15.8 %. The values generated shows that with increase in moisture content, seed densities decrease.

3.3 Seed Volume

The values of the seed volume for different moisture levels varied from 0.4 to 0.9cm^3 for cowpea; 0.2 to 0.6 cm^3 for soybeans; 0.02 to 0.05 cm^3 for rice; and 0.3 to 0.7 cm^3 for maize.

3.4 Moisture Content

The values of the moisture content wet basis varied from 3.57% to 55.00% for cowpea; 5.26% to 41.94% for soybeans; 9.52% to 36.67% for rice; and 5.88% to 23.81% for maize. These show that the moisture content wet basis increases with soaking time.

3.5 Surface Area

The value of the surface area for different moisture levels increases with soaking time from 234.33 mm^2 to 353.79 mm^2 for cowpea; 93.85 mm^2 to 238.54 mm^2 for soybeans; 45.82 mm^{2}to 59.23 mm^2 for rice; and 21.40 mm^2 to 27.27 mm^2 for maize.

3.6 Rupture Force

From Figures 3.9-12 below, it can be seen that the force required initiating the seeds rupture decreased with the increase in moisture content. The rupture force values ranged from 192.82 N to 133.75 N for rice; 600.70 to 160.21N for maize; 466.66 to 56.47N for cowpea; and 358.94 to 103.27N for soybeans. The results demonstrated that, in the range of moisture content investigated, the rupture force along principal axis is highly dependent on moisture content. For the curve, the cereals at less moisture content need greater rupture force. The small rupturing force at higher moisture content may be due to the fact that the corn might have soft texture at high moisture content. Similar results were reported by Vursavus and Ozguven (2004), Altuntas and Yildiz (2005), and Olaniyan and Oje (2002) for apricot pit, faba bean and shea nut, respectively.

3.7 Rupture Energy

The range of rupture energy values was from 0.10 to 0.18J for rice; 0.12 to 1.59 J for maize; 0.52 to 1.19 J for cowpea; and 0.50 to 0.89 J for soybeans.

The results showed that the rupture energy is highly dependent on moisture content as reported by Guner*et al.* (2003), Oloso and Clarke (1993), and Altuntas and Yildiz (2005).The rupture energy was low at the lower moisture content levels.

4.0 CONCLUSION

The average length, width, thickness, seed mass, and volume of the seeds investigated increased with soaking time until the seeds became saturated while density decreased with soaking time.

The density were found to decrease from 0.98 to 0.67 gcm^{-3} for cowpea, as the moisture content increases; 1.13 to 0.6 gcm^{-3} for maize; 1.2 to 0.6 gcm^{-3} for rice; 0.95 to 0.52 gcm^{-3} for soya beans.

The values of the seed volume for different moisture levels varied from 0.4 to 0.9 cm^3 for

cowpea; 0.2 to 0. 6 cm^3 for soya beans; 0.02 to 0.05 cm^3 for rice; and 0.3 to 0.7 cm^3 for maize.
The mechanical properties of the seeds were determined in terms of average rupture force and rupture energy. With an increase in moisture content, rupture energy of the seeds generally increased in magnitude while rupture force decreased with increase in moisture content.

REFERENCES

Altuntas, E., and M. Yildiz, 2005. Effect of moisture content on some physical and mechanical properties of faba bean (*Viciafaba L.*) cereals. Journal of Food Engineering 78, 174–183.

Chopra, V.L., and S. Prakash, (eds).2002. Evolution and Adaptation of Cereal Crops. Science Publishers Inc, NH, USA.

FAOSTAT, 2006. Crops production. Food and Agriculture Organization of the United Nations. (Available at http://faostat.fao.org/site retrieved on 26 December, 2006).

Guner, M., E. Dursun, and I.G. Dursun, 2003. Mechanical behaviour of hazelnut under compression loading. Biosystems Engineering, 85(4), 485–491.

Gupta, R.K., and S.K. Das1997. Physical properties of sunflower seeds. Journal of Agricultural Engineering Research, 66: 1–8

International Institute of Tropical Agriculture 2009) Handbook.
Mohsenin, N.N. 1980. Physical Properties of Plant and Animal Materials, 2nd ed. Gordon and Breach Science Publishers, New York.

Olaniyan, A.M., and K.Oje. 2002. Some aspect of the mechanical properties of shea nut. Biosystems Engineering, 81, 413–420.

Oloso, A.O. and B. Clarke, 1993. Some aspects of strength cashew nuts. Journal of Agricultural Engineering Research, 55, 27–43.

Parde, S.R., A., Johal, D.S. Jayas.and N.D.G White. 2003. Physical properties of buckwheat cultivars.Canadian Bio-systems.Engineering, Technical Note.

Pomeranz, Y., and L. Munck, 1981. Cereals: A Renewable Resource. American Association of Cereal Chemists, St. Paul, MN

Sahay, K.M., and K.K. Singh, 1994. Unit Operations of Agricultural Processing.1st ed. Vikas Publishing House Pvt. Ltd., New Delhi, India

Sreenara jarah, V.V., V. Subramanian, and R. Visvanathan, 1989. Evaluating calculations involving some physical properties of Agricultural materials; Transaction of the ASAE, 1506-1522.

Vursavus, K.and F. Ozguven, 2004. Mechanical behaviour of apricot pit under compression loading. Journal of Food Engineering, 65, 255–261.

Wikipedia. 2012.Cereal. Available at: http://en.wikipedia.org. Accessed 17 August 2012.

Mayoclinik 2012. Health: Legumes. Available at: http://www.mayoclinic.com. Accessed 17 August 2012

Table 1: Surface Area Determination

		Time of soaking			
Parameters	**Seeds**	**0hr**	**5hrs**	**10hrs**	**15hrs**
L	Rice	7.14	8.00	8.29	8.30
	Cowpea	10.43	12.54	14.01	14.00
	Soybean	7.00	10.90	12.36	12.37
	Maize	9.28	11.00	12.01	12.00
W_d	Rice	3.00	3.27	3.40	3.40
	Cowpea	9.50	9.99	10.10	10.10
	Soybean	5.50	6.97	7.75	7.75
	Maize	8.30	9.98	10.90	10.90
T_h	Rice	2.60	2.80	2.91	2.90
	Cowpea	6.50	7.76	8.44	8.45
	Soybean	4.24	6.01	6.90	6.90
	Maize	4.10	4.60	5.00	5.00
D_e	Rice	3.82	4.18	4.34	4.34
	Cowpea	8.64	9.91	10.61	10.61
	Soybean	5.47	7.70	8.71	8.71
	Maize	6.81	7.96	8.68	8.68
A_s	Rice	45.82	55.01	59.31	59.23
	Cowpea	234.33	308.33	353.68	353.79
	Soybean	93.85	186.31	238.41	238.54
	Maize	21.40	25.02	27.28	27.27

Where;

L = Length (mm)
W_d = Width (mm)
T_h = Thickness (mm)
D_e = Geometric mean diameter
A_s = Surface area (mm^2)

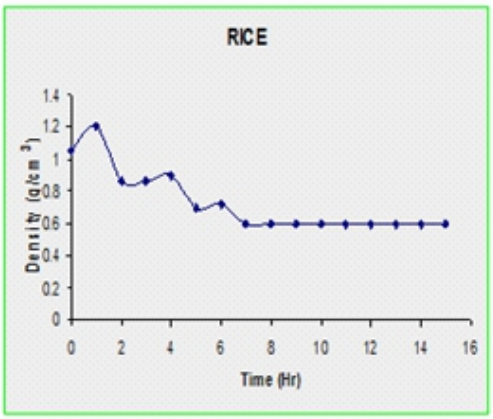


Fig. 3.1: Graph showing density of Rice with soaking time

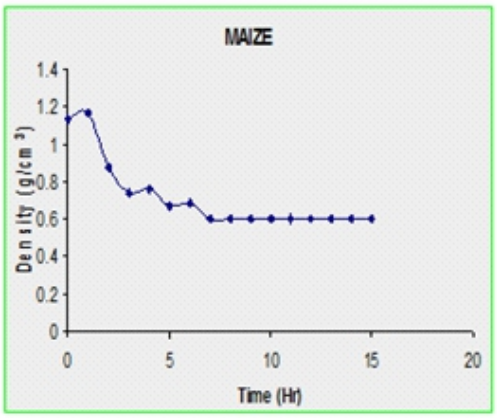


Fig. 3.2: Graph showing density of Maize with soaking time

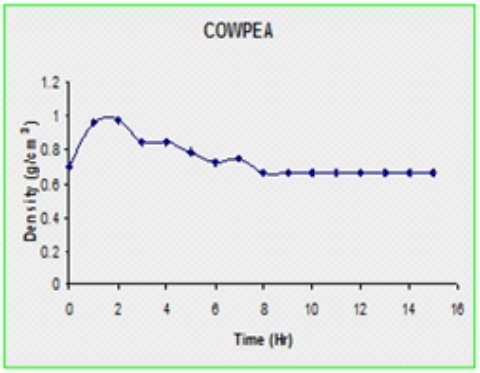


Fig. 3.3: Graph showing density of Cowpea with soaking time

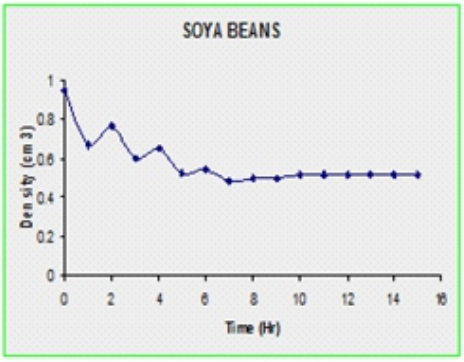


Fig. 3.4: Graph showing density of Soya beans with soaking time



Fig. 3.5: Graph showing volume of Maize with soaking time

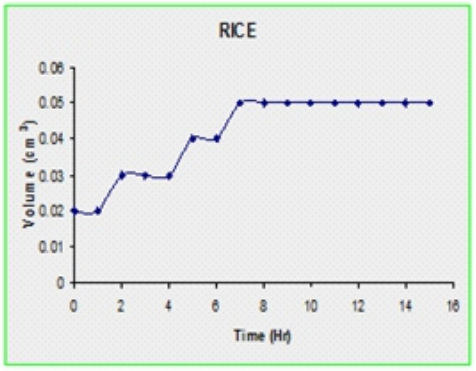


Fig. 3.6: Graph showing volume of Rice with soaking time.

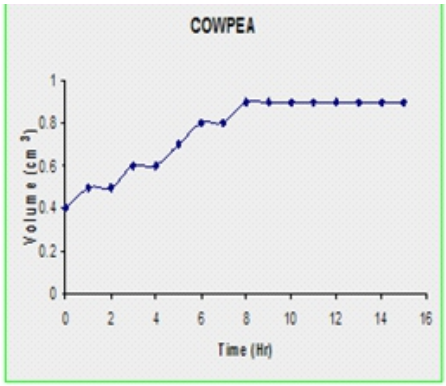


Fig. 3.7: Graph showing volume of Cowpea with soaking time

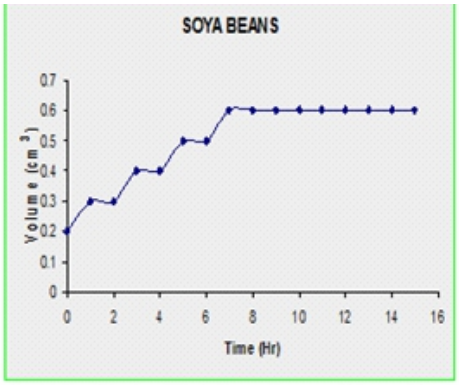


Fig. 3.8: Graph showing volume of Soya beans with soaking time

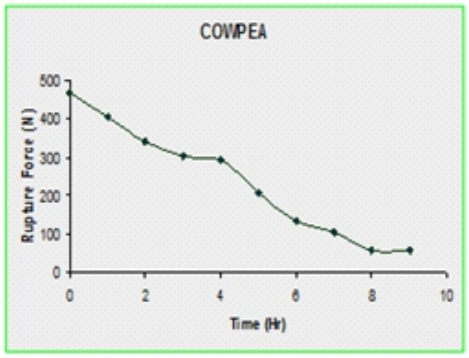


Fig. 3.9: Graph showing Rupture Force of Cowpea with soaking time

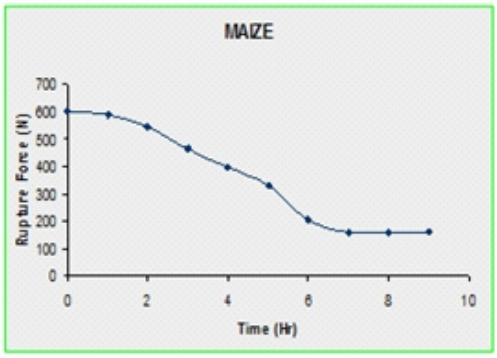


Fig. 3.10: Graph showing Rupture Force of Maize with soaking time

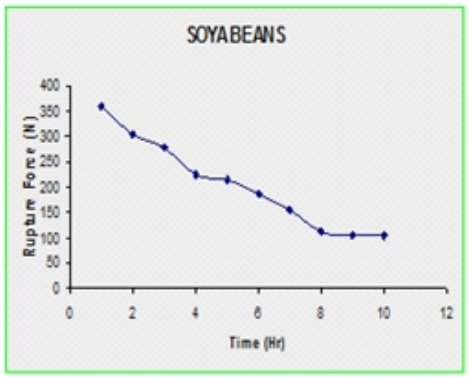


Fig. 3.11: Graph showing Rupture Force of Soya beans with soaking time

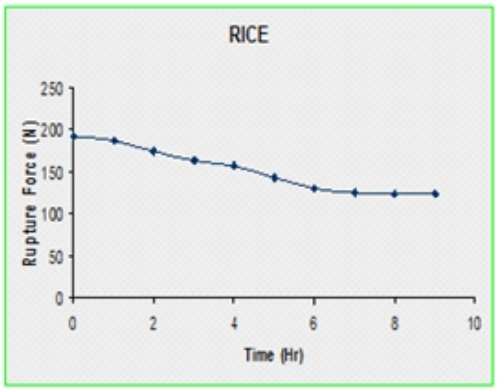


Fig. 3.12: Graph showing Rupture Force of Rice with soaking time.

EFFECTS OF PROCESSING METHODS ON THE BRABENDER AMYLOGRAPH PASTING PROPERTIES OF FALSE YAM (*Icacinatrichantha*) FLOUR

Umoh, EnobongOkon
Department of Agricultural Engineering, Faculty of Engineering,
AkwaIbom State University
IkotAkpaden, P. MB 1167, Uyo. AkwaIbom State, Nigeria.
E-mail: enoumoh2003@gmail.com +2348035408924

ABSTRACT
This work investigates the effects of different processing methods on the BrabenderAmylograph pasting properties of false yam (*Icacinatrichantha*). False yam tubers were processed into different flour samples: The raw, steeped-Sun-dried, steeped-oven-dried, blanched-Sun-dried and blanched-oven-dried samples. The pasting properties of the flour samples were studied, using BrabenderAmylopgraph. The results showed that the gelatinization temperature(set) ranged between 40.00 to 84.85°C; 58.50 to 93.85°C for peak gelatinization temperature; 771.00 to 2000 BU peak viscosity; 619.00 to 761.00BU set back viscosity; and 51.00 to 1240.00 BU stability, among the samples. Processing significantly affected the pasting properties of the flour samples.

Keywords: Processing, Pasting Properties, False Yam, Flour, Brabenderamylograph.

1.0 INTRODUCTION
False yam (*Icacinatrichantha*) belongs to the family of *Icacinaceae*, and it is indigenous to West and Central Africa. It is a shrubby perennial, small and drought-resistant plant which sends up erect leafy shook from a large, underground fleshy tuber. It is found growing wild on light sandy soils in the Savanna area of Senegal, Gambia, Northern Ghana, Guinea and part of Sudan and requires a marked wet and dry season, but with only moderate rainfall in the wet season (80 to 100cm). It is known as *Bankanas*or*Kouraban*in Senegal, *Manankaso*in Gambia, *Pane*' in Sudan, and *Takwara* in Ghana (Kay, 1987). It is known as *Urumbia* or *eriagbo* among the Ibos, *gbegbe*by the Yorubas (Asuzu and Abubakar, 1995) *Efikisong* by the Ibibios(Etukudo, 2003) all in Nigeria.

False yam in Seldom cultivated, however, it is occasionally planted in Africa, and it is reported to be propagated by pieces of tubers. No pests and disease have been reported yet (Kay, 1987).

The tubers are harvested by hand as required; owing to their size. False yam has not been fully domesticated or even investigated horticulturally. Nevertheless, it has a future as both a subsistence and commercial food crop. It is a perennial that produces large quantities of three different foods a snack, a staple, and a famine food (NRCNAP, 2008) . It could therefore be a valuable food security crop for the most difficult regions and most threatening times.

It has been reported that the objective of processing includes the extraction of non-proteinacious components; to remove undesirabletaste and odour component; to remove or inactivate nutritionally undesirable components to prepare a protein material that is suitable for application in food products (Iwe, 2003).

False yam tubers after cleaning, are sliced and soaked in cleaned water for several days to soften the flesh and leach out bitter compounds .They are then dried in the sun,

pulverized and sieved. What results in white, grayish or creamy –yellow flour . Drying the damp flour in a pot over a fire produces clear, hard "rock" of what is probably almost pure starch (NRCNAP, 2008).

The extension of known methods of processing and utilization of false yam mean introducing new techniques and food products, thus offering variety to the consumers. This could as well help in providing the ultimate in value addition and sustainable food security. This study is therefore aimed at examining the effects of different processing methods on the pasting properties of false yam flour, in order to evaluate its potential food uses.

2.0 MATERIALS AND METHODS

2.1 Sample Collection and Preparation

The tubers of *Icacinatrichantha* were obtained from AkwaIbom State College of Agriculture and was identified in the Department of Botany, University of Uyo, Uyo, all in AkwaIbom State.

Four different samples of flour were prepared from the tubers of *Icacinatrichantha* using four different methods of processing as shown below:

2.1.1 Steeped-sun-dried flour sample

The tubers were cleaned, peeled and washed before cutting into pieces, using Kitchen knife, of uniform sizes as described by Kay (1987). They were then soaked in clean water for about 24h after which they were sun-dried. That was followed by pulverization, using a CORONA LANDER & CIA. S.A. KI manual grinder, and was sieved using 500mm mesh sizes. The flour obtained was package in dry polyethylene sack and stored for subsequent use.

2.1.2 Steeped-oven-dried flour sample

The same method for the preparation of Steeped-Sun-dried flour sample as described by Kay (1987) was adopted, except that Oven was used in the drying process at 50^0C

2.1.3 Blanched-sun-dried flour sample

The freshly cleaned, peeled, and sliced tubers were dipped in boiling water for a brief length of time, as described by Okaka and Okaka (2005). They were then drained, and sun-dried. Dry Chips were Pulverized and sieved. The flour obtained was packaged in dry polyethylene sack and stored in a cool dry place for subsequent use.

2.1.4 Blanched - oven –dried flour sample

The blanched –oven-dried flour sample was prepared according to the method described by Okaka and Okaka (2002) except that Oven was used in the drying process.

2.1.5 Determination of Pasting properties

The pasting characteristics of the different flour samples were determined by the method of Rasper andCoursey (1967), using a Brabenderamylograph. The standard mode was used in which the sample was heated at constant heating rate (2.5^0C/min) from starting point up to final temperature (92^oC), the viscosity was recorded at a constant rotational velocity (50 rev/min) of the measuring vessel, and was read-off from a calibrated BRABENDER graph. The data samples were taken in triplicates, and the mean values were finally recorded.

2.3 Statistical Analysis

The mean, standard deviation and standard error were calculated. Samples were compared using analysis of variance (ANOVA) and mean separation test was done using Least Significant Difference (LSD) method (Ihekoronye and Ngoddy, 1985). All Statistical analysis were carried out using Statistical Package of Social Science (SPSS) version 15. (a computer software package). Significance was judged at $p<0.05$.

3.0 RESULTS AND DISCUSSION

The results of the effects of processing methods on the amylograph pasting properties of false yam (*Icacinatrichantha*) are presented in Table 1. There was no significant difference ($p>0.05$) in the gelation temperature (set) between the raw and steeped-sun-dried sample. Rather, significant difference ($p<0.05$) existed between the raw and other samples (Table 1) The raw sample had 73.10°C (set). Blanched-Over-dried sample had the lowest (40.00°C) value and steeped-oven-dried Sample had the highest, 84.85°C. Blanched-sun-dried and steeped –sun-dried samples 52.50°c and 74.40°Crespectively.

The gelatinization temperatures (set) for the raw samples is comparable with 73.50°C for yam starch (Ciacca and D'Applonia, 1977) while that for blanched-oven-dried and blanched sun-dried samples may be comparable with 49.00°C for cassava starch (Ciacco and D'Appolonia, 1977). The results, however may suggest the important of pasting properties of false yam tuber flour when used in composite flour for bread making .

The peak gelation temperature showed no Significant difference ($p>0.05$) between the raw and steeped-sun-dried, steeped-oven dried, and blanched-oven-dried, samples (Table 1) But the raw Sample s significantly different ($p<0.05$) from blanched-Oven-dried sample in terms of peak gelation temperature. Peak gelation temperature for the raw sample is 84.20°C, while that of blanched –oven-dried, blanched-sun-dried,steeped-sun-dried, and steeped-oven-dried samples are 58.50°C, 83.60°C, 88.70°Cand 93.85°C respectively. This range of values for gelation temperature are higher than that of sweet potato starch samples, 67.0 to 73.8°C (Walter, Jr*et al*., 2000) and cocoyam –soyabean-crayfish flours, 56.88 to 76.25°C (Oti and Akobundu, 2007). Rate of gelling and gel firmness depend on temperature, time of heating and protein concentration (Iwe, 2003). If viscosity increases sufficiently, gel can be formed, which is a useful functional property. Gels are important in comminuted sausage products. The ability of gels to act as a matrix for holding water, lipids, sugars, flavours, and other ingredients is useful in food applications and in new product development.

Consequently, false yam tuber flour could be useful in food application such as comminuted sausage owing to its ability to form gel.

Peak viscosity (Vm) of the raw samples was 2000.00 BU, being the highest, while that of blanched-oven-dried, blanched-sun-dried and steeped-oven-dried samples were 1500.00BU, 771.00BU,1500.00BU and 1209.00BU respectively. Blanched –oven-dried sample was not significantly different ($p<0.05$) from other samples. The peak viscosity values were higher than values reported for cocyam-soyabean-crayfish flours. (4.00 to 75.00BU) (Oti and Akobundu, 2007); while Walter,Jr*et al* (2000) reported that no pasting peaks starch samples (Table 1).

No significant difference ($p>0.05$) was observed in set backviscosity (Vr) among the samples. The raw sample had 760.00BU,steeped-oven-dried sample had the highest (761.00BU)while blanched-oven-dried had the lowest (619.00BU). Blanched-sun-dried and steeped-sun-dried samples had 720.00BU and 722.00BU respectively. Some of the values fall within the range for sweet potato starches (455 to 655 BU) as reported by Walter, Jr. *et al* (2000). The raw sample showed a high peak viscosity development followed by a rapid granular break down, leading to a progressive decrease of viscosity at

92 °C, that is from 2000.00 BU to 760.00BU. The same trend was observed in blanched-oven-dried, steeped-sun-dried and steeped-sun-dried samples. Conversely, blanched-oven-dried sample showed a low peak viscosity and low granular breakdown, that is, from 771.00BU to 720.00BU. This pasting properties is somewhat similar to the behaviour of normal cereal starches with a low peak viscosity and low granular breakdown (Gunaratne*et al*., 2007).

Similarly, no significant difference ($p>0.05$) in the stability (Vm-Vr) between blanched-oven-dried and steeped-sun-dried flour sample.

However, significant difference ($p<0.05$) exists between the raw sample and other samples. Blanched-Sun-dried sample had the lowest Stability (51.00 BU) while the raw sample had the highest (1240.00BU). Blanched –oven dried had 881.00 BU, steeped-sun-dried and steeped-oven-dried had 777.50 BU and 448.00BU respectively. From the results in Table 1, there was a drastic reduction in stability from 1240.00BU to 51.00 BU, as a result of processing.Viscosity is an important functional property of foods that affects mouth-feel, the textural quality of fluidfoods such as beverages and batters, and the design of processing lines (Iwe, 2003). Fluid flow through pipes, pumps, spray, dryer, extruders and heat exchangers is a function of the viscosity of material being processed.

4.0 CONCLUSION

The study has shown that false yam flour has some pasting properties like viscosity and gelatinization. The values of these pasting properties: gelation temperature-set (40to84.85°C) Peak gelation temperature (58.50 to 93.8°C), peak viscosity (771.00 to 2000.00BU), set back viscosity (619.00 to 761.00°C) and stability (51.00 to 1240.00BU), have suggested the importance of the pasting properties of false yam flour when used in composite flours for bread –making.

It is therefore significant to note that false yam which has not been known as a food crop by the people has been observed from this study to be edible and has potential food uses/industrial application in the confectionery food system. However, processing generally reduces the peak viscosity and stability, while heat processing prolongs the temperature at which gels are formed.

Further studies on formulation of food products from false yam tuber or flour are hereby recommended.

REFERENCES

Asuzu, I. U and Abubakar, I. I (1995) The Effect of *Icacinatrichantha* tuber extract on the nervous system phototherapy Res. 28:21-25

Ciacco, C. F.and D' Appolonia, B. L. (1977) Characterization of Starches from various Tubers and their Use in Bread-Baking. Cereal Chem. 54:1096-1107

Etukudo, I. (2003) Ethnobotary: Conventional and Traditional Uses of Plants. Vol. I. The Verdict Press, Uyo, Nigeria. P. 665.

Ihekoronye, A. I. and Ngoddy, P. O. (1985) Integrated Food Science and Technology for the Tropics. Macmillan Education Ltd. P. 273-293.

Iwe, M. O. (2003) The Science and Technology of Soyabean. Rejoint Communication ServicesLtd Enugu, Nigeria P. 70-97,149

Kay, D. E (revised by Gooding, E. G. B.)1987) Crop and Product Digest No. 2 root crops. 2nd edn. London: Tropical Dert. and Research Inst. P. 91-93

National Research Council of the National Academic Press (NRCNAP) (2008) Lost Crops of Africa: Fruits, Vol. III Icacina
Http://www.books .nap.edu/open book. PhD. 23/07/2008.

Okaka, J. C. and Okaka, A. N. C. (200) Foods: Composition, Spoilage, Shelf Life extension. OCJANCO Academic Publishers, Independent Layout, Enugu.Nigeria. P. 57-58.

Oti, E. and Akobundu, E. N. T. (2007) Physical, Functional and Amylograph Pasting Properties of Cocoyam –Soyabean-Crayfish flour blends. Nig. Food J. 25 (I) 161-170.

Rasper, V. and Coursey, D. G (1967) Properties of Starches of some West African Yams. J. Sci. Food Agric 18:240-244

Walter, W. M. Jr. Troung, V. D., Wiesen Born, D. P. and Carvajal, P. (2003) Rheological and Chemical Properties of starches from moist and Dry-type Sweet Potato J. Agric.

Table 1: Brabender Amloygragh Pasting Properties of Raw and Processed False Yam Tuber Flour

Sample	Gelation Temp (°C) (Set)	Gelation Temp (°C) (Peak)	Peak Viscosity (Vm BU	Viscosity at 92°C after 15 minutes (set back) (Vr) BU	Stability (Vm-Vr) BU
RAW	73.10^{b}	84.20^{a}	2000.00^{a}	760.00 ^{a}	1240.00 ^{a}
Blanched –Oven-dried Flour sample	40.00^{d}	58.50^{b}	1500.00 ^{b}	619.00 ^{a}	881.00^{ab}
Blanched –Sun-dried Flour sample	52.50^{c}	83.60^{a}	771.00 ^{a}	720.00 ^{a}	51.00 ^{c}
Steeped-Sun-dried flour sample	74.40^{b}	88.70^{a}	1500.00 ^{b}	722.00 ^{a}	777.50^{ab}
Steeped-Oven-dried flour sample	84.85^{a}	93.85^{a}	1209.00^{bc}	761.00 ^{a}	448.00^{bc}
Least Significant difference	2.63	12.05	475.52	201.97	673.13

Means with similar superscripts in the same column are not significantly different ($p>0.05$) from each other.

DEVELOPMENT OF AN IMPROVED MULTIPURPOSE COWPEA DEHULLER: A VALUE CHAIN ADDITION IN FOOD PROCESSING AND SECURITY.

Aniyi, O. S.
Department of Agricultural and Biosystems Engineering, College of Science and Engineering, Landmark University, Omu – Aran.
E-mail:- aniyi4real@gmail.com; aniyilanre@yahoo.com. Tel:- 08033920266.

ABSTRACT
Cowpea seed is a popular food resource in several parts of West Africa. It is presently being dehulled manually in the absence of a suitable mechanized device, the need to develop a suitable process flow system, which will be a value chain addition in food processing, for cowpea seed. The machine was developed in order to remove the drudgery involved in dehulling the seeds. The machine consist of a screw auger which rob the seed against the stationary housing and transport the material into the separating bucket, where the agitator separate the seed from the hull by suspending and washing off the hull, in a continually flow water. The developed Machine was fabricated and tested.

Keyword:- Cowpea, Cowpea Seed, Machine, Dehull, Screw Auger.

1.0 INTRODUCTION

Cowpea, known botanically as *Vigna Unguicalata* is an ancient plant widely spread in tropical and sub-tropical Africa. It is a leguminous plant containing about 22% protein and is an important food item in West Africa because of its portentous content. Cowpea is a drought tolerant crop that has the unique ability to fix nitrogen even in very poor soils. It is also shade-tolerant (i.e covered crop) and therefore compatible as an intercrop with many cereals and root crops. Subsistence farmers in sub- Saharan Africa usually intercrop their cowpea with maize, sorghum, millet and cassava. The largest areas under cultivation are in central and West Africa.

There are different varieties of cowpea with different in size, shape and colour. The seed colour may be white, brown or black and the common ones in Nigeria include; Black eyed, Brown beans, Chary beans, Asparagus e.t.c. It can be consumed in various forms especially for ruminant animals and human being. In fresh from, the young leaves, immature pods and peas are used as vegetables, while several snack and main meal dishes are prepared from the grain. It can also be processed into different forms such as boiled bean cake (Moin-Moin), fried Beans cake (Akara), Beans soup e.t.c.

All parts of the plant that are used for food are nutritious; providing protein, vitamins (notably vitamin B) and minerals. The benefits of eating cowpea were well known by researchers. The researcher described it variously as giving protein, giving blood, body building, giving strength and being an adequate substitute for meat. It is also a covered crop (anti-erosion crop) that helps in replenishing soil nutrient and is also a good green manure crop which aid in soil improvement, therefore is a great value to farmers. Modern technology has made the processing of different food crops easier, faster and saving a lot of labour as well. The developed dehulling machine can be powered by electric motor or a diesel or petrol engine, and this made it easy in the industry where cowpea is used for flour production. Hull in botany is the outer shell or coating of a seed. Dehulling is the process of removing the hull or chaff from the beans and other seeds.

Dehulling of the beans significantly improved the nutritional value. Removal of

the hulls decreased the condensed tannin content from 0.57 to 0.06% and the crude fiber content from 8.0 to 1.3%. Furthermore, dehulling increased the crude protein content from 29.2 to 33.2% and the N-free extract content from 56.7 to 59.4%. As a result the in vitro digestibility of crude protein for pigs increased from 92 to 96% and of organic matter from 86 to 99%.

A dehuller is a machine that removes the hull (Seed coats) from wet or dry beans, and often splits the beans into two colyledons in the process. A separator is a device, which was incorporated to separate the unwanted hulls from the cotyledons. The developed Machine performs both the bean dehulling and separation of hulls from the cotyledon simultaneously. This Machine, due to its dual operational performance, is a must for households and all beans cake/moin-min vendors. Hence it constitutes a value chain addition in food processing and security.

The objective of the work is to develop an improved multipurpose motorized cowpea dehulling Machine and carry out its performance evaluation.

2.0 MATERIAL AND METHOD

2.1 Design Concept

Improved multipurpose cowpea dehuller is used for dehulling cowpea in the production of various foods in food processing industry. It is designed to increase food production efficiency through the gentle dehulling of cowpea seed. After the fabrication, an experiment was design to determine the dehulling efficiency, cleaning efficiency, overall efficiency and machine capacity using variety of available beans (i.e black eyed beans and brown beans). Common available local variety of cowpea bought from market was used. 2.0kg of cowpea seeds was weighed for testing. The cowpea was soaked and drained before dehulling, the weight of the undehulled grains was measured, the cleaned grains and the suspended hulls were also measured.

2.2 Design Consideration

The design of this machine has taken the following major factors into consideration such as Material Selection and Stability.

2.2.1 Material selection

The selection of material for this project, as reflected in Table 2.0, placed more emphasis on the following criteria:-

Cost: The selected materials were those of low price as this will eventually determine the cost at which the machine could be sold and affordable by the small scale enterprise.
Durability: - The selected materials would give an assurance to withstand any wear and tear.

Size and weight: The materials choose were lighter in weight and not too large so as to ease the transportation of the machine from one place to another.

Appearance: The materials selected possess a good finishing touch as this will beautify the machine to the extent of being attractive to people.

Availability: The material used was locally and readily available so that if there is any cause to change any part, much time will not be wasted.

2.2.2 Stability of the machine

Stability is the ability of the machine to operate in the required range of duty

without vibration. To ensure this function, the materials selected were rigid enough to withstand any vibration. An experiment on auger conveyor (Aniyi, 2004), reported the following as factors affecting the through put of auger conveyor.

1. Speed:- The peak of through put is attained when the speed is in the region of 100 rev./min. commercial augers in common use, run at speed range between 1000-1200 revolution per minute for a 3 inch diameter (76.2mm approximately) auger and 600-750 revolution per minute for a 6 inch diameter (approximately 152.4mm) auger.
2. Pitch: - Most commercial augers have a value of pitch divided by diameter which is approximately equal to 1. For high capacity conveying of free flowing materials (e.g dry grain), Value of pitch divided by diameter which is approximately equal to 1.5 are also recommended.
3. Moisture Content: - The result shows that while an increase in moisture content up to a value of 20% has a negligible effect on through put, any increase above 20% is likely to have a marked effect on the auger tested.
4. Clearance: - The test indicates that a clearance of any size of auger will reduce the through put, although with one of 0.2inch (5.08mm).

2.3 Description of the Machine Components

The major components of the improved multipurpose cowpea dehuller are the hopper, dehulling unit and the separating unit (see Fig. 2.0, [a & b]). The machine is powered by a 1 horsepower single phase electric motor. The hopper is shaped as frustum of a cone with the walls sloping at 39^0 angles which is beneath the hopper consists of a rotating screw auger mounted on a shaft driven by the electric motor through a V-belt and pulley drive.

A clearance of 5mm is maintained between the rotating screw auger and the stationary plate. The shaft incorporates an auger towards the dehulling zone to aid in transporting the cowpea seed from the hopper to the dehulling zone. At the end of the rotating shaft a bevel gear teeth is connected with a spike shaft into the separating bucket. The separating unit consist of a bucket (Plastic) filled with water and agitated by a spike shaft to prevent the settlement of the dehulled seed and the hulls.

2.4 Design Calculations

In designing the improved multipurpose cowpea dehulling machine, the calculations involve are expressed below:-

2.4.1 Screw Auger Design

In designing a screw conveyor for a specific purpose, many questions must be answered in order to achieve optimal performance:

The following factors are to be considered,

- ⇨ The material being conveyed.
- ⇨ Density of the materials
- ⇨ The desired volume speed
- ⇨ Distance that need to be conveyed.
- ⇨ Abrasiveness, Corrosiveness or Viscosity of the materials to be conveyed.

The screw conveyor was then designed with the appropriate metal, diameter, pitch, length and trough and motor requirement.

Parameters needed are:-

Auger major diameter (d_A)	=	75mm
Auger minor diameter (d_a)	=	55mm
Density of cowpea (ρ_c)	=	1180kg/m^3
Length of Auger (L_A)	=	500mm

Screw pitch P_S = 40mm
Diameter of motor pulley (DP_1) = 60mm
Diameter of Auger pulley (DP_2) = 210mm.
Revolution per minute of electric motor pulley (Nm) = 1000rpm

(i) Revolution per minute of Auger pulley (Ni)

$$= \frac{Nm \times DP_1}{DP_2}$$

$$= \frac{1000 \times 60}{210}$$

$$= 285.7\text{rpm}$$

(ii) Angular velocity (ω) $= \frac{2\pi N_1}{60}$

$$= \frac{2 \times 3.142 \times 285.7}{60}$$

$$= 29.92\text{rads}^{-1}$$

(iii) Velocity (V) $= \frac{\omega Ps}{2\pi}$

$$= \frac{29.92 \times 0.04}{2 \times 3.142}$$

$$= 0.1905\text{m/s}$$

(iv) Auger capacity (C_A) $= \frac{\pi}{4}(d_A^2 - d_a^2)(V \times \rho c)$

$$= \frac{3.142}{4}(0.075^2 - 0.055^2)(0.1905 \times 1180)$$

$$= 0.7855 \times 0.0026 \times 224.79$$

$$= 0.4591\text{kg/s}$$

(v) Machine Capacity (C_m) $= \frac{\pi}{4}(d_A^2 - d_a^2)(\rho c \times L_A)$

$$= \frac{3.142}{4}(0.075^2 - 0.055^2)(1180 \times 0.5)$$

$$= 0.7855 \times 0.0026 \times 590$$

$$= 1.204957\text{kg}$$

(vi) Volume of Auger (Au) $= \frac{\pi}{4}(d_A^2 - d_a^2) LA$

$$= \frac{3.142}{4}(0.075^2 - 0.055^2) 0.5$$

$$= 0.7855 \times 0.0026 \times 0.5$$

$$= 0.00102\text{m}^3$$

Power required conveying material (Cowpea) horizontally (P_R),

P_R = Weight of material X Velocity

Weight of Material (W_M) $= \frac{\pi}{4}(d_A^2 - d_a^2) \rho c \times LA$

$$= \frac{3.142}{4}(0.075^2 - 0.055^2) \times 1180 \times 0.5$$

$$= 0.7855 \times 0.0026 \times 1180 \times 0.5$$

$$= 1.204957\text{kg}$$

$$= 12.05\text{N}$$

$P_R = W_M \times V$

= 12.05 x 0.1905
= 2.3Nm/s
= 0.918 watts. (Hall e tal 1980).

Screw depth (L) = 10mm

Main auger diameter (d_m) = $d_A - L/2$
= 75 – 10/2
= 70mm

Tan = $\frac{L}{\Pi d_m}$ = $\frac{0}{3.142 \times 70}$

Tan = $\frac{10}{219.94}$

Tan = 0.04547
= $\tan^{-1}$ 0.04547
= 2.6^0 = 3^0

Co-efficient of friction = 0.20

Tan = = 0.20
= $\tan^{-1}$ 0.20
= 14.04^0

Power required for compression: (P_c)

P_c = tan (+)

$e\tau$ = Machine Capacity (C_m) x gravitational Pull
= 1.205 x 9.81
= 11.82N.

P_c = 11.82 tan (2.6 + 14.04)
= 11.82 tan 16.64
= 3.5327 watts
= 3.53watts.

Total power requirement of Auger (P_A).

= $P_R + P_C$
= 0.918 + 3.53
= 4.448 watts.

2.4.2 Shaft design

A shaft is the component of a mechanical device that transits rotational motion and power. It is integral to any mechanical system in which power is transmitted from a prime mover such as electric motor or an engine to other rotating parts of the system.

Procedure for design and analysis of a shaft:

v Determine the rotational speed of the shaft n (rpm).

v Select the material from which the shaft will be made and specify ultimate tensile strength Su, yield strength by and its surface condition.

From the equation above, that power required by the screw conveyor, one horsepower single phase motor was therefore selected. The diameter of the shaft was determined by using the maximum stress theory by Hall el at (1980).

The value obtained for diameter was 21.5mm; therefore a 25mm shaft was selected.

2.4.3 Agitator design

From the equation above, the revolution per minutes of shaft is 285.7rpm, converting the horizontal motion into vertical motion via bevel gear with a ratio of 2:3.

Therefore, 285.7rpm of ratio 2:3 is selected for the speed of the agitator.

N_3 = 2/3 x 285.7

$= 190.05\text{rpm.}$

$$\text{Speed, } S = \frac{2\pi N_3}{60}$$

$$= \frac{2 \text{ X } 3.142 \text{ X } 190.05}{60}$$

$= 19.9 \text{ rad/sec}$

Total combine width of the paddles divided by diameter of the bucket. (R)
Total paddle length = 225mm
Bucket diameter = 300mm

$$R = \frac{225}{300}$$

$= 0.75\text{mm}$

Speed of the agitator = $3.26 \text{ X } 10^{-11} R^{0.585} S^{3.41}$ ……..by (Aniyi, 2004)
$= 3.26 \text{ X } 10^{-11} \text{ X } 0.845105326 \text{ X } 26{,}858.94751$
$= 7.4 \text{ X } 10^{-7} \text{ kW}$
= 0.00074 watts

2.4.4 Hopper design This is designed in such form to accommodate large quality of the material. It is designed in form of frustum of a cone which aids the ease flow of the feed material into the machine

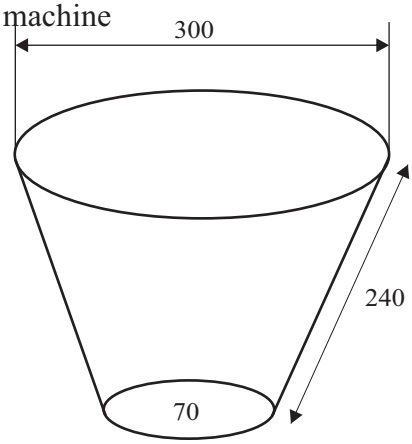


Fig. 2.4.4: Hopper Design.

Volume of frustum of a cone

$$V = 0.2618h \times D^2 + D \times d + d^2$$

where D, is larger end diameter = 300mm
d, is smaller end diameter = 70mm
h, is height of the frustum = 240mm

$$V = 0.2618 \text{ x } 0.24 \times 0.3^2 + 0.3 \text{ x } 0.07 + 0.07^2$$

$0.062832 \times 0.09 + 0.021 + 0.0049$

$= 0.0315549\text{m}^3$

2.4.5 Dehulling housing design

This is designed by making close fitness with the auger conveyor with little clearance of 5mm at each side of the conveyor. This will surely allow the rotation of the auger and assist it in moving the material horizontally

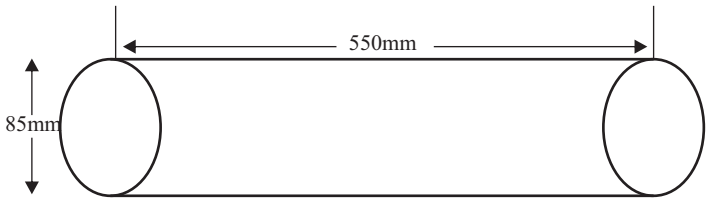


Fig. 2.4.5: Dehulling housing design

Volume of the cylinder (V) = $\pi r^2 h$.

= $3.142\,(0.0425)^2 \times 0.55$

V = $0.00312 m^3$

2.4.6 Belt design

There is a need to select a belt that will suitably transmit the rotation as required under a reasonable speed tension without failure. Also the belt must possess a surface area that will fix into the pulley groove. However, the following expressions are taken.

The minimum distance between the centers of the pulley ©:

$C = \frac{1}{2}(DP_I + DP_2) + DP_1$

$= \frac{1}{2}(60 + 210) + 60$

$= \frac{1}{2}(270) + 60$

= 195mm.

Length of belt (L) $= \frac{2C}{2} + \pi(DP_1 + PD_2) + \frac{(DP_2 - DP_1)^2}{4C}$

$= \frac{2(195)}{2} + 3.142(60 + 210) + \frac{(210 - 60)^2}{4(195)}$

$= 195 + 848.34 + 28.85$

= 1072.186mm. Or 1.072m.

Velocity of belt (V_b) = $\pi DP_2 \times N_1$

$= 3.142 \times 0.210 \times 285.7$

= 188.5m/min

= 3.142m/s.

3.0 RESULT AND DISCUSSION

The performance was evaluated based on the following:

(i) Dehulling efficiency (%) = $\frac{M-C \times 100}{M}$

Where M = mass of cowpea seeds feed into the machine (kg)

C = mass of undehulled cowpea seeds (kg)

Cleaning efficiency (%) = $\frac{Mc \times 100}{Mt}$

Where Mc = mass of clean dehulled grains (kg)

Mt = total mass of dehulled grains (kg)

(ii) Overall efficiency = $\frac{\text{Dehulling efficiency} + \text{Cleaning efficiency}}{2}$

(iii) Machine capacity = $\frac{\text{Weight of dehulling seeds (kg)}}{\text{Time taken (hr)}}$

3.2.1 Estimation of dehulling efficiency

(a) Dehulling efficiency of the machine for black eyed beans.

M = 1000g C = 180g

$D_e = \frac{M - C \times 100}{M}$

$= \frac{1000 - 180 \times 100}{1000}$

= 82%

(b) Dehulling efficiency of the machine for brown beans.

M = 1000g C = 250g

$$D_e = \frac{M - C}{M} \times 100$$

$$= \frac{1000 - 250}{1000} \times 100$$

= 75%.

3.2.2 Estimation of cleaning efficiency

(a) Cleaning efficiency of the machine for black eyed beans

Mc = 720g Mt = 1000g

$$Ce = \frac{Mc}{Mt} \times 100$$

$$= \frac{720 \times 100}{1000} = 72\%$$

(b) Cleaning efficiency of the machine for brown beans

Mc = 680g Mt = 1000g

$$Ce = \frac{Mc}{Mt} \times 100$$

$$= \frac{680 \times 100}{1000}$$

= 68%

3.2.3 Estimation of Overall efficiency

$$\text{Overall efficiency} = \frac{\text{Dehulling efficiency} + \text{Cleaning efficiency}}{2}$$

(a) Overall efficiency for black eyed bean

$$= \frac{82\% + 72\%}{2}$$

= 77%

(b) Overall efficiency for brown bean

$$= \frac{75\% + 68\%}{2}$$

= 71.5%

3.2.4 Estimation of the machine capacity

$$\text{Machine Capacity} = \frac{Wt}{T}$$

Where Wt = Weight of dehulled seeds (kg)

T = Time taken (hr)

Wt = 2.0kg

T = 1min 45 secs (0.03hr)

$$= \frac{2.0\,kg}{0.033hr}$$

= 60.61 kg/hr.

In the evaluating performance of the machine. The evaluating parameters are dehulling efficiency, Cleaning efficiency, overall efficiency and Machine Capacity. These parameters were estimated using the evaluation results in the table 3.0

3.4 DISCUSSION

After the performance evaluation of the machine, as shown in Fig. 3, result obtained shows that the dehulling efficiency was observed to be 82% for black eyed beans and 75% for brown beans. The machine has cleaning efficiency of 72% for black eyed beans and 68% for brown beans. The overall efficiency of the black eyed and brown beans are 77% and 71.5% respectively the capacity of the machine was estimated to be about 60.61kg/hr at speed of 285.7 revolution per minutes.

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

An improved multipurpose cowpea dehulling machine was designed fabricated and had satisfactory performance because of its capacity and effective efficiencies in the area of dehulling and cleaning. The dehulling efficiency was observed to be 82% for black eyed beans and 75% for brown beans. The machine; has cleaning efficiency of 72%; for black eyed beans and 68% for brown beans. The overall efficiency of the black eyed and brown beans are 77% and 71.5% respectively the capacity of the machine was estimated to be about 60.1kg/hr. However the machine can be used by both small scale and large scale vendor because the machine can be operated with either electric motor or petrol engine and the local materials are used to construct the machine therefore the machine can be repaired and manufactured with local materials.

4.2 Recommendation

The dehulling unit of the machine must be constructed with non-corrosive materials such as stainless steel and the separating unit bucket seat must be adjustable for easy bucket remover.

REFERENCES

Aniyi. O. S. (2004). Performance evaluation of a manually operated decoating machine for cooked locust bean seed: Journal of Agricultural Engineering and Technology (JAET). 12, 26 – 32.

Hall et al. (1980). Theory and problem of machine design S.I metric edition. Mc Graw Hill book company Singapore page 255 -276

Mohsenin N.N (1979). Physical properties of plant and animals materials. Gordan and Breach Science Publishers, New York. Page 278.

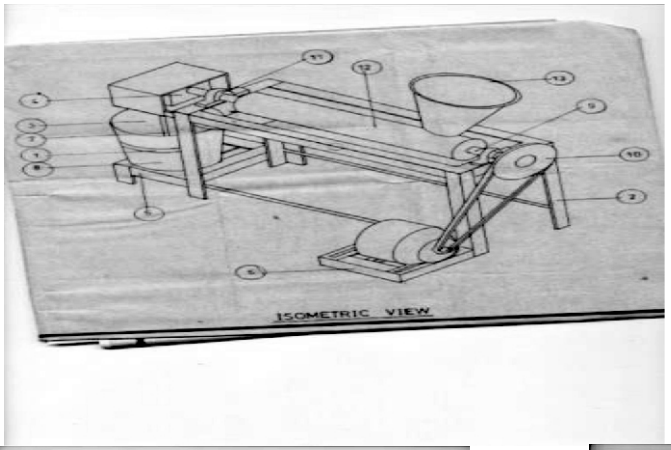
Reighert et al. (1979). Village scale mechanical dehulling of cowpea, cereal chemistry 56(3). Page 181-184.

Table 2.0: Bill Of Engineering Measurement And Evaluation

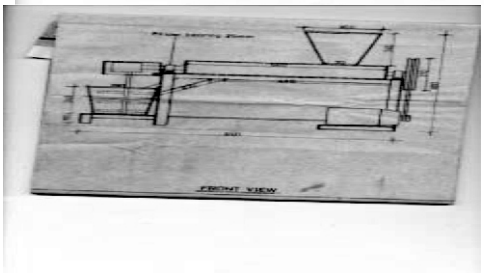
S/N	MATERIALS	SPECIFICATION	QUANTITY	AMOUNT (₦)
1	Angle Iron	40X40mm	2Full length	3,200
2	Metal Sheet	2mm thickness	1/4	750
3	Shaft	25mm diameter	800mm length	6000
4	Mild steel rods	16mm	1/2full length	1300
5	Pillow bearing	25mm	2	3000
6	Ball bearing	16mm	1	400
7	Pulley	210	1	800
8	Bolts and Nuts.	M, 17,13,7		600
9	Mild steel rod	10mm	1 full length	1,200
10	Belts	A62	1	600
11	Body filler		Small quantity	500
12	Sand paper	Coarse and smooth	1/2	200
13	Thinner		2Thin	400
14	Paint	Green	1thin	2000
15	Electrodes			1500
16	Hollow pipe	15mm	300mm	200
17	Workmanship			7000
18	Transpiration			1500
19	Bevel gear	2;3		1000
20	Plastic bucket	Transport		500
21	Galvanized hollow pipe	85 diameter		1500
			TOTAL	₦30,000.00

ÇĂĽ’▄ ى¢□t š’ŋźơ’▒Ă■l’š 9 ōĂ▄ĂĆ■ wś£ĵ ▄□

/ ◘Ŏ♫šĂ Variety	Quantity(Kg)	Dehulled grains (Kg)	Undehulled grains (Kg)	Clean grains (Kg)	Hulls (Kg)
Black eyed	1.0	0.82	0.18	0.72	0.18
Replicate	1.0	0.80	0.20	0.71	0.20
Brown	1.0	0.75	0.25	0.68	0.25
Replicate	1.0	0.77	0.23	0.70	0.23



S/No	COMPONENT
13	HOPPER
12	DEHULLING HOUSING
11	PILLOW BEARING
10	PULLEY
9	SHAFT
8	SEPARATING BUCKET
7	AGITATOR
6	MOTOR SEAT
5	BUCKET SEAT
4	BEVEL GEAR HOUSING
3	OUTLET
2	FRAME
1	BRACKET



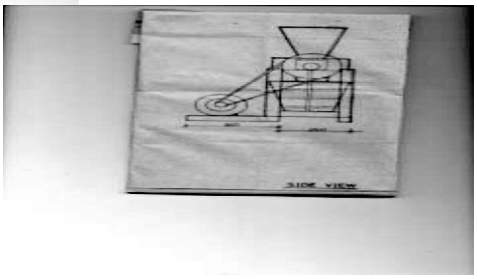


Fig. 2.0(a): The Isometric View of the Machine.



Fig. 3.1: Pictorial View of the Machine at the Construction Stage

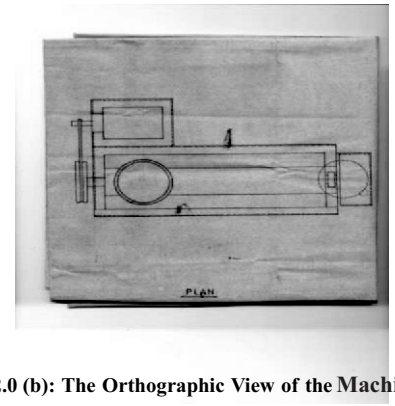


Fig. 2.0 (b): The Orthographic View of the Machine



Fig. 3.2:- Pictorial View of the Machine at the Finished Stage.



Fig. 3.3: Pictorial View of the Machine at the Testing Stage.

PROXIMATE ANALYSIS OF TOMATO (*Syria variety*) UNDER COMMON PREPARATIONS

Oiganji Ezekiel [*], Emefiene Mercy*, A.H Makama[*], A.A Stanley*
[*]Forestry Research Institute of Nigeria. Federal College of Forestry, Jos. PMB 2019
Crop Production Technology Department
****Dept of Agricultural Engineering, Ahmadu Bello University, Zaria
Corresponding Author Email: ezeganji@gmail.com, +2348061279887

ABSTRACT
The present study was conducted to evaluate proximate analysis of Tomato (Syria variety) which was subjected to common preparation methods: boiling, frying with raw paste as control. The result **showed** significant variation in the preparations for crude protein, crude fat, Ash, and NFE; while for moisture content, Calcium, and phosphorus there was no significant difference on proximate compositions with respect to the three method of preparation. However, For crude protein, raw tomato had a significantly low effect with *10.08%*, while fried tomato showed a very high significant effect on crude fat with *20.52%.* For ash content for raw, boiled and fried were 3.*22%, 4.48%* and *6.33%* respectively, while fried tomato gave a low value of *20.32%* of NFE. It can be inferred that crude protein, crude fat, ash content and nitrogen free extra (NFE) can vary depending on the method of preparation used.

Keywords: Tomato, Proximate Analysis, Moisture Content, Processing

1.0 INTRODUCTION
Tomato (*Lycopersicon esculentum Mill)* is one of the most important fruits staple recognize all over the world and Syria variety is commonly consumed in Nigeria (Alao, 2000). it is one of the most important vegetable in most regions of the world and the constituent are important source of food and cash in Nigeria (Olaniyi *et al.,* 2010); production is seasonal resulting in a glut during the season and scarcity at off season (Chukwu *et al*., 2008). Due to their soft texture, they are easily bruised or wounded as a result of harvesting and other post harvest handling operation such as packaging, transportation and storage. (Chukwu *et al,* 2008). The fruit are eaten raw, cooked and fried, large quantities of tomato are used to cook soup, juice, sauce and powder in some ingredient (Aditi *et al*.,2011). The seed contains 24% oil and this is extracted from the pulp and residues of the canning industry. This semi-drying oil is used as a salad oil and in manufacture of margarine and soap. The residual press cake is used for livestock feed and fertilizer. (Chukwu *et al,* 2008) . They are an excellent source of vitamin A, vitamin K, vitamin C and vitamin E as well as potassium, protein dietary, fiber and iron. The medicinal parts are the fresh leaves, the fresh herbs collected during the flowering season or the whole plant. (Potischman *et al*, 2002). The higher concentration of tomato preparations, lower the effectiveness of tomatoes Some preservatives added to tomato are unhealthy to human diet. (Potischman *et al*, 2002).Tomato nutritional elements are denatured during processing period due to the preservatives added in the tomato or the method of processing used and this affects the nutritional composition of some certain elements of tomato. This study was focused on proximate analysis and nutritional composition of tomato under cooked and fried preparations.

2.0 MATERIALS AND METHODS

2.1 Materials

Tomato *Syria variety* was obtained from a local market on the same day of preparation. Nine (9) containers, blender for grinding the tomato samples, weighing balance, Stove and oil were made available as well.

2.2 Frying Process

The frying process was done as follows: The tomato samples were grinded into liquid form, samples were weighed 250grams, and 100 grams of Oil was poured into an empty container and was heated for 2 minutes. The tomatoes were poured into the hot oil and the samples were fried for 15minutes each according to the traditional method usually employed by Nigerians.

2.3 Boiling Process

The boiling process was done as follows: The tomato samples were grinded into liquid form. The samples were weighed 250grams .The pot was placed on the stove (heat source).The three (3) samples were cooked for 20 minutes respectively.

2.4 Proximate Analysis

Samples (100 grams) were taken to the Biochemistry Division of National Veterinary Research Institute, Vom- Plateau State for analysis. The moisture content, crude protein content, crude fat , Ash content, phosphorus, Nitrogen free extract, calcium and crude fiber were determined according to AOAC (1995).

2.5 Statistical Analysis

The analysis of variance was performed to examine the significant effect in all measured parameter. Means were tested by analysis of variance (ANOVA) (Mead *et al*., 1983).

3.0 RESULT AND DISCUSSION

3.1 Moisture Content

The moisture content of tomato contains excellent source of vitamin A, vitamin C, vitamin E and vitamin K as well as potassium (Charles *et al*, 2001). Moisture content of the raw tomato was higher when compared to the cooked and fried. From Table 1, it shows that the level of moisture in raw tomato is higher at 45.39% compare to the cooked and fried tomato which were 36.17% and 28.61%; there is no significant difference in the processing, however the values are not the same but they are on the same range statistically.

3.2 Crude Protein

The level of protein is higher in fried preparation of tomato compare to cooked and raw preparation which is in agreement with what Talburt and Smith (1959) reported that frying causes significant increase in protein. Kala and Prakash (2001) also reported that boiling decreases the protein content of vegetables. The fried tomato contain crude protein at 19.17%, followed by the cooked tomato which was at 15.83% and the raw tomato which was lower at 10.17%. Based on the result from table 1 , it showed that there is a significant difference of crude protein content in the three processing methods. The crude protein in the tomato helps in the growth and development of the body. It helps in building up the tissues of human body(Charles *et al*, 2001).

3.3 Crude Fiber

The level of crude fiber is higher in fried preparation compare to cooked and raw preparation. In fried tomato, it is at 5.09%, follow by the cooked tomato is at 4.57% and the raw tomato is at 3.11% which was in agreement with what Varo *et al*., (1984) reported that boiling increases slightly the fiber content of vegetables, in contrast FAO(1995) reported that both boiling and frying reduces the fibre content of potato . Based on the result from the Table 1, for the three preparations, there is no significant difference in the processing. However the values are not the same but they are on the same range statistically. For Crude fibre, fried tomato is recommended for growing people and young babies for their growth(Charles *et al*, 2001).

3.4 Crude Fat

The level of crude fat is higher in fried preparation compare to cooked and raw preparation, in the fried tomato, crude fat is at 20.52%, while in the cooked tomato, it is at 1.09% and the raw tomato, it is at 0.55%; these findings are consistent with those reported by Talburt and Smith (1959), surprisingly Kala and Prakas (2001) found that fat content showed a slight increase after boiling. Based on the result from Table1, it shows that there is a significant difference in the three processing methods which is the raw, cooked and fried tomato.

3.5 Ash

Ash no effect in the diet of human being, nevertheless it is more concentrated in the fried tomato which was consistent with what Kala and Prakash(2001) reported that ash content decreased insignificantly by boiling, however frying causes significant increase in ash Content. Table 1 shows that the level of ash is higher in fried preparation compare to cooked and raw preparation, in the fried tomato, it is at 6.33%, while the cooked tomato, it is at 4.48% and the raw tomato, it is at 3.22%. Based on the result it can be inferred that there is significant difference in the three preparation methods.

3.6 Nitrogen Free Extracts (NFE)

This is a free extracts which is used to complete any proximate analysis of air in the tomato samples (Charles *et al*, 2001). It has no effect in human diet. But it is more concentrated in the raw and cooked tomato compare to the fried tomato. From the fig 6, it shows that the levels of NFE in raw is 37.65 and cooked tomato is higher with 37.86%, compare to the fried tomato processing. While the fried tomato is lower in NFE content at 20.32%. Based on the result from table 1, it shows that there is a significant difference in the three processing methods which is the raw, cooked and fried tomato.

3.7 Calcium and Phosphorus

Calcium in tomato helps in the development of healthy hair, skin and teeth (Charles *et al*, 2001). The level of calcium is higher in cooked and fried tomato than in raw tomato in this study which was also reported by FAO (1995) that frying and boiling generally reduces the mineral content of vegetables. Table 1 reveals that the levels of calcium in cooked and fried tomatoes are 0.30% and 0.31%. While the raw tomato is lower in calcium content at 0.21%. Based on the result from Table 1, there is no significant difference in calcium in the preparation methods considered. However, the values are not the same but they are on the same range statistically.

Phosphorus is a yellowish waxy element in the tomato which is also a source of energy (Charles *et al*, 2001). It is recommended to consume fried tomato followed by cooked tomato because to the level of phosphorus is higher compare raw tomato for the provision of energy. From fig. 8, it shows the level of phosphorus is higher in fried preparation compare to cooked and raw preparation, in the fried tomato, it is at 0.10%, follow by

cooked tomato is at 0.07% and the raw tomato is at 0.02%. Based on the result from Table

Table 1: Variation in Nutritional Composition

Preparations	MC	CP	CF	C Fat	ASH	NFE	Ca	Ph
Raw Tomato	45.39[a]	10.08[b]	3.11[a]	0.55[b]	3.22[c]	37.65[a]	0.21[a]	0.02[b]
Cooked Tomato	36.17[a]	15.83[a]	4.57[a]	1.09[b]	4.48[b]	37.86[a]	0.30[a]	0.07[ab]
Fried Tomato	28.61[a]	19.17[a]	5.09[a]	20.52[a]	6.33[a]	20.32[b]	0.31[a]	0.10[a]
SE	5.46	1.36	0.71	0.82	0.15	1.97	0.04	0.02
LSD	0.174	0.009	0.207	0.000	0.000	0.001	0.268	0.068
Remark	NS	S	NS	S	S	S	NS	NS

S= Significant variation at 5%; NS=Not Significant variation at 5%

1, for the three preparations, there is no significant difference in the processing. However the values are not the same but they are on the same range statistically.

4.0 CONCLUSION

Crude protein, Crude fat, Ash, and NFE from Table 1 showed significant variation at 5% while other proximate compositions have no significant differences. This implies that the method of preparation have significant effect on the proximate compositions of Tomato. For crude protein, raw tomato had a significantly low effect, while fried tomato showed a very high significant effect on crude fat. For ash content, all the three treatments are significantly different, while fried tomato gave a low significant effect on NFE. The raw tomato has the highest moisture content compared to the cooked and fried processing which it has a significant variation. The fried and cooked tomato has more calcium content compare to the raw tomato. The result showed significant variation in the preparations for crude protein, crude fat, Ash, and NFE; while for moisture content, in Calcium and Phosphorus, there was no significant difference on proximate compositions with respect to the methods of preparation. Further should be done on *carotene* and *lycopene* content in tomato under different preparations. Carotene and Lycopene are of great importance to human health; they are anti-oxidant for the treatment of cancer and protect the skin UV rays effect.

REFERENCE

Aditi Gupta, A. Kawatra, S. Sehgal (2011). Physical- Chemical Properties and Nutritional Evaluation of Newly Developed Tomato Genotypes. African Journal of Food Science and Technology.ISSN:2141-5455. Vol.2(7)Pp.167-172

Alao, S.E.L (2000). Nigerian Stored Product Research Institute, 2000 kana Pp.1-12.

A.O.A.C (1995).Official Method of Analysis of the Association of Official Analytical Chemists.Edn. 14th Washington, D.C Pp.125-139.

Charles Onugwo and Adeyola Kahinde (2001). Nutrition and Diet, New Edition. Page 32-39.

Chukwu E.C, D.N Ogbonna, B.A Onueghu and M.T. Adeleke (2008). Comparative Studies on the Fungi and Bio-Chemical characteristics of snake Gourd and Tomato in Rivers State,Nigeria. Journal of applied sciences, 8:168-172

INVESTIGATION OF EFFECT OF PRE-STORAGE THERMAL PROCESSING TEMPERATURE AND EXPOSURE TIME ON STORAGE STABILITY OF BLACK-EYED COWPEA (*Vigna unguiculata*)

***[1]Ohanwe, C.N., [2]Ogunlowo, A.S., [3]Agbetoye, L.A.S., and [4]Sule, S.**
[1,4]Department of Agric. & Bio-Environmental Engineering, Federal Polytechnic, Bauchi
[2,3]Department of Agric. & Environmental Engineering, Federal University Technology, Akure.

Written for Presentation at the NIAE International Conference, Uyo 2013
University of Uyo, Uyo, Nigeria, October 21-24, 2013

ABSTRACT
Thermostatically controlled cabinet dryer with temperature range of 0-200°C was used to investigate the effect of pre-storage thermal processing temperature and exposure time on storage stability of black-eyed cowpea (*Vigna unguiculata*). Five temperature levels namely: 40, 50, 60, 70 and 80°C were selected to accommodate every use of thermally processed cowpea. For each thermal processing temperature, a minimum of 2kg of the cowpea was subjected to such temperature and samples drawn at 30 minutes interval for 150 minutes, that is, 30, 60, 90, 120 and 150 minutes, respectively. Thermally processed samples were packaged and stored for six months and analysed for storage stability using levels of bruchid infestation and dry matter loss as test parameters. F-distribution test was carried out using Minitab software package for the analysis. Results showed that temperature effect was significant at both 5% and 1% levels with degrees of freedom of V_1:V_2 (5:89). Likewise, the exposure time interaction on the storage stability of the cowpea was significant at both 5% and 1% levels with DF of V_1:V_2 (4:89). The interaction of the temperature and time factors (T*t) on the storage stability at both 5% and 1% levels with DF of 20:89 also showed significant difference on the storage stability. The coefficient of determination that tended to 100% indicates the interaction of the pre-storage thermal processing temperature and the exposure time had a very strong effect on the storage stability of the cowpea.

Keywords: Thermal, Temperature, Time, Stability, Bruchid, Infestation, Storage, Dry-matter

1.0 INTRODUCTION
Cowpea, *Vigna unguiculata* (L) Walp is an important food legume and a versatile crop cultivated between 35°N to 30°S of the equator covering Asia and Oceania, the Middle East, Southern Europe, Africa, Southern U.S.A, and Central and Southern America (Singh *et al*, 1997).

1.1 Origin, Climatic Requirement and World Cowpea Production
Its origin is uncertain, it is believed that cowpea originated in Africa and became an integral part of traditional cropping systems throughout Africa, particularly in the semi-arid region of West Africa Savanna (Mortimore *et al*, 1997). Cowpea has the unique ability to fix nitrogen even in a poor soil (pH range 4.5 – 9.0, organic matter <0.2% and a sound content of >85%) (Singh *et al.*, 1997). The crop also tolerates shade and it is compatible as an intercrop with a number of cereals and root crops. Statistics showed that

cowpea is currently cultivated on at least 12.5 million hectares with annual production of over 3 million tones worldwide (Singh *et al*, 1997). Cowpea is widely distributed throughout the tropics, but Central and West Africa account for 64% of the area (with about 8 million hectares, followed by about 2.4 million hectares in Central and South America, 1.3 million hectares in Asia and 0.8 million hectares in East and South America). The important cowpea growing countries according to Singh *et al*, (1997) are Nigeria, Niger Republic, Mali and others, with Nigeria accounting for 70% of world production (Blade, 1997).

1.2 Importance of Cowpea

Cowpea provides an inexpensive source of protein for the urban and rural poor of West Africa. It is the most economically and nutritionally important indigenous African grain legume, grown by millions of resource-poor farmers (Dieudonne *et al*, 2010). It is a key cash crop in areas too dry to grow cotton or other export crops. Cowpea is rich in protein. Nielsen *et al*, (1997), stated that both leaves and seeds of cowpea (*Vigna unguiculata* (L) Walp) is grown primarily for feeds in the United States.

1.3 Challenges of Cowpea Preservation

Dieudonne *et al*, (2010) estimated that around 80% of the cowpea trade in the world is in West and Central Africa. In the late 1990s, official cowpea trade, accounted for over 300, 000 metric tons per year within the Nigerian Cowpea Grain-shed (Langyintuo et al, 2003 and Langyintuo *et al*, 2005). However, market and trade is severely hampered by storage insects, especially the cowpea weevil emanating from poor processing and inadequate thermal drying of the produce (Murdock *et al*, 1997). It has been stated that a conservative estimate of cowpea storage loss is 25%, while Caswell (1994), found that pods stored for 8 months had 50% of the grain damaged by bruchids, but when stored as grain, 82% of the grain had one or more bruchid holes since emergence holes represent insects that have developed and left seed. Wolfson *et al* (1990), Kitch *et al* (1997 and Taylor (1981), have identified cowpea beetle, otherwise called *Callosobruchus maculates* Walp erroneously known as "cowpea weevil" as the principal cowpea storage pest in sub-Saharan Africa. Messina (1984), observed that in low-resource farm, *C. maculates* infestations start in the field and continue in storage. Another important cowpea bruchid beetle is *C. subinnotatus* which also attack mature pod in the field along with *C. maculates* before harvest. Mould attack on improperly dried cowpea is another source of serious damage. Damage and weight loss in stored seeds is caused by larvae which develop within the grain consuming the seed (New Agriculturist, 2005). Other important bruchid pest of cowpea is *Bruchidus atrolineatus* which causes loss primarily around harvest time, and does not reproduce in storage (Gomez, 2003). Studies reported by Sukprakarn (2003) indicate that most of the storage loss in cowpea is caused by *Callosobruchus maculates.* Damage caused by this specie of beetle can be as high as 30 to 70 percent as reported in various publications. Despite this colossal cowpea post-harvest loss researches on cowpea storage pest control have not been at pace with researches on cowpea production especially in sub-Saharan Africa where farmers and traders could experience 100 percent loss.

1.4.0 Cowpea Preservation Techniques

Several methods have been adopted by various cowpea growing communities, among these methods drying is found to be the most common. Drying, if properly engineered could be used to reduce moisture contents of grain to safe moisture levels where most of the stored grain insects are unable to survive and reproduce. Study by Sukprakan (2003) revealed that grain storage pests do not survive and reproduce in grain whose moisture content is below 9% (wb) while grain moisture contents of 12 to 15% (wb) favour their development. If, by various means, it is possible to reduce and maintain the moisture below than favourable for reproduction then, we have in effect, controlled the insects. Other methods of post-harvest preservation of cowpea include:

1.4.1 Thermal control techniques

These involve the subjection of the produce to elevated temperatures or freeze temperatures with the main aim of disinfesting it from insect pests other than drying. Usually, insects die when exposed to either high or extreme low temperatures because of their limited physiological capacity to thermo-regulate. Cowpea bruchid eggs, larvae and pupae do not thermo-regulate and, being immobile, are unable to escape from extreme temperature environment. The insects are more critical in their response to high temperatures and most insects are killed by temperatures above 40^{o}C. Temperatures of 55 – 65^{o}C maintained for 10 to 12 hours are effective (Murdock and Shade, 1991, Sukprakarn, 2003, and Gomez, 2003). Gomez (2003) reported that one alternative to chemical pest control is the use of cold storage. In his report, he observed that exposure to -18^{o}C for 6 to 24 hours reduced *C. maculates* population by more than 99 percent. It should be noted here that low temperature control is costly and will demand stable source of power.

1.4.2 Hermetic control methods

These involve the exclusion of oxygen and promotion of carbon-dioxide production on a storage granary which in effect suppresses infestation in stored grain (James, 1993). This is in sealed containers which may be huge, elaborate underground silos, or simple metal drums, plastic sheets and plastic bags (Gomez, 2003).

1.4.3 Chemical control technique

The use of synthetic insecticides to protect grain in storage is probably more common and more controversial than their use on the field crop because chemical residues are either correctly or erroneously feared to persist in the bean after cooking. Due to this poison scare, the landscape of insecticide use has changed over the years from dependence on the highly toxic and or persistent insecticides like DDT, endosulfan and monocrotophos to era of great skepticism and reduced usage, typified by a shift towards less toxic and more environmentally friendly and narrow spectrum, target-specific technology e.g. phostoxin, detia, gastoxin coopex, actellic and k-othrin (Jackai and Adalla, 1997). This practice has reduced the effectiveness and led to the subsequent high failure rate of most chemicals. Moreover, economic necessity and sensitivity to environment have rendered synthetic insecticide use socially unacceptable. Afun *et al*, (1991), advocated for monitored rather than calendar-based insecticide application if synthetic insecticides must indeed be used. Dieudonne *et al*, (2010), reported the misuse

and abuse of the chemicals by illiterate and uninformed farmers and traders. Sukprakarn (2003) observed that resistance to pesticides is developing fast in storage pests. Another limitation of insecticides for control of cowpea storage pests is the continued importation of the band chemicals (e.g. DDT and lindane) by developing countries which has resulted to deaths (Mcfarlene *et al*, 1997). No matter how safe insecticides may be, nevertheless, transportation and handling of the concentrates are hazardous.

1.5.0 Justification and Objective

Due to controversy in the use of synthetic chemicals for control of storage pests especially in cowpea, researches are on-going on the alternative methods such as use of phyto-chemicals (plant extracts) and hermetic system. The use of plant chemical may be limited, because in plant, the quality and quantity of pure compounds produced may be dependent on factors like plant species and variety, climate, soil, maturity at harvest and storage condition before use. All these factors would influence the efficacy of a given extract against stored product pests, thus interfere with comparability and reproducibility of results. Adler (2003) raised a suspicion that botanicals toxic to potential pests may prove quite toxic to human as well. The main focus of this study was to determine the appropriate pre-storage thermal processing temperature and exposure period on storage stability of black-eyed cowpea (*Vigna unguiculata).* The use of thermal processing of cowpea would ensure large throughput and capable of replacing chemical method of cowpea preservation if well engineered.

2 METHODOLOGY

The black-eyed cowpea (*Vigna unguiculata)* used for this investigation was acquired at the point of decortications to ensure storage pesticide free samples. Prior to thermal treatment the initial moisture content of the cowpea was determined to be 7.2% (wb) by A.O.A.C (1984).

$$M_{wb} = \left(\frac{W_o - W_D}{W_o}\right)\frac{100}{1} \qquad \text{.....2.1}$$

Where:

M_{wb} = moisture content web-basis

W_o = initial mass of the material

W_D = mass of dry matter of the material

A sample of 200 seeds were randomly collected by repeated quartering and inspected for bruchid infestation prior to thermal treatment. The infestation determined from equation 2.2 formed the basis for the computation of the storage stability (SS).

$$bb\ (\%) = \frac{100N_{bho}}{200} = \frac{1}{2}N_{bhc} \qquad \text{..... 2.2}$$

Where:

bb (%) is the infestation basis.

N_{bho} is the number of beans with bruchid holes.

To verify the presence of bruchid eggs, larvae or imago in the acquired cowpea, a 1kg sample was tied in a new jute sac and kept in a natural environment (34^{o}C) to serve as control. The daytime mean temperature during the period of the

investigation was 34°C. Thermostatically controlled cabinet dryer with temperature range of 0° to 200°C was used for the investigation. Six temperature levels, namely 34° (control), 40°, 50°, 60°, 70° and 80°C were selected to accommodate every use of the thermally treated cowpea. For each temperature, a minimum of 2kg of the *Vigna unguiculata* was subjected to such temperature and samples drawn at 30 minutes interval for 150 minutes, that is, at 30, 60, 90, 120 and 150 minutes, respectively. The temperature levels of 40° – 80°C at 10°C interval was respectively designated T_2, T_3, T_4, T_5, T_6 with the control (34°C) symbolized as T_1, that is, no treatment. The detention time of 30 – 150 minutes at 30 minutes interval was similarly designated T_1, T_2, T_3, T_4, and T_5. The samples drawn were cooled to a room temperature under fan. The cooled samples were packaged in a washed dried 250g capacity jute sac and stored in a clean dried room with natural ventilation for a period of six months (November – May). Three replicates were packaged for each temperature and time treatment and designated R_1, R_2, R_3, respectively. At the end of the storage period, samples were drawn from each replicate of the treatment by repeated quartering and inspected for bruchid holes. The result is as represented in equation 2.3.

$$x = \frac{100N_{bh}}{N_t} \quad \text{.. 2.3}$$

Where:

N_{bh} = number of seeds with bruchid holes in the sample drawn

N_t = total number of seeds drawn

The dry matter loss (DML) was estimated using equation 2.4 as specified by FAO (1987).

$$DML(\%) = 1 + x(0.0085x + 0.15) \quad \text{.............................. 2.4}$$

Where:

x is as defined in equation 2.3.

Since equation 2.4 is dependent on the extent of bruchid damage, the storage stability of the cowpea was defined based only on the level of bruchid infestation as shown in equation 2.5

$$SS(\%) = 100\left[1-\left(\frac{N_{bh}}{N_t}\right)\right] + bb \quad \text{.................................... 2.5}$$

3.0 RESULTS AND DISCUSSION

The data generated from the investigation were subjected to analysis of variance (ANOVA) in a factorial design using MINITAB statistical software application to test for significance of the temperature and time treatment on the storage stability of cowpea. The ANOVA for the effect of the thermal processing temperature and exposure time on storage stability (SS) of cowpea after six months of storage are as presented. From the ANOVA tables, the replications were consistent, since F-value > P-value. With degrees of freedom (DF) of $V_1:V_2$ (5:89) the thermal processing temperature was significant at both 5% and 1% levels since F-calculated (1093207.59) was much more than critical value of F (3.17) (i.e. $F_{cal} > F_{tab}$). Likewise, the exposure time interaction on the SS was significant at both 5% and 1% levels as $F_{cal} > F_{tab}$ (i.e. 25871.20 > 2.45 at $F_{0.05}$ or $F_{0.01}$) with DF of $V_1:V_2$(4:89). The interaction of temperature and time factors

(T*t) showed significant difference on the SS at both 5% and 1% levels since $F_{cal} > F_{tab}$ (12196.42 > 1.62 at $F_{0.05}$ or > 2.03 at $F_{0.01}$) with DF of V_1:V_2 (20:89).

The coefficient of determination (R^2) that tended to 100% indicates that the interaction of the independent variables (T*t) has very strong effect on the storage stability of cowpea. Also the correlation coefficient which tended toward +1 indicates that as the two interacting factors increase the SS also increases. This is expected as increase in thermal processing temperature and detention time would result to increased heat penetration into the bulk and kernels of the cowpea thereby killing all stages of the cowpea pests both on the surface and inside the kernel of the cowpea as these pests cannot thermo-regulate (Gomez, 2003). Moreover, if the cowpea that is being subjected to the thermal processing is of high moisture content of 25% and above, the endosperm will gelatinize, and gelatinization process usually produces heat which kills all the stages of bruchid development. From ANOVA means, thermal processing temperature factor plays more significant effect than time factor, since SS of the cowpea was affected from a range of 0.00 – 99.407% as treatment temperature varied from $T_1 – T_6$ (34 – 80°C), while time factor range was 55 – 71% from $t_1 – t_5$ (i.e. 30 – 150 minutes). T*t ANOVA means showed that SS varied from 0.00% to 100% as the two factors increased. It is worth noting that the quality parameters such as starch yield and protein levels of grains with low initial moisture content of 18% (wb) and below are not significantly affected by the range of thermal processing temperatures used in this investigation as observed by Peplinski *et al*, 1982 and Kent, 1984. This is because grains at low initial moisture content exhibit poor thermal properties and as such low drying characteristics. For cowpea, the average moisture content at harvest rarely exceeds 18% (wb) and as such the temperature range investigated would not affect these two quality parameters.

The results showed that if drying grain is exposed sufficiently to pre-storage thermal processing air temperature of up to 50°C and adequately exposed to a period of not less than 120 minutes an SS of not less than 88% after six months of storage could be possible. At higher thermal processing temperature in excess of 60°C or above for grain of low initial moisture content, exposure time as short as 30 minutes significantly checked bruchid attack as SS of 96% was recorded after 6-month storage period. In essence, pre-storage thermal processing temperature of less than 50°C for grain of low initial moisture content of 18% (wb) or lower would require a longer exposure time to effectively check the activities of bruchid in storage as SS for pre-storage thermal disinfestations at 40°C ranged from 4 – 37% as exposure time moved from 30 – 150 minutes depicting that more exposure time would be required to attain an acceptable SS. The control recorded 0% SS.

REFERENCES

Adler, C (2003). Potential of Phyto-chemical for the Prevention, Detection and Control of Insect Pests in Integrated Stored Product Protection. Institute for Stored Production Protection, Federal Research Centre for Agriculture and Forestry, Konigin-Luise – St. Berlin Germany. Email: c.adler@bba.de

Afun, J.V.K., Jackai, L.E.N., and Hodgson, C.J. (1991). Calendar and Monitored Insect Application for the Control of Cowpea Pests. Crop Protection, 10:363-370.

Blade, S.F. (1997). Recent Developments in Cowpea Cropping Systems Research in Advances in Cowpea Research Co-publication of IITA, Ibadan, Nigeria, Pp. 114 – 128.

Caswell, G.H. (1994). The Value of the Pod in Protecting Cowpea Seed from the Attack by Bruchid Beetles. Samaru Journal of Agricultural Research (2):49-55.

Dieudonne, B., Lowenberg-Deboer, J., Murdock, L., and Moussa, B. (2010). Profitable Chemical-Free Cowpea Storage Technology for Smaller-holder Farmers in Africa. Opportunity and Challenges.

Gomez, C.C. (2003). Cowpea Postharvest Operation. FAO of the United Nations, Rome, Italy. INPho email: inpho@faoorg, www.fao.org/inpho

Jackai, L.E.N., and Adalla, C.B. (1997). Pest Management Practice in Cowpea, a Review. In: Advances in Cowpea Research, IITA Ibadan, Nigeria, pp. 240 – 248.

Kent, N.L. (1984). Technology of Cereals, 3rd Ed. Pergamon Press.

Kitch, L.W., Bottenberg, H., and Wolfson, J.L. (1997). Indigenous Knowledge and Cowpea Pest Management in sub-Saharan Africa. In: Advances in Cowpea Research Co-publication of IITA, Ibadan, Nigeria.

Langyintuo, A.S., Lowenberg-Deboer, J., Faye, M., Lambert, D., Ibro, G., and Moussa, B. (2003). Cowpea Supply and Demand in West and Central Africa. Field Crops Research, 82(2003), 215 – 231.

Langyintuo, A.S., Lowenberg-Deboer, J., and Arndt, C. (2005). Potential Impacts of the Proposed West African Monetary Zone on Cowpea Trade in West and Central Africa. Agricultural Economics, 33(Supplement), 411-421

McFarlane, J.A., and Taylor, R.W.D. (1997). Integrated Pest Management (IPM) in the Control of Storage Insects. Grain Storage Techniques. faO Agricultural Services Bulleting, 109:189 – 227.

Messina, F.J. (1984). Influence of Cowpea Pod Maturity on the Oviposition Choices and Larval Survival of a Bruchid Beetle, *Callosobruchus maculates,* Entomology Experimentation and Application (33):241-248.

Mortimore, M.J., Singh, B.B., Harris, F., and Blade, S.F. (1997). Cowpea in Traditional Cropping Systems. In: Advances in Cowpea Research. Co-publication of IITA, Ibadan, Nigeria, pp.99-110.

Murdock, L.L., Shade, R.E. (1991). Eradication of Cowpea Weevil (*Coleoptera, Bruchidae*) in Cowpeas by Solar Heating. American Entomologist, 37:228-231.

Murdock, L.L., Shade, R.E., Kitch, L.W., Ntoukam, G., Lowenberg-DeBoer, J.,

Huesing, J.E., Moar, W., Charmbliss, O.L., Endodo, C., and Wolfson, J.L. (1997). Post-harvest Storage of Cowpea in sub-Saharan Africa. In Advances in Cowpea Research. IITA Ibadan, Nigeria, pp.302 – 306.

New Agriculturist (2005). Counting on Cowpeas and other Grain Legumes. WRENmedia, www.renmedia.co.uk

Nielsen, S.S., Ohler, T.A., and Mitchell, C.A. (1997). Cowpea Leaves for Human Consumption, Production, Utilization and Nutrient Composition. In: Advances in Cowpea Research, IITA, Ibadan, Nigeria, pp. 302-306.

Peplinski, J.A., Anderson, A.R., and Brekken, L.O. (1982). Corn Dry Milling as Influenced by Harvest and Drying Conditions. Transactions of the ASAE, 25(4):1114 – 1117.

Singh, B.B., Chambliss, O.L, and Sharma, B. (1997). Recent Advances in Cowpea Breeding. Advances in Cowpea Research, IITA, Ibadan, Nigeria, 30-31.

Sukprakarn, C. (2003). Insect Pests of Stored Products. New Agriculturist, http://www.wrenmedia.co.uk

Taylor, T.A. (1981). Distribution, Ecology and Importance of Bruchids Attacking Grain Legumes and Pulses in Africa. In the Ecology of Bruchids Attacking Legumes (Pulses). Edited by S.R. Singh. John Wiley and Sons, Chichester, U.K.

Wolfson, J.L., Murdock, L.L., Shade, R.E., and Ntoukam, G. (1990). Preservation of Postharvest Cowpea by Subsistence Farmers in Cameroon. Beans/Cowpea CRSP Cameroon. Project Annual Report, East Landing, MI, U.S.A.

APPENDIX

ANOVA: SS versus Temp, Time

Factor	Type	Levels	Values
Rep.	fixed	3	1, 2, 3
Temp	fixed	6	1, 2, 3, 4, 5, 6
Time	fixed	5	1, 2, 3, 4, 5

Analysis of Variance for SS

Source	**DF**	**SS**	**MS**	**F**	**P**
Rep.	2	0.2	0.1	3.67	0.032
Temp	5	153363.2	30672.6	1093207.59	0.000
Time	4	2903.5	725.9	25871.20	0.000
Temp*Time	20	6844.0	342.2	12196.42	0.000
Error	58	1.6	0.0		
Total	**89**	**163112.6**			

S = 0.167504 R-Sq = 100.00% R-Sq(adj) = 100.00%

Expected Mean Square for Each Term (using unrestricted model)

Source		Variance component	Error term
1	Rep.		5	(5) + Q[1]
2	Temp		5	(5) + Q[2,4]
3	Time		5	(5) + Q[3,4]
4	Temp*Time		5	(5) + Q[4]
5	Error	0.02806		(5)

Means

Rep.	**N**	**SS**
1	30	62.537
2	30	62.447
3	30	62.427
Temp	**N**	**SS**
1	15	-0.000
2	15	13.800
3	15	64.800
4	15	98.013
5	15	98.800
6	15	99.407
Time	**N**	**SS**
1	18	55.006
2	18	59.011
3	18	60.667
4	18	66.667
5	18	71.000

Temp	**Time**	**N**	**SS**
1	1	3	0.00
1	2	3	0.00
1	3	3	0.00
1	4	3	0.00
1	5	3	0.00
2	1	3	4.00
2	2	3	9.00
2	3	3	16.00
2	4	3	13.00
2	5	3	27.00
3	1	3	37.00
3	2	3	50.00
3	3	3	50.00
3	4	3	88.00
3	5	3	99.00
4	1	3	96.00
4	2	3	96.07
4	3	3	99.00
4	4	3	99.00
4	5	3	100.00
5	1	3	96.00
5	2	3	99.00
5	3	3	99.00
5	4	3	100.00
5	5	3	100.00
6	1	3	97.03
6	2	3	100.00
6	3	3	100.00
6	4	3	100.00
6	5	3	100.00

DESIGN AND CONSTRUCTI ON OF A MELON DRYER

O.E. Akangbe, K.A. Jimo, A.O. Ilori, A.J. Adesope, S.O. Timothy and O.A. Ogunsina
Department of Agricultural and Bio-Environmental Engineering, Oyo State College of Agriculture, P.M.B. 10, Igboora, Nigeria.
E-mail: oluseyiakangbe@yahoo.com

ABSTRACT
The Ibarapa and Oke-Ogun areas of Oyo State which were formally a centre of mass production of melon in Nigeria have recently opted for water melon due to the problem of drying harvested melon seeds. Since melon matures at the peak of rainy season when the climatic conditions do not favor sun-drying and the moisture contents of seeds depodded ought to be reduced to at least 6.25% dry basis within two days to prevent undesired wastage, then this research presents hot air fluidized inclined bed dryer as an alternative method. This dryer consists of the drying chamber of 1800mm by 900mm by 600mm prismatic distribution chamber of louvered top type, the coal fueled furnace, hot air sucking fan and spark ignition engine as prime mover to cater for the epileptic power supply in this region.
The sucked hot air has direct contact with melon seeds thereby causing drying to take place. Test running was done on the dryer for freshly washed seeds of 0.5tons in a day with relative humidity of 78% at ambient temperature. This drying was done in 5 batches at 100kg each batch, taking an average of 1.5hours to dry to the moisture content of 6.25% dry basis for each batch which is a good condition for storage.
It is concluded that both drudgery and losses involved in old and traditional method of drying melon will be reduced drastically with the introduction of this dryer and farmers will be encouraged to embark on optimum production of this agricultural produce without any fear of this post-harvesting process for better storage.

Keywords: Design, Melon, Dryer, Moisture Content, Hot Air

1.0 INTRODUCTION

Melon (*Colocynthis citrullus* L.) is a widely cultivated and consumed oil seed crop in West Africa. The seeds popularly called 'egusi' contain about 53% oil, 28% protein and some other important mineral nutrients (Oyolu, 1977; Abaelu, 1979; Bankole et al., 2005). The crop was one of the major crops planted by Ibarapa and Oke-Ogun people of Oyo state. This was revealed in the works of Odebode (2007) that both male and female participation were 99% and 97% respectively. Lately, the production trend has fallen drastically which made dry melon seeds scarce in the region to the extent that the people have started bringing the seeds from the Northern part of the country for consumption. The study carried out revealed that farmers in these areas have shifted from planting melon to water melon due to the challenges facing them in processing the seeds after depodding.

One major problem that besets melon seeds is that it deteriorates quickly in storage due to fungal infection (Aboaba and Amasike, 1991; Bankole, 1993; Bankole et al, 2005). The effect of fungal attack on melon seeds include decreased nutritive value,

change in colour, and increase in the peroxide value, reduced seed germination and mycotoxin production (Bankole et al., 1999; 2004a, b). The moisture content plays a vital role in the maintenance of seed quality in stores. Harrington (1972) observed that a 1% decrease in moisture doubles the life of seeds. To reduce quality loss in stored products, rapid drying to low moisture is often emphasized, because all processes leading to mould contamination and subsequent damage relate to non-maintenance of stored products at safe moisture content (Awuah and Ellis, 2002; Bankole and Adebanjo, 2003; Bankole et al.,2005). Farmers generally dry the seed by sun drying. This proves difficult because the harvest period usually coincides with peak of rainy season. Although, Bankole, et al.(2005) compared effect of drying methods on quality and storability of melon seed and reported oven dried seed as having the least moisture content. Yet for a commercial production of these essential seeds, there is a need for an alternative method of drying that can guarantee continuous processing of the seeds for better storage irrespective of period or season. This necessitated the design and construction of a melon dryer. According to Somogyi and Luh (1986) several types of dryers and drying methods, each better suited for a particular situation, are commercially used to remove moisture from a wide variety of fruits and vegetables. But dryer with drying distribution chamber of louver bed type that distributes evenly the hot air across the bed inlet and hence initiates effectively gas – solids contacting is not common. And this informed the design and construction of hot air inclined bed dryer for melon seeds for farmers in the agrarian areas in Oyo state and country at large.

2.0 MATERIALS AND METHODOLOGY

2.1 Design Description The melon dryer consists of different units namely: drying chamber, prismatic distribution chamber, the heating chamber, hot air sucking fan (blower) and the prime mover.

The materials required for the construction of different parts of the melon dryer were: galvanized steel, angle iron, cylindrical suction pipe, suction fan, spark ignition engine/electric motor (1hp).

Other materials used for operating the dryer and testing its efficiency were charcoal, fresh melon pods obtained from Igboora and Lanlate respectively in Ibarapa land, Oyo state.

2.2 Design of Drying Chamber

Volume of drying chamber was determined as follows:

$$V = \frac{M}{\rho} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.\ 1$$

Where: V = bulk volume of melon seeds to be dried

M = mass of melon seeds to be dried

ρ = bulk density of melon seeds

It was taken that 250kg of melon seeds should be dried per batch in the chamber, bulk volume of

$$\text{melon seeds} = \frac{250\ kg}{500 kg/m^3} = 0.5\text{m}^3.$$

The width (W) of the drying chamber was obtained from:

$$W = \frac{v}{l \times h} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.\ 2$$

Where: l= length of drying chamber

h = effective drying height

$$W = \frac{0.5m^3}{1.8m \times 0.3m} = 0.9m$$

Where *l* was assumed to be 1.8m and effective drying height assumed to be 0.3m which is half the total drying height.

The total drying chamber volume (V) was determined from:

$V = l \times W \times H$ ……eqn.3

Where H = the height of the drying chamber.

V = 1.8m x 0.9m x 0.6m = $0.972m^3$

2.3 Design of Prismatic Distribution Chamber

The height of the prismatic distribution chamber was assumed to be 0.6m and the base length of the distributor was determined as below:

$$L = \sqrt{(l)^2 - H_2{}^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.4$$

Where: L = base length

H = prismatic distribution chamber height

l = hypotenuse of chamber

$$L = \sqrt{1.8^2 - 0.6^2} = 1.7m$$

2.4 Design of the Blower

Moisture content of freshly washed melon seeds was pre-determined at the central laboratory of Oyo state College of Agriculture, Igboora to be 61.5% on wet basis. Therefore, 250kg of freshly washed melon seeds would have 153.75kg of water.

Taking air entering the distribution chamber via blower being at 55^oC temperature and relative humidity of 15%. From psychometric chart by Universal Industrial Gases Inc., humidity ratio shows that every 1kg of dry air contains 15grams of moisture. If the temperature and relative humidity of air leaving the drying chamber are taken to be 40^0C and 60%, the humidity ratio shows that 1kg of dry air contains 28.5grams of moisture. Therefore, 1kg of dry air that enters the distribution chamber would carry (28.5-15) = 13.5grams of water out of the drying chamber. Since 153.75kg of water is to be removed from 250kg of wet melon seeds based on our design, the dry air mass required is

$$M_a = \frac{m_1}{m_2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.5$$

Where: M_a = dry air mass required

m_i = mass of water to be removed from 250kg of wet melon seeds

m_2 = mass of water removed by 1kg of air

$$M_a = \frac{153750}{13.5} = 11388.89kg.$$

From psychometric chart, specific volume was found to be $0.942m^3/kg$. Volume of dry air (V_a) is

$$V_a = S_v \; x \; M_a \ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.6$$

$$V_a = 0.942\, m^3/kg \; x \; 11388.89kg = 10728.33m^3.$$

If the drying time is taken to be 1.5hrs (90mins.), the air flow rate will be

$$q = \frac{v_a}{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.6$$

Where q = air flow rate in m^3/s
v_a = volume of dry air in m^3
t = time taken in min
q = 10728.33/90 = 119.2 m^3/min
Therefore, the blower is designed to discharge 119.2 m^3/min and using factor of safety of 1.2; the air discharged will be 1.2 x 119.2 = 143 m^3/min.
Using straight blades as shown in fig.1 below:

Each blade will discharge volume (v_v) of air and v_v is given as follows:

$$v_v = Ah = \frac{\theta}{360}\,\pi\,(R^2 - r^2)h \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.7$$

Where: A = area
R = radius of the blower
r = radius of the inner circle of the blower
h = height of the blade
If the blade is made up of 12 blades, then each sector will be subtended at centre at an angle 30^o.

Each blade has volume $v = \frac{30}{360}\,\pi h\,(R^2 - r^2) = \frac{1}{12}\,\pi h\,(R^2 - r^2)$. Hence in one revolution, each blade will discharge: $Vv = {}^{12}/_{12}\,\pi h\,(R^2 - r^2) = \pi h\,(R^2 - r^2)$ Since the blower is running with 1hp motor at 1500 rpm, therefore for 1500 revs. 12 blades will discharge as follows: Vv = 12 x 1500πh ($R^2 - r^2$) = 143m^3/min. Hence, the height of the blade h is determined from $h = \frac{143}{12\,x\,1500\pi(R^2 - r^2)}$. . If the diameter of the blower is 300mm and the diameter of the inner space is 100mm then, R =150mm and r = 50mm.

Therefore, $h = \frac{143}{1131.12} = 0.126m.$ hence, each blade of the blower will be 126mm by 100mm for the blower to discharge 143 m^3/min of air.

2.5 Design of the Heating Chamber

Energy required to remove 153.75kg of water from wet melon of 250kg at assumed ambient temperature of 28^0C was derived from Heat energy
H=(mct+ml)……eqn.8
Where: m = the mass of water to be removed
c = the specific heat capacity of water
t = change in temperature
l = the specific latent heat of vaporization of steam

H= (153.7 x 4.2 x 10^3 x (100-28))+(153.75 x 2.260 x 10^3)=393.969 x10^3 kJ/K

According to Girard (2002), 1kg of charcoal would produce 7500kcal = 31500kJ = 31.5MJ.

Therefore, the mass of charcoal to give 393.97 MJ = $\frac{393.97}{31.5} = 12.5kg.$ The thermal yield of charcoal is about 28% (Girard, 2002) and the total mass of charcoal required based on the thermal yield $= \frac{12.5\,x\,100}{28} = 44.6kg.$ Bulk density of charcoal is 420kg/m^3 (FAO, 2008).

The volume of charcoal required (V_c) $\frac{44.6}{420} = 0.1062m^3.$ For convenience and consideration we decided to load this volume 4 times. Therefore, the volume of the heating chamber (V_h) $= \frac{0.1062}{4} = 0.027m^3.$

2.6 Construction of the Dryer

The fabrication of each designed unit of the melon dryer based was done in the workshop of the department of Agricultural and Bio-Environmental Engineering, Oyo State College of Agriculture Igboora. The Distributor was made to be a louver bed type and lagged with saw dust to conserve heat within the chamber. Its base was framed with angle iron 50x50mm to support both the weight of the dryer and its contents. The suction fan (blower) was a bought out item having a blowing capacity of 143m^3/min with 1 hp motor running at 1500rpm. The suction of the blower was connected to the heating chamber through two long pipes connected at the center with wire gauze to do hot air cleaning, and the discharge outlet of the blower was connected to the prismatic distribution chamber at the rear section of the chamber. All the components were



Fig 1: The Side View of The Melon Dryer



Fig 2: The Front View Of The Melon Dryer

2.7 Test Running of the Dryer

500kg of mature melon pods were collected from Lanlante area in Ibarapa, deppoded and allowed to ferment for 8 days. Seeds were manually extracted from the fruits, washed and drained awhile before spread loading inside the dryer at 100kg per batch at an average ambient temperature of 27.5°c and relative humidity of 78%. The drying efficiency of the machine was also estimated using the equation:

$$\varepsilon_{\zeta} = \frac{W_r}{W_E} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.9$$

Where: ? = drying efficiency of the dryer

W_r = water removed by the hot air

W_E = expected water to be removed.

If 1kg of dry air would remove 13.5gm of water

Volume of air (V_a) discharged in 90min by the blower with blowing capacity of $143m^3/m$ = $Va = t\ x\ q$ ----------eqn. 10

Where: t = time taken for drying

q = discharge

Va = 90 X 143 = $12870m^3$

If the specific volume ($S_{v)}$ is $0.942m^3/kg$, then; mass of air (M_a) is

$$M_a = \frac{V_a}{S_v} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eqn.11$$

$$M_a = \frac{12870}{0.942} = 13662\ kg\ of\ dry\ air.$$

13,662kg of air would be expected to remove =13,662

$$\varepsilon_{\zeta} = \frac{153.75 \times 100}{184.44} = 83.4\%$$

3.0 RESULT AND DISCUSSION

The results obtained from batch drying of the melon seeds are shown in table 1.

Table 1. Parameters of Five Batch Runs of The Dryer For 100kg Per Batch.

Runs	Inlet		Outlet		Drying Time
	Temp. (°C)	R. H (%)	Temp. (°C)	R.H (%)	(min)
1	75	15	32	80	98
2	76	14	31	82	95
3	78	13	32	80	91
4	78	13	33	81	90
5	78	13	33	81	88

From the results obtained, the average inlet temperature and relative humidity are 77 °C and 13.6% respectively while the outlet temperature and relative humidity are 32.2 °C and 80.8% respectively.

These values differ from the designed values due to the prevailing climatic condition which made the atmosphere highly damped. The average drying time per batch is 1.5hrs at average moisture content of 6.25% on d.b. which is a good condition for durable storage of melon seeds (Bankole et al, 2005). The drying time obtained shows that design parameters are adequate and the used factor of safety is appropriate.
The drying efficiency of the machine obtained to be 83.4% shows that the dryer is highly efficient.

4.0 CONCLUSION

The development of the melon dryer with 83.4% efficiency and drying time of 1.5hrs per 100kg drying batch ensures optimum production of dry melon seeds to a very suitable storage condition. This post-harvest process which poses serious challenge to melon farmers – particularly in Ibarapa and Oke-Ogun areas- will be reduced to minimal level, and resolve the problem of shifting into water melon production in these areas.
Finally, with the introduction of this dryer, drudgery and losses associated with old and traditional method of drying melon (sun-drying) will be reduced and farmers will be encouraged to embark on optimum production of this agricultural produce without any fear of weather conditions for better economic gain.

REFERENCES

Abaelu A. M, Makinde M. A, Akinrimisi E. O (1979). Melon (egusi) seedprotein 1: Study of amino acid composition of defatted meal. Nutr.Rep. Int. 20: 605-613.

Aboaba O.O. and Amasike J. (1991). Storage of melon seeds. Niger J. Botany 4,213 - 219.

Awuah RT, Ellis WO (2002). Effects of some groundnut packaging methods and protection with
Ocimum and Syzygium powders on kernel infection by fungi. Mycopathologia 154: 29-26.

Bankole S.A.,Osho A., Joda A.O. and Enikuomehin O.A. (2005). Effect of drying methods on the
quality and storability of 'egusi' melon seeds (*colocynthis citrullus L*). Afri. J. Biotech. 4(8), 799-803

Bankole S. A., Lawal O. A. and Adebanjo A (2004a). Storage practises and aflatoxin B1 contamination of 'egusi' melon seed in Nig. Trop. Sci. 44:150 – 153.

Bankole S.A., Ogunsanwo B.M. and Mabekoje O. O. (2004b). Natural occurrence of moulds and .
aflatoxins in melon seeds from markets in Nig. Food Chem. Toxicol.42, 1309 – 1324

Bankole S. A. and Adebanjo A. (2003). Mycotoxins in food in West Africa: Current situation and possibilities of controlling it. Afr. J. Biotech. 2(9), 254-263

Bankole S.A., Ikotun B. and Ekpo E.J. A. (1999). Fungal deterioration of melon seeds stored in jute
sacks and polyethylene bags in Ago-Iwoye, south western Nig. Mycopathologia 146, 135-146.

Bankole S.A. (1993). Moisture content, mould invasion and seed germinability of stored melon.
Mycopathologia 122: 123-126.

Harrington JF (1972) Seed storage and longevity. In: Seed biology (Kozlowski TT, ed.), pp. 145-
240. Lond. Academic Press.

Odebode S.O. (2007). Gender Participation of melon farmers in Ibarapa area of Oyo state, Nigeria.
Agric. J. 2(1):108-111

Oyolu O (1977). A qualitative and quantitative study of seed types in'egusi' (Colocynthis citrullus
L.). Trop. Sci. 19: 51-61.

Somogyi L. P. and Luh B. S (1986) Dehydration of fruits in: Commercial Fruit Processing, 2nd ed. (J.G. Woodroofand B.S. Luh, Eds.), AVI Publishing, Westport, CT, p. 353.

PERFORMANCE EVALUATION OF A 50 - LITRE COLD STORAGE FACILITY FOR FRUITS AND VEGETABLES FOR SMALL SCALE TRADERS IN JOS, NORTHERN NIGERIA.

[1]Omoniyi O.I., [2]A. S. Popoola, [1]S. M. Joshua, [1]Y. M. Sani, [1]A. R. Ojo and [1]D. B. Gwong.
[1]Department of Agricultural Technology.
[2]Department of Forestry Technology.
Federal College of Forestry Jos, Plataeu State.
Corresponding Author: Popoola A. Stephen – adrom835@yahoo.com, 07030648406.

ABSTRACT
The design and construction work of mini cold storage facility was made to meet the needs of small scale traders and low income earners and also to reduce wastage of perishable fruits and vegetables in agricultural production. A 50 - liter freezer was designed, constructed and tested for six days for both freezing and defreezing processess. The ambient temperature was 26^0c, freezing temperature was -1.5^0C and freezing efficiency was 61.69%. A key component to meeting efficiency targets was the liquid coolant used with hydro-cools' high performance. The choice of insulation levels and materials is another key factor as well. It was found out that the facility if produced in mass, would meet the yearning needs of low income earners in curtailing wastage of fruits and vegetables in Jos city, Nigeria and as these food items can be preserved for 6 days. This would contribute to National food security.

Keywords: Cold Storage Facility, Fruits, Vegetables, Temperature and Food preservation.

1.0 INTRODUCTION
Food preservation is an increasingly important component of the food industry as fewer people eat foods harvested from their own farm land. Fruits and vegetables are important food components in the human diet as they provide the essential minerals, vitamins and fiber required for maintaining health. Much of those food items produced is not fully utilized and about 25-30% of it is wasted due to spoilage. Therefore there is need for food preservation. The main aim of food preservation is to minimize the growth of micro-organisms during the storage period, thus promoting longer life and reducing hazard to health (Leistner, 1995). Methods of food preservation include curing, drying, canning, chemical additive, freezing and refrigeration, controlled atmosphere storage, aseptic packaging, irradiation, fermentation, pasteurization. Storage at low temperature slows many of the enzymatic reactions involved in spoilage and reduces the growth rate of micro-organisms (though it does not kill them). In this case, Refrigeration is advantageous because it does not cause chemical or physical changes to food. Freezing allows foods to be stored for longer period than refrigeration because it inhibits enzyme activity and microbial growth to a greater degree. The greatest disadvantage of freezing is that the water in food expands and forms ice crystals. The ice crystal formation disrupts the structure of plant and animals cells, giving frozen food a softer texture after thawing. Newer technologies in which freezing occurs more rapidly help minimize this problem. Faster freezing, such as flash freezing means that smaller ice crystals form resulting in less damage to cell (Yousef *et al*., 2003). An increasing amount of food is being preserved

by freezing. The frozen packs of vegetables, apples, apricots, peaches, and cherries and some new products have increased tremendously in the last few years. Research in the Department of Agriculture's western region research laboratory at Albarry, California has contributed greatly to these developments, (Stephanie *et al*., 2001). The aim of this work is to design, contruct and evaluate a portable cold storage facility that is suitable for preserving fruits and vegetable and to help reduce wastes.

2.0 MATERIALS AND METHODS

The design, construction and evaluation of the facility were carried out in Federal College of forestry Jos, Plateau State Nigeria. The cold storage facility for local use, efficient and economically viable among traders was design and constructed with readily available, reliable and cheap materials. The major components of the facility were as follows: (1) The compressor (2) Condenser (3) Copper pipe (4) Mini cooler (5) Capillary/evaporator (6) Drier (7) Charging and oil component (8) Gas and oil (9) Wire and plug (10) 1.5cm angle iron (11) A 50-litre Cooler (12) Aluminum plate. The isometric drawing of the freezer is shown in figure 3.

2.1 Construction

The frame for the refrigerator was constructed using the 1.5cm angle iron which was cut into different sizes using the hack saw and weldded together to make the stand. The length of the frame was 66.04cm for the breath. The diameter of the cooler and frame was 15.24cm.

2.2 The Panel/Outer Cabinet

The panel was constructed using an aluminum plate to give the frame work a shape and make a cover for the material beneath the frame of the compressor, evaporator and the fan. Pieces of metal sheet were either welded or clinched together; clinching is a process closely resembling stapling in that the two pieces are clinched together under pressure. Part of the cabinet was visible from behind as it was welded and ground down to appear on one piece to create an opening for ventilation.

2.3 The Inner Cabinet (Cooler)

The inner cabinet used for inner liners is plastic from the local cooler. The inner cabinet was inserted into the outer cabinet (frame) and snapped before other components were fixed.

2.4 The Cooling System

The refrigeration components were attached to the cabinet using screws and clips. The tubing was soldered together and a protective coating was sprayed on the joints to maintain quality.

2.5 Refrigeration Cycle/Process

There are four fundamental steps required to complete the mechanical compression refrigeration cycle namely; Evaporation, Compression, Condensation and pressure reduction. Evaporation of the liquid refrigerant takes place in the evaporator. This was installed within the low pressure side of the refrigeration system and connected to a throttling device, usually called an expansion valve through which it receives the liquid refrigerant from the high pressure side of the system. After evaporation has taken place in the evaporator, the refrigerant vapor enters the compressor. The primary function of the compressor is to raise the pressure and temperature of the vapor to such a value that it may be condensed by utilizing water or air. The compressor is located between the

evaporator and condenser. The former was connected to the suction side, while the latter was connected to the discharge side of the compressor. The compressor is the diving component that joins the low pressure side to the high pressure side of the system, within the vapor zone. The third step is performed by the condenser, located between the compressor and the throttling device. The refrigerant flows from the condenser to a liquid receiver, and then to the throttling device. The liquid receiver is considered to be part of the condenser. The condenser converts the superheated refrigerant vapor (gas) to it liquid form. It extracts from the vapor, the heat absorbed by the refrigerant in the evaporator and the superheat resulting from compression. The last step in the refrigeration cycle is the pressure reduction. Before this point, the refrigerant in its liquid states is under high pressure in the receiver for being re-used in the evaporator. Pressure reduction is accomplished by placing a throttling device in the cine between the receiver and the evaporator. This throttling device consists of a small adjustable opening that limits the amount of refrigerant passing through it (THCS, 2003).

3.0 RESULTS AND DISCUSSION

Figure 1 shows the temperature recorded during the freezing process. The ambient temperature as recorded with a thermometer was 26^{0}C. The temperature falls as the vegetable (Tomatoes) undergoes cooling process. The lowest temperature recorded was -1.5 at 35hours. This agrees with a simillar work done by Davis *et al*., (1999) who designed a 126liters of both fridge and freezer for general purpose with an ambient temperature of 30^{0}C and freezing temperature of -18^{0}C. Meanwhile, the recommended temperature suitable for Fruits and Vegetable is between 5 and 7^{0}C (Davis *et al*., 1999). Figure 2 show the defreezing process of the facility. The graph pattern was the reverse of the graph for freezing process. It took 50 hours for the vegetable to completely defreeze. It shows that this work was able to preserve the fruits and vegetable (Tomatoes) for a total number 6 days from its 2 days natural shelf life at defrosting from 0^{0}C to 23^{0}C. The cost implication (#19, 500:00) was found to be affordable when compared with the imported cold storage facility (Table 1).

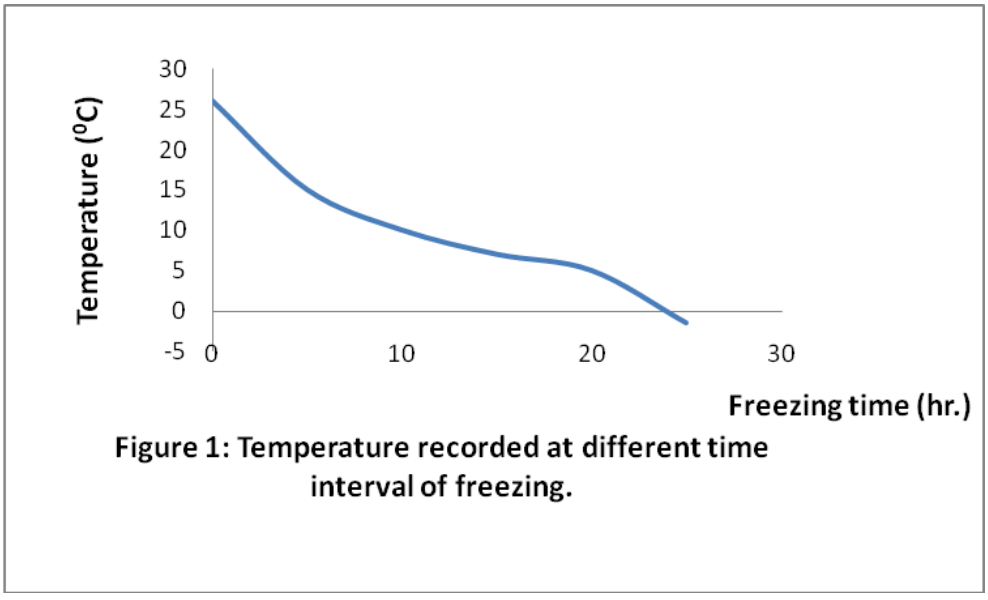


Figure 1: Temperature recorded at different time interval of freezing.

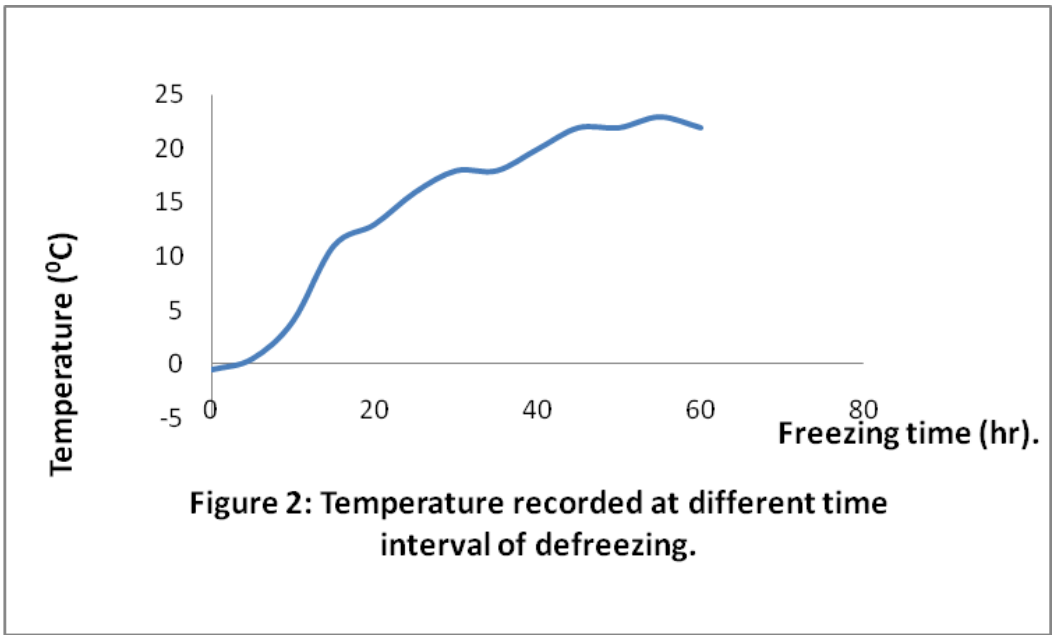


Figure 2: Temperature recorded at different time interval of defreezing.

Table 1: Cost Analysis Of The Cold Storage Facility

Components	**Cost (₦)**
Compressor	4,000:00
Evaporator	2,000:00
Condenser	1,200:00
Oil and Gas	2,250:00
Drier	200:00
Main Wire	200:00
Plug	200:00
Relay	150:00
Container	3,800:00
Frame	4,500:00
Transportation	600:00
Total	**19,100.00**

4.0 CONCLUSION

A mini cold storage facility had been constructed to serve the needs of small scale traders and the performance evaluation was satisfactorily compared with traditional method of food preservation. The ambient temperature was 26^0c, freezing temperature was -1.5^0c and freezing efficiency was 61.69%. Carrying out this project provided several valuable lessons. It showed that innovative and creative design is necessary to achieve performance chose to compressor drives refrigeration. Interestingly, the cost comparism with factory made type were reasonable, indicating that low income earners and small scale farmers including traders of these perishable foods (tomatoe) can afford it and meet targets.

5.0 REFERENCES

Davis M, B. Manners and P. Clark, (1999); A design of a 126liters refrigerator and freezer commercial prototype; P.Clark hydrocool pty ltd. Peter C@hydrocool.com.

Leistner, L. 1995. Principles and applications of hurdle technology. In Gould. G. W. (Ed.), New
Methods of Food Preservation. BlackieAcademic and Professional, London. pp. 1-21.

Stephenie T. D.,and Marhta B. (2001) A Comprehensive History of Food Preserving, from Primitive Techniques to Current Practices. Contributed by Taylor Davis, Stephanie and Stone, Martha B. "Food Processing and Preservation" Microsoft ® Encarta 2009. Redmond, WA: Microsoft Corporation, 2008.

THCS (2003). The Basic Refrigeration Cycle. Tecumseh Compressor Services handbook. www.tecumseh.com (06/20/2003).

Yousef A.E. and Caroly. Carlstrom C. (2003); Food microbiology: a laboratory manual Wiley, page 226 ISBN 9780471391050.

APPENDIX A

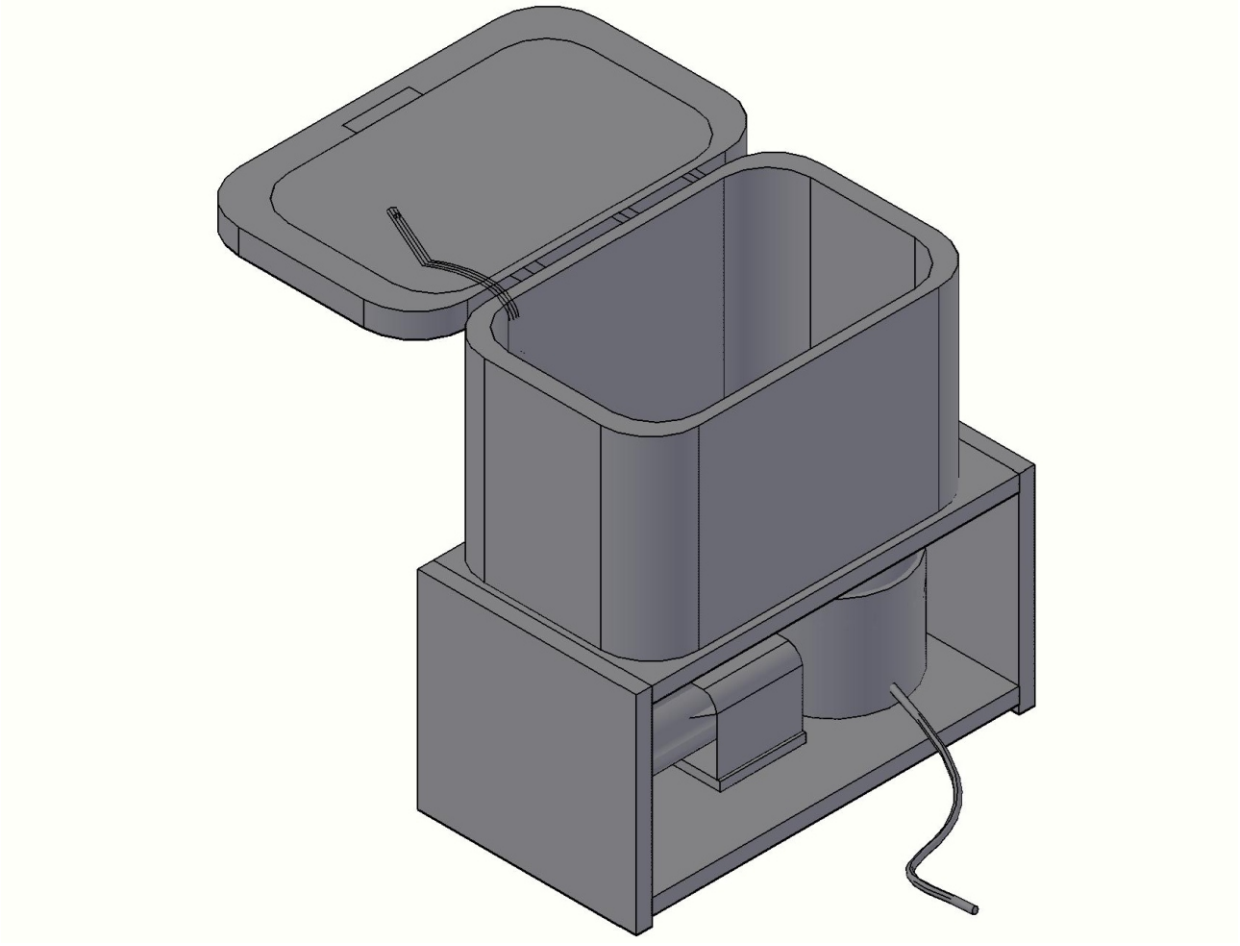


Figure 3:An Isometric Drawing Of The Cold Storage Facility.

Paper No: 766

PHYSICAL PROPERTIES OF FRESH TURMERIC RHIZOMES RELEVANT TO POSTHARVEST PROCESSES

Ikejiofor, M.C
Engineering Research Unit,
National Root Crops Research Institute, Umudike
P.M.B. 7006, Umuahia, Abia State
E-mail: mauikejiofor@yahoo.com

ABSTRACT

The physical properties of fresh turmeric rhizome (Curcuma Longa) obtained from National Root Crops Research Institute, Umudike useful for the design of the processing machines were determined. The rhizomes were subdivided into three categories: mother, secondary and tertiary. Measured properties include: moisture content, size (length, width and thickness), geometric mean diameter, sphericity, weight, surface area, bulk density, true density, porosity, angle of repose and coefficient of static friction. Results obtained showed that the tertiary rhizome had the highest moisture content of 76.14% while the mother rhizome had the lowest value of 72.83%. The average length, width and thickness of the mother, secondary and tertiary rhizomes were (3.87cm, 2.25cm, 2.20cm), (4.47cm, 1.41cm, 1.55cm), (2.81cm, 1.24cm, 1.11cm) respectively. The mother rhizome had the highest geometric mean diameter value of 1.9157cm, while the tertiary rhizome had the lowest value of 1.0795cm. The secondary rhizome had the highest sphericity value of 0.99, while the mother rhizome had the lowest value of 0.89. Also, the mother rhizome had the highest average mass and surface area of 3.75g and 11.53cm^2, while the tertiary rhizome had the lowest values of 1.52g and 3.66cm^2. The mother rhizome had the highest bulk and true density values of 345kg/m^3 and 786kg/m^3. The tertiary rhizome had the highest average porosity of 58.65%, while the mother rhizome had the lowest porosity value of 56.11%. The highest angle of repose of 24.52^o was obtained for the mother rhizome, while the lowest value of 21.32^o was obtained for the tertiary rhizome. Finally, the mother rhizome had the lowest coefficient of static friction of 0.42 against stainless steel surface, while the tertiary rhizome had the highest value of 0.86 against the plywood surface.

Keywords: Turmeric, Physical Properties, Fresh Rhizome, Postharvest, Processes

INTRODUCTION

Turmeric (Curcuma Longa) belongs to the family Zingiberaceae. It originated from South-East Asia and its center of domestication is certainly the Indian subcontinent (Dahal and Idris, 1999). Turmeric is cultivated mostly in the homestead gardens in about 19 states in Nigeria. It is used as a natural colouring agent for food, cosmetics or dye and medically for treating various kinds of diseases. It also applies as an antiseptic for skin abrasions and cut (Robbins, 1995). Turmeric is a spice used extensively by all classes of people in India. It is one of India's most ancient and traditional export commodities. It is part of Indian's culture: it is used in many religious observances, as a cosmetic, a dye, and it enters in the composition of many traditional remedies (Narayana et al., 2000). Currently, India is the leading producer, consumer and exporter of turmeric with an annual production of 598,400 metric tones in 1999 (Rema and Madan 2001), followed by Pakistan, Bangladesh, Sri Lanka, Taiwan, China, Burma and Indonesia. Turmeric is also

produced in the Caribbean and Latin America: Jamaica, Haiti, Costa Rica, Peru and Brazil (Weiss, 2002).

The United States imports of turmeric come from India at 97%, and the rest is supplied by the islands of the Pacific and Thailand (ASTA, 2002). It is interesting to note that in the United States, turmeric is considered as a spice by the food industry, whereas it is classified as a food colorant by the FDA (Tainter and Grenis, 2001)

Turmeric can be grown in diverse tropical conditions from sea level to 1500m above sea level on a well drained sandy or clay loam soil (Rema and Madan 2001). Nigeria has favourable condition for turmeric cultivation, thus Nigeria can play a dominant role in turmeric production. However, there is a strong need for mechanization of its processing in Nigeria to facilitate harnessing of its utilization and economic potentials.

According to Nunes (1989), turmeric is rich in yellow food pigment called curcuminoid (6%) and essential oils (5%). Turmeric powder is a major ingredient in curry powder and paste.

Turmeric content in curry powder blends ranges from 10 – 15% to 30% (Govindarajan, 1980). Turmeric powder has also been used as a colorant in cereals (Brescher and Yang, 2000), and is highly valued in international markets especially in US, UK, Japan and Middle East as a functional food due to its health promoting properties. Medically, it is efficacious in the treatment of circulatory problems, liver diseases, dermatological disorders and blood purification (Semwal et al., 1997). Turmeric also has antioxidant, antiarthritic, antibacteria, antifungal, antiviral and nematocidal qualities (Negi et al., 1999; Ruby et al., 1995). The objective of this paper is to report on the determined physical properties of fresh turmeric rhizomes that are relevant in the design of the processing machines.

MATERIALS AND METHODS

Studies on determining the physical parameters of fresh turmeric rhizomes were conducted at National Root Crops Research Institute, Umudike. The physical properties like moisture content, size, shape, bulk density, true density, porosity, angle of repose, surface area and coefficient of friction were determined.

Moisture Content

The moisture contents of the rhizomes were determined using the oven method. Sliced rhizomes from each of the categories: mother, secondary and tertiary rhizomes were weighed with an electronic balance and then oven dried at a temperature of 75°C. The percentages of moisture content wet basis were calculated as according to (Kajuna et al, 2001).

$$Mc\ (wb)\ \% = \frac{W_w - W_d}{W_w} \times 100$$

Where Mc (wb) % = Moisture content wet basis; W_w is the weight of the wet sample (g); W_d is the weight of the dried sample (g).

Size

The size of fresh turmeric rhizomes was determined by measuring the dimensions along three principal axes, namely, major (length), minor (width) and intermediate (thickness) of each rhizome piece using vernier calipers (least count: 0.01cm). Turmeric rhizome is of three categories: mother, secondary and tertiary and the sizes were determined for 50 rhizomes for the different categories.

Shape

The major (a), intermediate (b) and minor (c) diameters of each category of the turmeric

rhizome were measured with digital vernier caliper to an accuracy of 0.01mm. The values obtained were used to calculate geometric mean diameter (GMD) and sphericity for 50 rhizomes.

$$GMD = (abc)^{1/3} \quad \text{---------- (1)}$$

$$\text{Sphericity} = \left(\frac{abc}{a}\right)^{1/3} \quad \text{---------- (2)}$$

Mass, Volume and Surface Area

The mass of the different categories of the turmeric rhizomes were determined separately using a precision electronic balance (readability: 0.01g). Volume of rhizome was determined as true volume by immersing the rhizomes in water contained in a measuring cylinder and determining the volume of water displaced (Mohsenin, 1970). In obtaining the surface area of the rhizome samples, the equation given by Topuz et al. (2005) was used.

$$S = \pi D^2_{GM} \quad \text{---------- (3)}$$

Where S = surface area (cm^2), $\pi = 3.142$ and D_{GM} is the geometric mean diameter.

Bulk density, True density and Porosity

The bulk density was determined as the ratio between the mass of the turmeric rhizome in a container to its volume (Kaleemullah and Kailappan, 2003). Rhizomes were filled in a container and the mass of contents was determined. The true density of rhizome was determined by platform scale method (Mohsenin, 1970). The porosity of the fresh turmeric rhizomes was computed using the formula:

$$\varepsilon = 1 - \left[\frac{P_b}{P_t}\right] \quad x100 \quad \text{---------- (4)}$$

Where, ε is the porosity (%); P_b is the bulk density (kg/m^3); P_t is the true density (kg/m^3)

Angle of Repose and Coefficient of friction

In determining the angle of repose, 100g of the turmeric rhizomes were piled on mild steel sheet, placed on a table. The mild sheet was tilted gradually until the rhizomes began to slide freely. The angle the mild steel sheet makes with the table as at the time of sliding was taken as the angle repose of the rhizomes on mild sheet surface. The apparatus used to determine coefficient of friction consisted of a frictionless pulley fitted on a frame, a bottomless cylindrical container, loading pan and test surface was filled with a known quantity of rhizomes and weight were added to the loading pan until the container began to slide. The mass of the rhizomes and the added weights represent the normal force and frictional force respectively. The coefficient of static friction was calculated as the ratio of frictional force to the normal force as:

$$\mu = \frac{F}{N_f} \quad \text{---------- (5)}$$

Where, μ is the coefficient of friction, F is the frictional force, kg; N_f is the normal force, kg. The experiment was performed using the following test surfaces: plywood, galvanized iron, mild steel and stainless steel sheets.

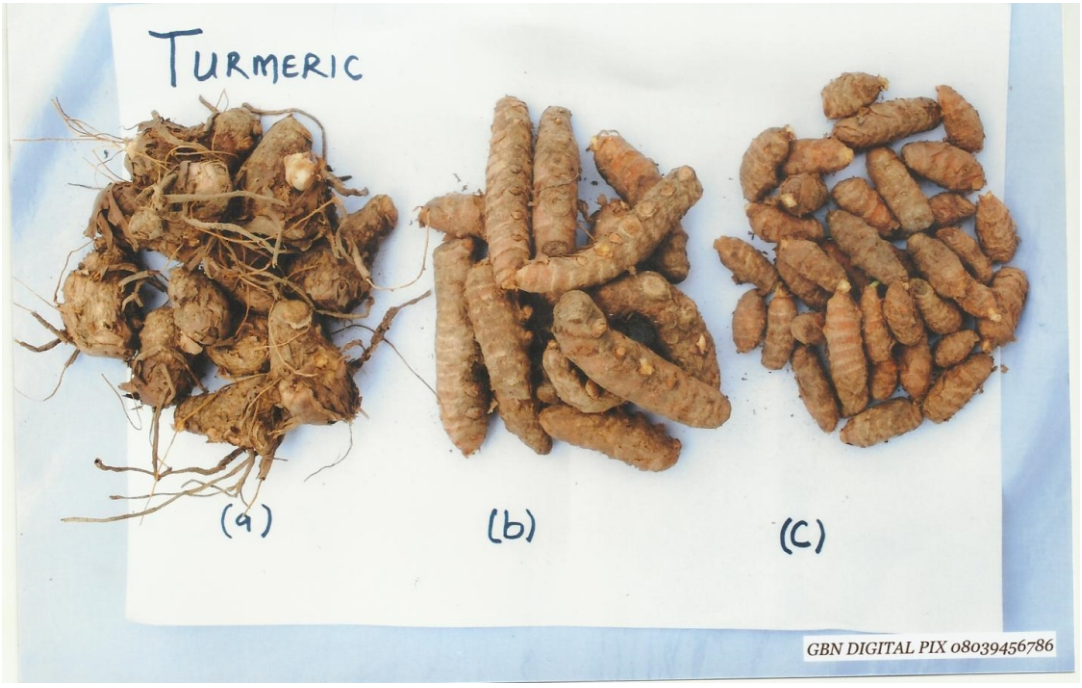


Fig.1: The Fresh Turmeric Rhizomes (a) Mother (b) Secondary (c) Tertiary

RESULTS AND DISCUSSIONS

From the table 1, 2 and 3, the secondary rhizomes have the highest average values in length and sphericity. The mother rhizomes have the highest average values in thickness, (major, intermediate and minor) diameters, surface area, weight, bulk / true densities, angle of repose and the least value in coefficient of friction for stainless surface and moisture content. The tertiary rhizomes have the highest values in porosity and moisture content.

Table 1: Physical Properties Data for the Mother Rhizomes

Parameter	Sample Size	Mean Value	Standard Deviation
Length (cm)	50	3.87	0.47
Minor diameter (cm)	50	1.46	0.25
Intermediate Diameter (cm)	50	2.25	0.23
Major diameter (cm)	50	2.14	0.22
GMD (cm)	50	1.92	0.31
Sphericity	50	0.89	0.02
Surface area (cm^2)	50	11.53	0.03
Weight (g)	50	3.75	0.21
Bulk density (kg/m^3)	50	345	4.12
True density (kg/m^3)	50	786	3.27
Porosity (%)	50	56.11	0.06
Angle Repose (°)	50	24.52	0.25
Coefficient of Static Friction	50		
- Mild Steel		0.71	0.04
- Stainless		0.42	0.02
- Galvanized		0.57	0.04
- Plywood		0.80	0.03
Moisture Content	50	72.83	0.43

Table 2: Physical Properties Data for the Secondary Rhizomes

Parameter	Sample Size	Mean Value	Standard Deviation
Length (cm)	50	4.47	0.42
Minor diameter (cm)	50	1.15	0.07
Intermediate Diameter (cm)	50	1.41	0.26
Major diameter (cm)	50	1.28	0.15
GMD (cm)	50	1.27	0.02
Sphericity	50	0.99	0.03
Surface area (cm^2)	50	5.11	0.03
Weight (g)	50	2.79	0.19
Bulk density (kg/m^3)	50	308	3.03
True density (kg/m^3)	50	731	2.41
Porosity (%)	50	57.87	0.24
Angle Repose (^{o})	50	22.42	0.12
Coefficient of Static Friction	50		
- Mild Steel		0.70	0.03
- Stainless		0.43	0.02
- Galvanized		0.54	0.04
- Plywood		0.83	0.02
Moisture Content	50	74.87	0.35

Table 3: Physical Properties Data for the Tertiary Rhizomes

Parameter	Sample Size	Mean Value	Standard Deviation
Length (cm)	50	2.81	0.62
Minor diameter (cm)	50	0.89	0.06
Intermediate Diameter (cm)	50	1.24	0.14
Major diameter (cm)	50	1.14	0.06
GMD (cm)	50	1.08	0.02
Sphericity	50	0.95	0.03
Surface area (cm^2)	50	3.66	0.08
Weight (g)	50	1.52	0.07
Bulk density (kg/m^3)	50	294	3.03
True density (kg/m^3)	50	711	4.49
Porosity (%)	50	58.65	0.16
Angle Repose (^{o})	50	21.32	0.13
Coefficient of Static Friction	50		
- Mild Steel		0.69	0.03
- Stainless		0.46	0.04
- Galvanized		0.51	0.04
- Plywood		0.86	0.02
Moisture Content	50	76.14	0.50

CONCLUSION

The mother rhizomes with the least moisture content will require less energy to dry during processing, unlike the tertiary rhizome with the highest moisture content value. The secondary rhizomes with the highest sphericity value will be more suitable for mechanical peeling. The mother rhizomes also with the highest angle of repose may need more inclined hoppers during discharge for processing, and the tertiary rhizomes with the highest porosity will occupy less packing space. Finally, the coefficient of static friction of the rhizomes against stainless surfaces had the lowest values, which indicates that stainless material will be the most suitable material for easy conveying of the rhizomes during processing.

REFERENCES

ASTA, 2002. A Concise Guide to Spices, Herbs, Seeds and Extractives. American Spice Trade Association. Pg 48 – 50.

Brescher, R. and Yang, L. 2000. Turmeric. In : Natural Food Colorants. Science and Technology. G.L. Lauro and F.J. Fancis (Eds). Marcel Dekker, New York. Pg. 205 - 226.

Dahal, K.R. and Idris, S. 1999. Curcuma Longa L. In: de Guzman, C.C. and Siemonsma, J.S.
(Editors): Plant Resources of South – East Asia No13. Spices. Backuys Publishers Leiden, The Netherlands. Pg 111 – 116.

Govindarajan, V.S. 1980. Turmeric – Chemistry, Technology and Quality. Crit. Rev. in Food
Science and Nutrition, T. E. Furia, Ed., CRC Press, Boca Raton, FL. Vol. 12: 199 –301.

Kajuna, S.T; Silajo, V.C; Mkenda, A. and Makungu, P.J. 2001. Thin Layer Drying of Diced
Cassava Roots. African Journal of Science and Technology (AJST) 2 (2): Pg 94 – 100.

Kaleemullah, S. and Kailappan, R. 2003. Geometric and Morphometric properties of Chillies. International Journal of Food Prop. 6: Pg 481 – 498.

Mohsenin, N.N. 1970. Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers Ltd, New York. Pg 51 – 81.

Narayana, D.B.A.; Brindavanam, N.B.; Dobriyal, R.M. and Katuyar, K.C. 2000. Indian Spices: An Overview with special reference to neutraceuticals. Journal of Medicinal and Aromatic Plant Sciences. 22 (IB): Pg 236 – 246.

Negi, P.S.; Jayaprakasha, G.K.; Jagan Mohan Rao, L. and Sakariah, K.K. 1999. Antibacterial
Activity of turmeric oil: a byproduct from curcumin manufacture. Journal of Agricultural Food Chemistry 47 (10): Pg 4297 – 4300.

Numes, F.V. 1989. Cultivo Da Curcuma E Facil E Lucrativo, Manchete Rural. Pg 29.

Rema, J. and Madan, M.S. 2001. Turmeric. An Extension Pamphlet. Agricultural Technology Information Centre. Indian Institute of Spice Research. Pg 8.

Robbins, P. 1995. Tropical Commodities and their Markets (A Guide and Directory), Pg 229 – 230.

Ruby, A.J.; G. Kuttan.; K. Dinesh Babu.; K.N. Rajase Keharan.; R. Kuttan. 1995. Anti-Tumour and antioxidant activity of natural curcuminoids. Cancer Letter 94: 79 – 83.

Semwal, A.D; Sharma, G.K. and Arya, S.S. 1997. Anti-oxigenic activity of Turmeric (Curcuma Longa) in Sunflower oil. Journal of Food Science and Technology, 34(1), Pg 67 – 69.

Tainter, D.R. and Grenis, A.T. 2001. Spices and Seasonings. A Food Technology Handbook.
2nd Ed. Wiley – VCH. New York.

Topuz, A; Topakel, M; Akinei, I. and Ozdemir, F. 2005. Physical and Nutritional Properties
of Four Orange Varieties. Journal of Food Engineering Research, 66. Pg 299 – 305.

Weiss, E. A. 2002. Spice Crops. CAB. International Publishing, Oxon, UK.

DESIGN AND CONSTRUCTION OF *Thevetia peruviana* SEED DEHULLER FOR BIO-DIESEL PRODUCTION IN NIGERIA

***Jimo, K. A, Nasirudeen, A. R, Balogun, L.A, Oladebo, M.A And Gbopa, A.R**
Department of Agricultural & Bio-Environmental Engineering, Oyo State College of Agriculture, Igboora.
*Corresponding authors: kabyjayengineer@gmail.com
(08038177175)

ABSTRACT
The alarming rate of the increase in the price of diesel oil (0.72EUR) in Nigeria has called for an alternative source for this highly demanded product for both Industrial and transport sectors of the country. *Jatropha curcus* Is most widely promoted crop for bio-diesel production all over the world and locally produced seeds in South-western Nigeria were discovered to have less than 10% oil. This necessitated a research into another oil producing crop with no other economic use. *Thevetia peruviana* which contain more than 50% oil (19% of whole seed) with less demand for more economic use except as an ornamental tree and to provide shade in schools and hospitals. Dehulling, being a major process in getting whole nuts from the seed for extraction of oil led into the design and construction of thevetia peruviana dehuller. The machine was designed such that each kernel would drop in between two reciprocating blades which in turn split the kernel and allow the splitted kernel to drop for another one to take position while the whole process continues. The hopper has a metering device and below the blade mechanism lies a positioner and the two systems are controlled by a camshaft similar in operation to the inlet and outlet valves of an internal combustion engine. The timing of the three operations is controlled through the timing chain and sprocket mechanism on the cam shaft and the slider crank mechanism shaft. The machine was tested and the operation capacity for cracked kernel was obtained as 300kg/hr.With this achievement, the use of thevetia peruviana as an alternative source of fuel to jatropha curcus in the production of bio-diesel becomes feasible.

Keywords: *Thevetia peruviana*, Dehulling, Jatropha Curcus, Bio-diesel, Kernel

1.0 INTRODUCTION
The ever-increasing need for energy in both the developed and the developing nations calls for nations to rise up to look for alternative sources of energy. In the course of this, many oil yielding seeds have been tried for

the production of bio-diesel; *Jatropha caucus* has been the most widely accepted, basically for two reasons.

- That the plant has no economical use as of now makes its use for bio-diesel production economical.
- That it is drought tolerant makes it cultivatable in most part of the country.

Unfortunately, the breed of this seed available in the south-western part of Nigeria has less oil yield.

It is in the light of this, that research was conducted into the use of *thevetia peruviana* seed which incidentally grows normally on every part of Nigeria. It is drought tolerant and requires minimum input for cultivation. It fruits round the year and has no known economic use for now.

The oil content of this seed was found to be 50% which is about 19% of the whole seed (Paul *et al*., 2007). Various physical properties of the seed, like the shape, bulk density, true volume, bulk volume, sphericity etc were also determined. The seed is found to have a very hard endocarp which encloses the nut that contain 50% oil, when it is dried to 13% moisture content, the endocarp becomes hard and it can at this point be easily splitted into two equal halves and at this moisture content, the nut shrinks and become detachable. (Nasirudeen *et al*., 2013)

The study on *Thevetia peruviana* shows that the major task to be accomplished if it is to be used as a raw material for bio-diesel production is to develop a seed de-huller for it and the above facts led into the design and construction of this machine.

2.0 MATERIALS AND METHOD

2.1 Materials

The materials used include Bajaj Crankshaft, Connecting rods, flat spring material for blade, coil springs, spur gears, mild steel plate, angle iron, bearings, pulleys, belt and Electric motor.

2.2 Methodology

The design of the machine is sectioned into five viz: The metering hopper, the splitting mechanism, the positioner, driving mechanism and the main frame.

2.2.1 The metering hopper

The metering hopper was designed such that it will discharge set of seeds in layers. The lower part was dimensioned such that it can only allow the kernels to pass horizontally; this makes it possible for the blade to only cut along the joint of the kernel, thereby splitting the kernel into two. The height of the slot for the blade was made to be half of the mean minor

diameter of the kernel, it is at this position that the blade will be for cutting.

2.2.2 The splitting mechanism

The splitting mechanism consists of the reciprocating blade, crankshaft, the bearings, timing spur gears.

2.2.3 The positioner

The Crank shaft via the connecting rod holds the blade which enters the slot at the lower part of the hopper. As the shaft rotates, it transmits a reciprocating motion to the blade which makes the blade to go in and out of the lower part of the hopper. The second crank shaft is connected to a positioner plate which covers the lower part of the hopper.

The prime mover is connected to the shaft of the positioner plate via pulley and belts, and the motion is transmitted to the blade shaft via the spur gears with the blade running at half the speed of the positioner plate. The spur gears serve as transmission system as well as timer in that the meshing is done such that the positioner plate leads the blade by 15^0

2.2.4 Driving mechanism

The shaft of the positioner is driven by a 1HP motor with 1500rpm via pulley system with speed ratio 1:3. Thus, the positioner plate is opening and closing five hundred times in a minute. Since the splitting blade will run half the positioner plate, then the belt will run at two hundred and fifty times in a minute.

For effective functioning of the blade and the positioner, the centre distance of the two driving shafts is 300mm.

Therefore, the pitch circle diameter of the two gears divided by 2 = *300mm*

If the circle diameter of the wheel is D_p

And the circle diameter of the pinion is d_p

$$\text{Then } \frac{D_p + d_p}{2} = 300mm$$

But $D_p = Z_D m \text{ and } d_p = Z_d m$, where M is the module

Choosing module to be 1.5, then

$$D_p = 1.5\, Z_D \text{ and } \quad d_p = Z_d m$$

$$\text{But } \frac{D_p}{d_p} = 2, \text{ therefore } D_p = 2\, d_p$$

$$3d_p = 300, therefore, d_p = 100mm$$

$$1.5\, Z_p = 100, \text{ then } Z_p = 67mm$$

$$D_p = 67 * 1.5 = 100.5$$

Therefore, tip diameter = $D_a = D_p + 2m = 100.5 + 6 = 106.5$

Root diameter $D_f = D_p - 2.5m = 100.5 - 7.5 = 93mm$

Similarly, for the wheel

$D_p = 2\,d_p = 200$

$1.5\,Z_p = 200$

Therefore, $Z_p = \frac{200}{1.5} = 133.33 = 134\ approx.$

$D_p = 1.5 * 134 = 201$

Therefore, tip diameter = $D_a = D_p + 2m = 201 + 6 = 207$

Root diameter $D_f = D_p - 2.5m = 201 - 7.5 = 193.5mm$

Having known the parameters of the gears. They were sourced from Owode Onirin market. Lagos.

2.2.5 The main frame

This was made out of Angle iron 50 x 50mm by 3mm thick and 3mm thick mild steel plate. The hopper was centrally positioned between the two driving shafts while the centre distance of the shafts was maintained at 300mm. there is one outlet centrally located at the lower part of the main body where both the nut and the shell will come out. The most critical part to assemble in the machine is the timing spur gears.

For proper timing, the positioner will be fixed at the end of closing the lower part of the hopper then the pinion will be fixed. It was thereafter moved 14mm along the circumference length of the tip diameter. It was kept in this position when the blade was moved to the end of splitting while in this position, the wheel was fixed.

With this assembly, the positioner leads the blade by 15^0 when splitting and when discharging.

3.0 RESULTS AND DISCUSSIONS

After assembling the de-hulling machine, it was test-run on no-load condition for about One hour while the movement of the blade and the positioned relative to each other, vibrations due to eccentricity, noise due to vibrations and the fact that the frame was fabricated and not cast were observed and found to be satisfactory within the level of scope of the observers.

Thevetia peruviana kernels, processed from the fruits gotten within Igboora and Eruwa in Oyo state were dried in the workshop of the department of Agricultural and Bio-environmental Engineering of Oyo state college of Agriculture and ensured 13% moisture content on dry basis.

The machine was tested with 50kg of kernel and they were completely splitted in 10minutes. The output which is a mixture of the nuts and the shell were separated manually after which it was discovered that 40% of the nuts were damaged and some of the shells were broken while some were splitted.

With these observations, it was discovered that one of the problems for much damage is that the kernel were not graded.

The minor diameter and the thickness dimensions are two close, this makes it difficult to use dimension on the metering hopper to position all kernels properly.

4.0 CONCLUSIONS

Though we were able to de-hull at the rate of 300kg/hr, with the problems associated with the result. More work still need to be done to improve its performance. Also, alternative design conception must be developed and tried.

REFERENCES

Ballancy, P.L, 1999 "theory of machines and Mechanisms" ISBN 81-7409-033-9,: 286-298

Fawcett J.N, Burdess J.S., 1993, "Basic Mechanics with Engineering Applications" ISBN 0-7131-3620-0; 43-47

Hindustan Machine Tools, 2002, "Design standard handbook": 73-74

Nasirudeen A.R., Balogun L.A., Jimo K.A., Akangbe O.E "Engineering Properties Of Thevetia Peruviana Kernel For The Development Of Processing Machines For Bio-Diesel Production" 2013

Paul A.et al 2007 "Green fuel development in Africa"

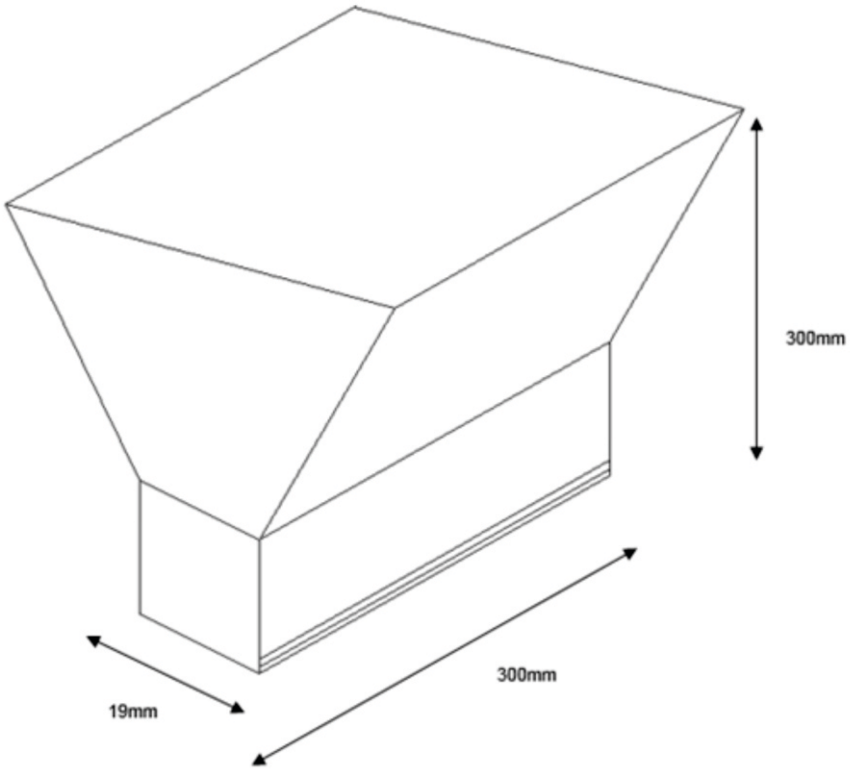


Fig 1: The Metering Hopper

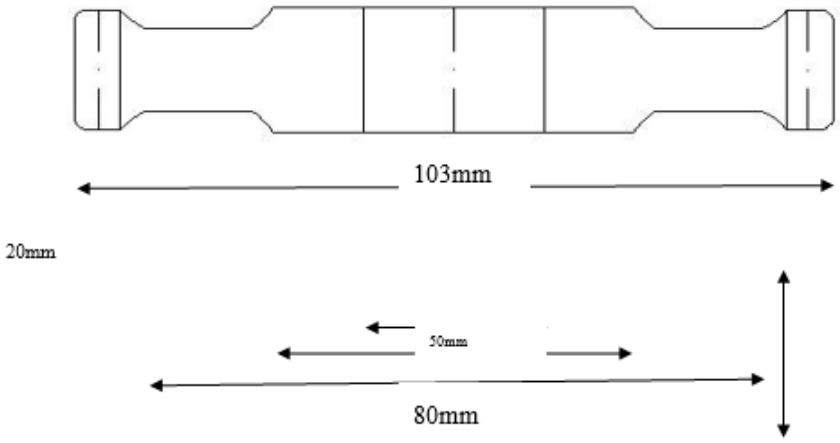


Figure 2: First Crankshaft

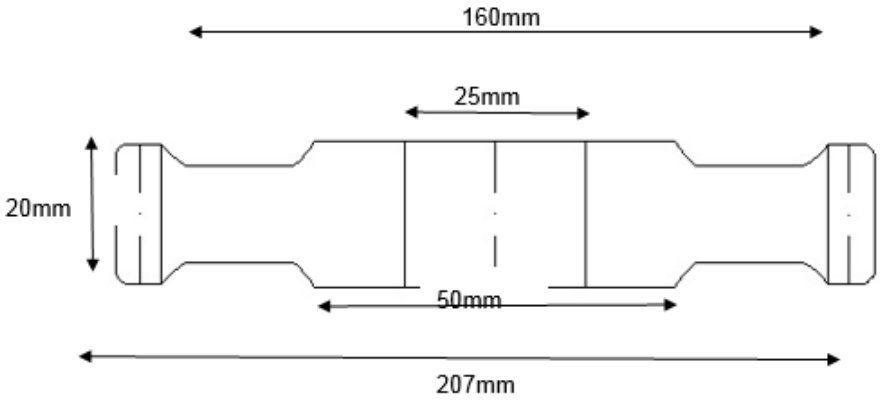


Figure 3: Second crankshaft

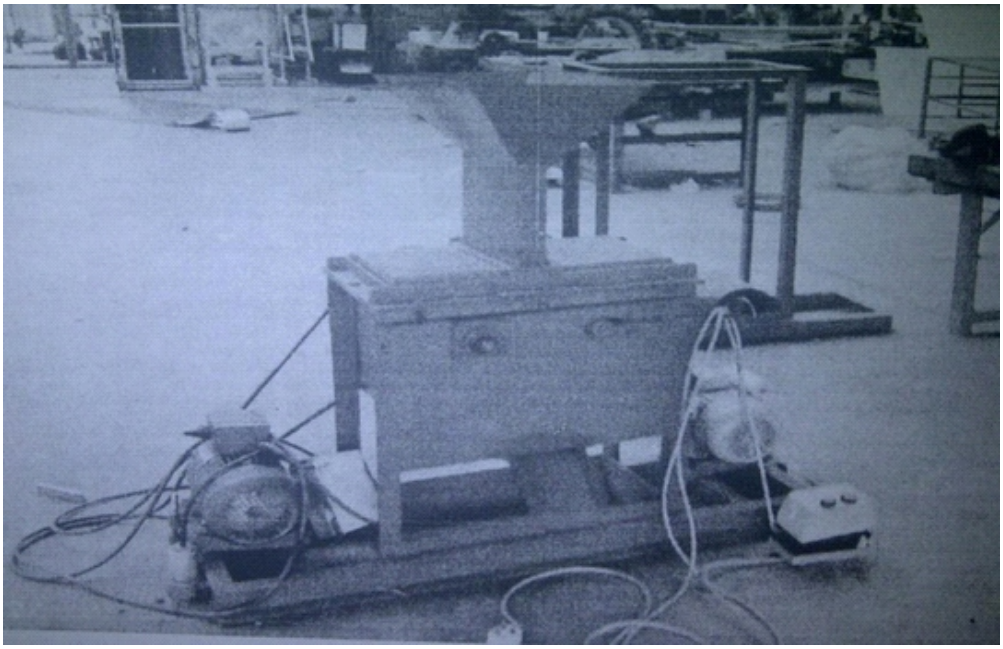


Plate1: *Thevetia Peruviana* Seed Dehuller

EFFECT OF UV-IRRADIATION ON MICROBIAL LOAD OF DRIED TOMATO SAMPLES

Atanu, S. O., V. A. Abodenyi and K. W. Leddi
Agricultural and Bio-Environmental Engineering Department, Federal Polytechnic, Bauchi
osatanu@yahoo.com; vicabode@yahoo.com Tel: 07039621534

ABSTRACT
Dried tomato samples were purchased from Muda Lawal market within Bauchi metropolis and examined for their bacterial and fungal loads. The samples were replicated three times and exposed to UV irradiation in the Bacteriological hood at exposure levels of180nm,200nm and 220nm and examined for both organism at intervals of 2, 4 and 6 hours respectively. The bacterial load of non- irradiated tomato samples was found to have an average count of 197.78 while fungal load averaged 205.33. A total of three different species of bacteria were isolated and identified as *staphylococcus aureus*, *Escheria coli* and *Enterobacter Spp*. While only *Aspergillus Spp.* was isolated for fungi. Results indicate a massive contamination of the product by both bacteria and fungi. However, after exposure of the samples to UV irradiation, microbial load reduced drastically with increasing exposure levels and contact time. Both bacteria and fungi were totally destroyed after exposure to 220nm irradiation for 6hours. When the result were subjected to analysis of variance (ANOVA) at $\alpha = 0.01$, there was no significant difference on the effect of the treatment on both bacterial and fungal load. It is suggested that exposure to UV irradiation at 220nm for 6hours be used to reduce the microbial load of retailed dry tomatoes.

Keywords: Ultra-Violet, Irradiation, Microbial Load, Dried Tomato

1.0 INTRODUCTION

Tomato is a widely cultivated vegetable grown for its edible fruits. It belongs to the genus lycopersicon and family solanaceace (Liverotti and Moresi 1982). Tomato production in Nigeria is mostly in the savanna region notably Kano, Bauchi, and Plateau states because the climatic conditions of these regions favor its growth (Atanu et al., 2013). However, most of the produce is wasted due to poor handling, processing, and storage techniques. Most of the wastages occur during the peak period of production usually between February and April of each year (Atanu et al., 2013). Tomato is highly vulnerable to post harvest losses because its high moisture content enhances spoilage either by microorganisms or its intrinsic enzymes. In Nigeria, the annual loss ranges from between 20 to 50% and this is a serious financial burden to the grower, middlemen and retailers (Mogaji and Fapetu, 2011).

Fresh tomato is eaten freely across the world, and their consumption is believed to benefit the heart, reduce cardiovascular risk association with type II diabetes. Also tomato consumption has been associated with decreased risk of breast cancer (Evangelia et al, 2005). Tomato contains ceratone lycopene one of the most powerful natural antioxidants. Studies show that lycopene, especially in cooked tomatoes have been found to help prevent prostate cancer (Evangelia et al., 2005). Tomato contain about 93% water, 1.1% protein, 0.3% fat which makes it more susceptible to spoilage by micro organism especially Fungi and bacteria (Ihekoronye and Ngoddy, 1985). Table 1 shows the proximate composition of fresh tomato fruits

Open-air sun drying (OAD) of the sliced tomato fruit is the method mostly adopted by the rural farmers to process their produce from spoilage leading to economic loss. The drying rate of open air drying is so slow that the drying period extends for days thereby giving room for mould infestation, loss of pulp and discoloration. OAD is not an efficient method of preservation.

Irradiation is the process of exposing foods to ionizing radiation to destroy micro organism, bacteria, viruses, insects and rodents that might be present in the food. Irradiated food does not become radioactive, but in some cases there may be subtle chemical changes. One of the first application of ionizing radiation for food was in 1943 on ground meat (Gold, 1966), Irradiation exposes the food to ionizing radiation, either high energy electron or X-rays from accelerated or by gamma rays (emitted from radioactive sources such as cobalt-60 or caesium-137). The treatment has a range of effects including killing and spoiling fruits, and at higher doses including sterility. The technology may be compared to pasteurization. It is sometimes called cold pasteurization, as the product is not heated (Anon, 1991).

Irradiation is not effective against viruses, it cannot eliminate toxins already formed by micro organism and it is only useful for food of high initial quality (Anon, 1991).

Hauther et al., 2008 reports that consumer organization, National and International bodies have declared food irradiation as "Wholesome". The UN, WHO and FAO have endorsed the use of food irradiation. It is estimated that about 500,000 tons of food items are irradiated per year worldwide in over 40years.

Food items exposed to UV irradiation range from potatoes, onions, meat, cereal, fruits, vegetable, fish, egg and yam, Although irradiation has not been increasingly accepted as a vital tool for modern day technology, it has been employed for the achievement of may objectives varying from Agriculture to Medicine (Screenirasan, 1990). The limited shelf-life or fresh processed tomato is one of the greatest problems encountered by commercial marketers. The objective of the study is to evacuate the efficiency of using UV-Irradiation in the reduction of microbial loads of dry tomato, thus ensuring safe and wholesome storage of tomatoes for a long period of time without deterioration thereby extending the shelf-life.

2.0 MATERIALS AND METHODS.

2.1 Collection of Samples

Samples of the dried tomato were purchased from Muda Lawal Market within Bauchi Metropolis in cellophane bags sterilized with UV irradiation at 230nm for 1hr in the laboratory.

2.1.1 Preparation of sample.

The dried tomato samples were transferred into a sterile mortar (swabbed with 70% alcohol) and blended using a pestle. Samples were stored later use.

2.1.2 Preparation of serial dilution for total microbial count.

1gm of the blended sample was dissolved in 9ml of distilled water in a sterile tube using a pipette; serial dilution of up to 10^{-5} dilution was used.

2.1.3 Isolation of bacteria

Nutrient Agar was used to support the growth of bacteria. 0.1ml of the serial dilution mixture was cultured on nutrient agar using the spread plate method. The plate was incubated for 24hrs at 37^{o}C. Total microbial count was determined using the colony

counter.

2.1.4 Isolation of fungi

Potato Dextrose Agar (PDA) was used to support the growth of fungi. The samples was inoculated into Petri dishes and allowed to gel. The plate was incubated at 28°C for 5days and colonies counted.

2.1.5 Identification and characterization of isolated organisms.

The isolated bacteria colonies were identified by picking discrete colonies, purifying by further culturing and then gram staining and performing motility tests as described by Cheesbrough, 2005.

The fungal isolates were identified based solely on the cultural and morphological characteristics using the methods described by Baker et al (1995), Cheesbrough (2005) and Ijebor et al (2013).

2.1.6 Colony counts

After incubation, the plates were taken for colony counting and the colonies counted using the colony counter device. The counting struck was to count the colonies and values recorded as colony forming unit per ml using the formula (Ijebor et al, 2013)

$$TML = \frac{N}{VR}$$

Where

TML = Total microbial load
N = Number of discrete colonies
R = Dilution factor
V = Volume of aliquot plated out

2.3 Irradiation

Samples of dry tomato were exposed to UV radiation in the bacteriological hood at 180nm, 200nm, and 220nm at 2, 4, and 6 hourly intervals. This was done to reduce the microbial load of the sample. A portion was removed at intervals of 2, 4 and 6 hours and analysis for total fungal and bacteria count to assess the rate of radiation of the Bacterial and Fungal loads

3.0 RESULTS AND DISCUSSIONS

Table 2 shows the microbial load of dried non-irradiated tomato samples. Before exposure to UV Irradiation all sample were analyses for both Fungal and Bacterial loads. The average count of microbial load of dried non irradiated tomato at 0 hour indicate that the tomato samples were heavily contaminated giving the average count of 205.33 and 197.78 for Fungi and Bacteria respectively. Table 3 shows the fungal load of dried irradiated tomato samples. Table 4 shows the bacterial load of dried irradiated tomato samples. The results from tables 3 and 4 show that as irradiation frequencies increase with time, the number of fungal and bacterial loads decreases at 180, 200 and 220nm for 2, 4 and 6hrs respectively. It is indicative that the number of viable microbes decreased due to the effect of the UV-irradiation on the microbial load. This shows that both fungi and bacteria are not resistant to UV-irradiation at 220nm for 6hrs of exposure as all the fungi and bacteria were totally destroyed. The UV-irradiation attacks the vital DNA of the organisms directly beyond its ability to repair. The radiation initiates a photochemical reaction that destroys the genetic information contained in the DNA. The microorganisms lose their reproductive and pathogenic capability and are destroyed. The reduction in the microbial load of irradiated dried tomato samples confirms the suggestion of the International Atomic Energy Agency (IAEA) (1991). The application of

food irradiation aims at certain biological effects such as the destruction of microorganisms. Table 5 shows the isolates identified in irradiated dried tomato samples at different time intervals. After 6hrs of exposure to UV irradiation there was no growth of both bacteria and fungi organisms. The complete disappearance of Aspergillus spp and Escheria coli after 6 hrs exposure suggest that even spores of the organisms are not resistant to UV irradiation.

CONCLUSION

The results suggest that the use of UV irradiation as a preservation technique greatly reduces the microbial loads of food since the use of UV irradiation at 220nm for 6hrs destroyed completely microorganisms thereby making the product safe for storage as well as prolong the shelf-life of the product.

REFERENCES

Anon., I (1991). Food Irradiation. A technique for preserving and improving the safety of food.

WHO publication, Geneva.

Atanu., O.S, Ohanwe C.N and S.J Yakmut (2013). Drying characteristics of ripened tomato fruits (Rinata variety). *Yankari Journal.* Vol. 9**:** 78 – 81.

Baker., F.T; D. Kilshaw and R.E. Silverton (1995) Preparation of culture media – Introduction to Medical Laboratory Technology. 6th Edition. Pp 7 – 12, 45, 263 – 274.

Cheesbrough., M (2005) District Laboratory Practice in Tropical Countries part 2: Cambridge Low price edition. Pp 34, 46, 50, 140, 190, 235 – 248.

Evangelia., M., G. Stefania, R. Ruggero and Stefani, R (2005). Passion flower fruits – "a new source of lylopene" *Journal of medical food* Vol. 2(6):180 – 188.

Gold., B. O (1966) "Preservation of meat by ionizing Radiation" 21st European meeting of Research workers, Rapporteeurs paper No: 14 Berlin, Germany..

Hauther., W., X. Worth and N. Zappedi (2008). Irradiation and the dearth of food. Food and water watch press. Washington DC.

IAEA (1991) Safety of Irradiated Food: Biological aspect in process - SOS 70. 3rd International Congress of Food Science and Technology. Washington DC Pp 78 – 83.

Ihekoronye., P.E and P.O. Ngoddy (1985). Intergrated Food Science and Technology for the Tropics. Macmillan publishers, Ibadan. Nigeria. Pp. 306 – 309.

Ijebor., J.A., Iruolaji F.O., Ijebor D.F. and A. Saminu (2013). Formulation of solid cultural medium from millet chaff for the Isolation and Enumeration of Bacteria and Fungi. *Yankari Journal*. Vol. 9: 69 –77.

Livoretti., C and Moresi M (1982) Economic Study of Tomato Paste Production. *Journal of Food Technology.* 17 (2)**:** 177 – 192.

Mogaji., T .S and Fapetu, O. S (2011) Development of an Evaporative Cooling system for the Preservation of fresh vegetables. *African Journal of Food science.* Vol. 5(4**):** Pp. 255 – 266.

Screenivasan., J (1990) "Benefits of irradiated foods" WHO Memorandum February 1990. Pp 99 – 101

Table 1: Proximate Composition of Fresh Tomato

Water	93%
Protein	1.1%
Fat	0.3%
Nutrients(mg/100g	
Calcium	11mg
Iron	0.6mg
Vitamin A	0.700
Thiamine	0.06mg
Ribonflavin	0.4mg
Niacin	0.5mg
Ascorbic acid (Vit.C)	23mg

Source: Ihekoronye and Ngoddy (1985)

Table 2: Microbial Load of Dried Non-Irradiated Tomato Samples

samples	Fungi	Bacteria
1	203.33	206.67
2	213.33	190.67
3	199.33	196.00

Table 3: Fungal Load of Dried Irradiated Tomato Samples

	Time (Hrs)		
Dose (nm)	2	4	6
180	72.33	52.00	30.67
200	23.67	12.67	10.33
220	13.67	2.67	0.00

Table 4: Bacterial Load of Dried Irradiated Tomato Samples

	Time (Hrs)		
Dose (nm)	2	4	6
180	32.33	24.33	6.00
200	23.67	10.33	9.00
220	10.00	2.67	0.00

Table 5: Isolates Identified In Irradiated Dry Tomato Samples

Time (hrs)	Fungal isolates	Bacterial isolates
0	Aspergillus Spp	Escheria Coli
		Enterobacter Spp
		Staphylococcus Spp
2	Aspergillus Spp	Escheria Coli
4	Aspergillus Spp	Escheria Coli
6	NG	NG

Design and Performance of HEFINC840 Micro-controller Based Incubator

A. Mohammad[1]; M. J. Musa[2]; K. Ahmad[3]; S. Garba[4] and M.D. Almustapha[5]
[1,2,3,4 & 5] Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT
Incubation and hatching of eggs is as old as man but what is not as old as man is the act of incubation using the artificial method. This paper presents the design and performance of the HEFIN840 micro-controller based incubator. To achieve a cost effective design, local material were used in the design. The design was implemented and performance test was run on full capacity (840 chicken eggs). The designed temperature and humidity were stable with number of data points failing test of 0 and 1 respectively. The overall % hatchability and % fertility of the design was found to be 88.21% and 95.83% respectively.

Keywords: Artificial Incubation, Microcontroller, Hefinc840, Performance

1.0 INTRODUCTION

Many domestic bird owners incubate eggs to help sustain their flock over time. This fact sheet is designed to assist those who wish to incubate small numbers of domestic poultry eggs. There are several patents on hatch incubator and some of these discussed here.

Cannon, (1993a**)** have built up an apparatus design for incubating and hatching eggs. The design is about positioning and moving tray of eggs at certain angle for optimum performance. One of the main concerns in hatchery process is to maintain the air temperature around inside the incubator within 99-102° F but unfortunately living embryos produce heats which will interfere with the environment. For optimum performance, Robert W. Cannon also have patent up heat removal and recovery system for incubators and hatchers to overcome this situation. (Cannon, 1993b).

Han-Way (2005) presents the accuracy that can be achieved by using PIC microcontroller for controlling automated system in his book "PIC Microcontroller: An Introduction to Software and Hardware Interfacing" Ionive (2000) proposed using PIC microcontrollers programmed using different programming languages to realize high degree of precision in monitoring systems like hatchery which require high level of parameter precision to achieve optimum results in this book "PIC Microcontroller Project Book". Horowitz and Hill (1995) in their book "The Art of Electronics" suggested the accurate method of selecting the suitable discrete and integrated circuits components in applications like incubation machines in order to avoid the problem caused by variation in the specifications of the components which normally happen during production stages. Parkers (2001) in his paper "New Design Ideas with Integrated circuits" proposed novel methods of designing electronic circuits that would be more accurate in their operation especially in designing systems that are highly sensitive to variations in key parameters.

2.0 MATERIALS AND METHODS

The material used for this design were microcontroller (PIC 16F877A), humidity sensor (HM-20G), temperature sensor LM35, drivers (UNL 2003), actuators, LCD

(16x2), crystal, micro-switches, LEDs (Light Emitted Diodes), assorted resistors and capacitors.
The methods adopt in this design include both the hardware and programming of;
Temperature control,
Humidity control and
Eggs turning control
Temperature Control test and tests of its special causes,
Humidity Control test and tests of its special causes,
General performance test of the complete system, based on its percentage of hatchability will be conduct.

2.1 Design Implementation

The design method and tests of the whole system was trickily followed:

2.1.1 Humidity sensor

The HSM-20G sensor was used to sense the humidity in the chamber and permits total control of humidity.

Humidity control when incubating chicken eggs

Under artificial incubation, the requirement for humidity is not as strict as that for temperature. The chicken embryos are more adaptive to humidity range, based on the fact that the water contained in chicken eggs is also enough for its embryonic development. However, it doesn't mean that humidity should not be paid attention. For high hatchability, humidity must be properly controlled.

Generally speaking, the relative humidity should be kept near 60% during the first seven days, and 50%-60% between the eighth and eighteenth day, 65%-70% after the eighteenth day. High humidity will obstruct the evaporation of the allantoises fluid, which will produce a chick with big stomach. At the sometime, because of excess water in the chick body, the chick appears stodgy and dull. On the contrast, low humidity will cause excess evaporation of water in the egg, which will produce bony and little chick. Therefore, to control the humidity is dispensable.
The humidity of HEFINC480 is easily controlled, safe and maintain through a unique, predefine, preset switch at the control panel. It also permits rest and reselection of humidity value.

2.1.2 Temperature sensor

The LM35 IC, from National Semiconductor Corporation was selected; this depends on factors such as the temperature range, required accuracy, environment, time response, ease of use, less cost, and interchangeability. It is precision integrated-circuit temperature sensor, which output voltage is linearly proportional to the ? temperature. This is an advantage over linear temperature sensors calibrated in °K, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling.

3.0 RESULTS AND DISCUSSION

It does not require any external calibration or trimming to provide typical accuracy. LM35 sensor is placed close to the heating circulation fan, to read the correct temperature of the air in the incubator's chamber. Tab.1 shows the output voltage from the sensor corresponded with the temperature.

3.1 The Temperature Range For Embryonic Development.

Chicken eggs have adaptive capacity awards ambient temperature, and some eggs can still hatch under temperature range of 36-40.5? (96.5-105°F). But when an incubation machine is utilized, the temperature mentioned above is not the most favorable temperature. Instead, the most appropriate temperature for incubation is 38.0? (100°F), and the most appropriate temperature during hatching process is 37.0-37.5? which the HEFINC480 can accurately provide.

3.2 The Influence of High or Low Temperature to Chicken Eggs Embryonic Development

High and low temperature has great influences on embryonic development.

3.3 The Influence Of High Temperature To Embryonic Development

Under high temperature, the chicken embryo develops very fast, which may lead to a shortening of incubation period and hence leads to increase of embryo death rate or decreases the quality of chicks. The death rate may vary depending on the degree of the temperature oversetting and the duration of this oversetting. When the temperature is over 47?, the embryo dies within 2 hours. When chicken eggs incubated for 5 days are incubated under 47?, all the embryos will dies within 2 hours. When chicken eggs incubated for 16 days are incubated under 40.6? for 24 hours, the hatchability will fall down to some degree, under 43.3? for 9 hours, hatchability declining to a great extent, under 48.9? (120°F) for one hour, 100% of the embryos in the incubator die.

3.4 The Influence Of Low Temperature To Embryonic Development

When the temperature is under appropriate temperature, the incubation period will be longer and the death rate will increase. When incubated under 35.6? (96°F), most of the embryos die in the egg shells. Little deviation from proper temperature will cause less influence to the embryonic development, due to adjustment from embryo itself.

3.5 Turning

In natural Incubation, mother hen frequently turns eggs with its feet and beak. This kind of intuitive work by hen is to warm every part of the embryo, avoid adhesion of embryo with egg shell, so as to increase hatchability.

Generally speaking, eggs should be turned more often in artificial incubator for good incubation. 8-12 times is ideal within one day. The egg should be turned for 90 degrees (i.e. 45^0 clockwise and 45^0 anticlockwise) always making an angle of 45^0 with the horizontal axis.

HEFINC480 was program with flexible eggs turning, user define selection switch, ranging from a minute to an hour and half. This deliberate eggs turning design of the incubator provides a minimum turning of exactly 16 times a day which is excellent for incubation.

3.6 Microcontroller (PIC 16F877A)

Microcontrollers, as stated, are inexpensive computers. The microcontroller's ability to store and run unique programs makes it extremely versatile. The microcontroller's ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuits. (John Iovin, 2000). Microcontrollers are general purpose microprocessors which have additional parts that allow them to control external devices. PIC16F877A is selected for this system because it is cheaper, adequate of analogue input and equipped with internal ADC circuit. By using PIC16F877A, the whole design circuit can be simplified and easy for troubleshooting.

3.7 Liquid Crystal Display (LCD)

The LCD was configured to drive its dot-matrix under the control of 4- bit output of the microcontroller. A regulated supply of 5V was used to supply the chip which is within the recommended supply voltage of the chip. The pin 2 of the chip is the *Vcc* while pin 1 is the ground and was connected to the 0 line of the supply. Since only four bits are used to receive data from the micro, the upper nibble of the byte line was used while the lower nibble (Do to D3) was connected to the ground. To achieve this, pins 7, 8, 9 and 10 (upper nibble) were grounded while pins 11 to pin 14 (lower nibble) were connected to receive the 4-bit data from the main microcontroller. A variable resistor is provided to adjust the brilliance of the LCD. For this design, a 10k variable resistor was used to vary the brightness of the LCD. Pin 6 of the LCD is used as the enable pin to activate the device and set it for operation. Pin 4 is the reset pin that is used to clear the registers of the LCD.

3.7 Relay

The relay is the actuator which serves as a switch to the temperature source, humidity element and the egg turner.

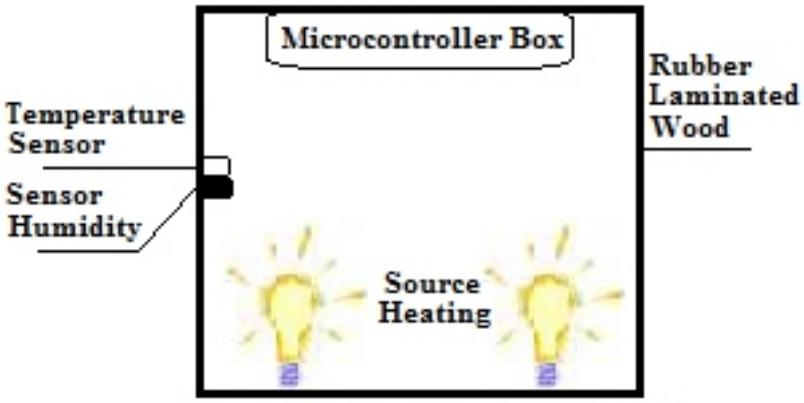


Fig. 1:Sketch of the System

3.8 Hardware

This design developed using rubber laminated wood. The heat element is a two 60W, 220V bulbs, mounted at the ground floor of the incubator's heating chamber. For measurement, system feedback uses a temperature sensor (LM35), humidity sensor (HSM-20G) and egg turning mechanism. Digital meter were embedded in the design to give the temperature, humidity and egg turning period display on LCD. Fig. 1 shows the

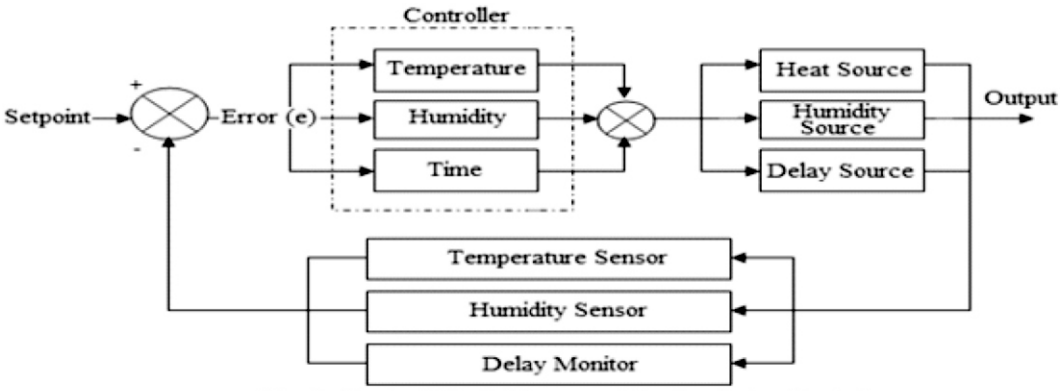


Fig. 2: Control Block Diagram of the Incubator Control

sketch of the system. The complete circuit of the design is presented on appendix A.

Fig. 2 shows the control block diagram of the system using microcontroller. By using microcontroller, the result has low overshot and low steady state error. The range of temperature and humidity of the incubator operation is between 36.2-37.9? and 57.2-60.4% respectively. User could set the temperature and humidity set points. The system will compare the desired value with the actual value and perform the control. The microcontroller uses the feedback from the sensor and gives the suitable output voltage based on the error. The error is the difference between the user-defined set point (the desired value) and the measured process variable (the actual value).

4.0 RESULT ANALYSIS

The overall reading of eighteen days of incubation gives the readings of the temperature and humidity as in Tab.2.

Days	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Temperature (Ä	**37.3**	**36.6**	**36.9**	**36.2**	**37.2**	**37.5**	**36.6**	**36.9**	**36.8**	**37.9**	**36.7**	**36.3**	**36.6**	**37.2**	**36.5**	**36.9**	**37.5**	**36.6**
R. Humidity (%)	**57.2**	**60.1**	**59.1**	**58.9**	**58.4**	**60.4**	**59**	**57.8**	**57.7**	**59.3**	**60.1**	**58.8**	**57.9**	**59.3**	**58.6**	**57.9**	**60.0**	**58.7**

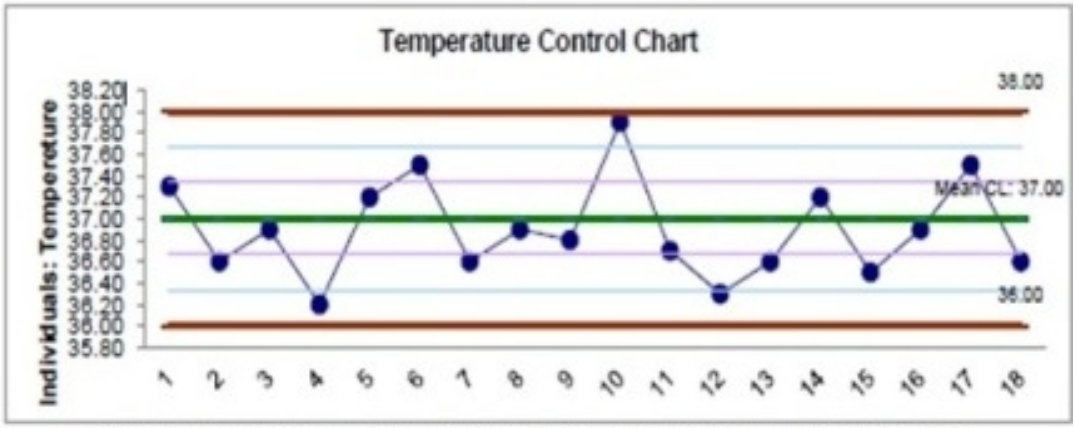


Fig. 3: Temperature Control of the Microcontroller Based HEFINC480

Tab. 2: Readings from the Incubator.

The temperature readings were analysed using the control chart tests for special causes and the chart with the observation summary is on Fig. 3 and Tab. 3.

Tab. 3: Tests for Special Causes of the Temperature Control Chart. Fig. 4.

Observation No.	Test 1: 1 point more than 3 Stdev from CL	Test 2: 9 points in a row on same side of CL	Test 3: 6 points in a row all increasing or all decreasing	Test 4: 14 points in a row alternating up and down	Test 5: 2 out of 3 points more than 2 Stdev from CL (same side)	Test 6: 4 out of 5 points more than 1 Stdev from CL (same side)	Test 7: 15 points in a row within 1 Stdev from CL (either side)	Test 8: 8 points in a row more than 1 Stdev from CL (either side)

Tests for Special Causes - Individuals: Temperature

Number of Data Points Failing Tests = 0

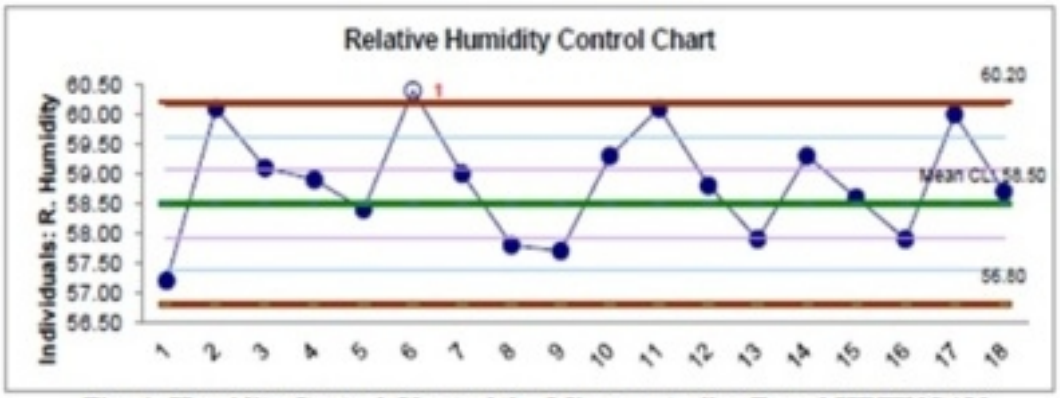


Fig. 4: Humidity Control Chart of the Microcontroller Based HEFINC480

The tests for special causes Tab. 3 of the temperature control chart Fig. 3 shows that, the

Tab. 4: Tests for Special Causes of the Humidity Control Chart. Fig. 5.

Observation No.	Test 1: 1 point more than 3 Stdev from CL	Test 2: 9 points in a row on same side of CL	Test 3: 6 points in a row all increasing or all decreasing	Test 4: 14 points in a row alternating up and down	Test 5: 2 out of 3 points more than 2 Stdev from CL (same side)	Test 6: 4 out of 5 points more than 1 Stdev from CL (same side)	Test 7: 15 points in a row within 1 Stdev from CL (either side)	Test 8: 8 points in a row more than 1 Stdev from CL (either side)
6	x							

Tests for Special Causes - Individuals: R. Humidity

Number of Data Points Failing Tests = 1

temperature of the incubator is withing the expected limits since all the readings are in between the Upper Control Limit **(UCL)** and the Lower Control Limit **(LCL)**. Hence the P- Value = 0.

Similarly, the humidity control chart Fig. 4 and its tests for special causes Tab. 4, shows that out of the eighteen readings plotted, one of the readings is not within the required limit. Hence, the humidity has an error of 5.6% and it has to be check.

$$\%\ hatchability = \frac{No.of\ eggs\ that\ hatch\ out}{No.of\ fertile\ eggs} \quad (1)$$

It can as well observe from the chart Fig. 4 that one of the points (point 6) is above of UCL, that gives a P-Value = 1.

Moreover, the overall hatchability of the HEFINC840 was calculated using equation (1) as 88.21% which very outstanding.

$$\%\ fertility = \frac{No.\ of\ fertile\ eggs}{No.of\ total\ eggs\ set} \quad (2)$$

The words "fertility" and "hatchability" are often used incorrectly by small producers. These terms are important and have very important meaning.

Percent hatchability: is the percentage of fertile eggs which actually hatch out as live young.

Percent fertility: is the percentage of fertile eggs of all eggs produced, equation (2) gave the mathematical expression of the term % fertility

Now the % fertility of the eggs sets is 95.83%. Fig. 5(a), (b), (c) and (d) show some important stages during hatching. While Fig. 6(a), (b) and (c) shows some important view of the finished products HEFINC840.

5.0 CONCLUSION

This paper uses microcontroller to control the parameters of HEFINC840 incubator for suitable and accurate egg hatchery process. It gives better output result than the manual and semi automatic control incubators. The important of this system is to reduce the overshoot as low as possible. The proper tuning is required to improve the system which was also achieved. Humidity is another variable that was also achieved. The output result of 88.21% hatchability out of 95.83% fertility was an excellent operation for optimum performance.

In conclusion, it was seen that overheating the embryo is much more damaging than under heating; overheating speeds up embryo development, lowers the percentage of hatchability, and causes abnormality in embryo development which may result to motility. Although a short cooling period may not be harmful, longer periods of low temperatures will reduce the rate of embryo development. Excessively low temperatures will kill the embryos. The main advantages of using microcontroller as the controller of the HEFINC840 are economical, high efficiency and user friendly.

6.0 RECOMMENDATION

This design could be beneficial to small scale poultry farmers.

REFERENCES

Robert W. Cannon (1993) a." Method and Apparatus Design for incubating and hatching eggs" United States Patent

Robert W. Cannon (1993) b. "Heat Removal and Recovery System for Incubators and Hatchers", United States Patent

John Iovine (2000) "PIC Microcontroller project book" Mc Graw-Hill Companies, New York San Francisco Washington, D. C. Auckland Bogota Caracas Lisbon London

APPENDIX A

Complete Control Circuit for the HEFINC840 Incubator

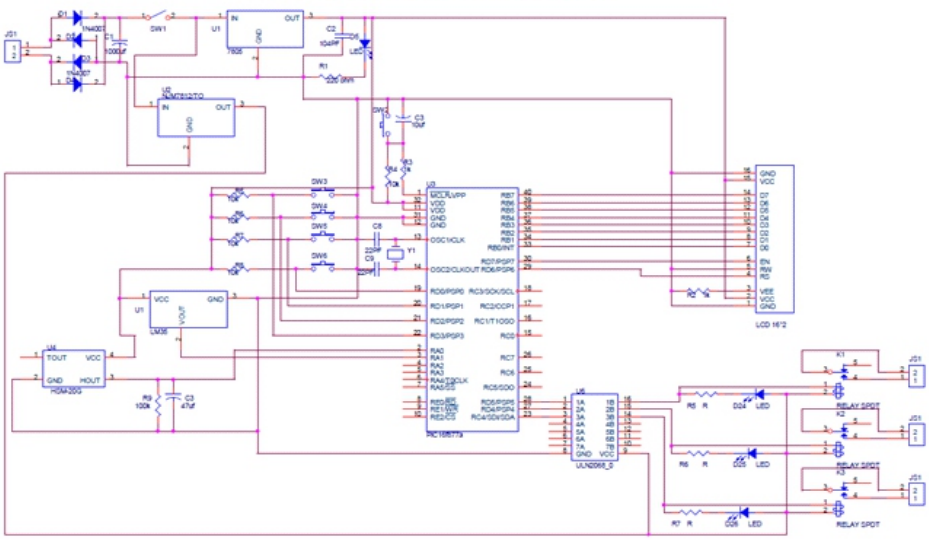




Fig. 5 (a): Eggs Ready to Hatch



Fig. 5 (b): Chicks Started Poping Out of the Shell







Fig. 6(a): Front View of HEFINC840



Fig. 6(b): Front View of HEFINC840 with 1 Door Open



Fig. 6(c): Front View of HEFINC840 Doors Open

FLOWERING RATE OF SNAKE TOMATOES AS AFFECTED BY DAY-LENGTH

***ohanyere, S. O.[1], C. O. Akubuo[2], And S. N. Asoegwu[1]**
[1]Department of Agricultural Engineering, F.U.T., Owerri
[2]Department of Agricultural and Bio-resources Engineering, University of Nigeria, Nsukka.
*Corresponding Author: E-mail:ohanyere1@gmail.com

ABSTRACT
The flowering rate of snake tomatoes (*Trichosanthes cucumerina, Linn*) as affected by day length was studied. Ten differently staked stands were used for the tests with the same number used as control. The tests were replicated four times over four different planting seasons with electricity used to extend the length of day. Sixty Watts (60W) bulbs with the luminous flux of 710 lumen spaced at 1.5m apart were used for the day-length extension. The average flowering rate of snake tomatoes with extended day length was 5 flowers per day while the control produced 1 flower per day. This shows that snake tomato is a long-day plant or conversely a short-night plant.

Keywords: Snake-Tomato, Day-length, Flowering, Luminous Flux, and Electricity.

1.0 INTRODUCTION

Snake tomatoes *(Trisochantes cucumerina, Linn)* belong to the family *cucurbitaceae* while those that grow in the wild are referred to as *Trisochantes anguina* (Chuku et. al., 2008; ECHO, 2000; Adebooye and Oloyede, 2006; Ojiako and Igwe, 2008).

Snake tomato is utilized as a substitute to the *Solanaceous* tomato *(Lycopersicon esculentum (L.) Mill)* due to its sweet tasting, aromatic, and deep red endocarp pulp when fully ripe and the fruit pulp does not go sour as quickly as the paste of *L. esculentum.* These good qualities have made this plant a substitute to the *solanaceous* tomato especially during the off-season when prices of *solanaceous* or vine tomato are very high (Chuku et. al., 2008). The pulp is a good source of ascorbic acid (23.1 – 23.3mg/100g), which is far higher than that of the popular *solanaceous* tomato varieties in Nigeria, thereby suggesting its possible use for paste and puree (Adebooye et. al., 2005; Adebooye, 2008; Adebooye, et. al. 2009). Snake tomatoes are also anthelminthic (Burkill, 1985). Tomatoes rank second in importance to potatoes *(Solanium tuberosum*) in many countries (Purseglove, 1977).

Snake tomatoes belong to the species of plants referred to as angiosperms or flowering plants. The flower is the part of the plant (shoot) specially modified for reproduction (Stone and Cozens, 1976; Okeke, et. al., 1983). Productivity of flowering plants is directly related to the number of flowers produced (Barnes and Poore, 1994) as they are responsible for both seed and fruit production. The snake tomato is a crawling plant which produces pods from its flowers which ripens to produce paste (i.e. the endocarp).

Among the several factors involved in inducing annuals to flower are juvenility, photoperiod, light intensity, and temperature. (Putterill, 2001; Izawa, 2007; Currey, et. al., 2011; Bartholomew and Kadzimon, 1977). The influence of the photoperiod on the flowering rate of snake tomatoes is being examined by this paper. Photoperiod is the

i. Short-day plants (SDP) which flower when day length is at or shorter than a certain time (also called long night plants);
ii. Long-day plants (LDP) which flower when day length is at or longer than a certain time (also called short-night plants) and;
iii. Day-neutral plants (DNP) which flower regardless of the day length. (Currey et. al., 2011; Barnes and Poore, 1998, Erwin et. al., 2002; Thomas and Vince-Prue; 1997).

They also concluded that it is actually the night length that determines flowering. Flowering in photoperiodic plants is sensed and regulated by a pigment known as phytochrome, which exists in two interconvertible forms – Pr 660 which absorbs light in the red (660nm) portion of the light spectrum and is converted to the second form – Pfr 730 that absorbs light in the far-red portion of the light spectrum (Kessler Jr., 2013; Barnes and Poor, 1998)

Pfr 730 is the physiologically active form of phytochrome and inhibits flowering in short-day plants and promotes flowering in long-day plants. A critical Pfr 730 level is reached below which flowering is no longer inhibited in short-day plants and flowering is no longer promoted in long-day plants (Kessler Jr.,2013)

Kressler (Jr) further stated that photosynthesis requires high light intensities for growth but in contrast photoperiodism is controlled by very low light intensities and short periods of lighting. This is commonly accomplished by supplying red light from incandescent lamps.

Some work has been done on snake tomato. Adebooye et. al. (2009) studied the root zone temperature effect on the emergence and growth traits of snake tomato. Phyto-constituents and anti-oxidant activity of the pulp of snake tomato has also been studied (Adebooye, 2008).

Fruit characteristics and nutrient composition of landrace morphotypes of snake tomato has also been undertaking by Adebooye, et. al., (2005). Adebooye and Oloyede (2006) studied the response of fruit yield and quality of snake tomato landraces to phosphorous rate. Chuku et. al., (2008) did comparative studies on the fungi and bio-chemical characteristics of snake gourd *(T. Cucumerina, Linn)* and tomato *(Lycopersicum esculentus, Mill)* in Rivers State, Nigeria. Oloyede and Adebooye (2005) studied the effect of season on growth, fruit yield and nutrient profile of two landraces of *Trichosanthes cucumerina, L.* The nutritive, anti-nutritive and hepatotoxic properties of *Trichosanthes anguina* (snake tomato) fruits from Nigeria has also been studied (Ojiako and Igwe, 2008).

From the above, it is seen that nothing yet has been done on the flowering of snake tomatoes which determines its reproduction and subsequent propagation. But some researchers have done some work on the flowering of some crops and trees. Olarewaju (1987) studied the effects of shoot pruning on flowering and fruit set in sweet pepper *(Capsium annuum L.)* while Mbah (1987) studied the flowering phenology of selected trees important in Southern Nigerian landscape.

The effects of day length on flowering, growth, and CAM (Crassulacean Acid Metabolism) of pineapple *(Annas Comosus [L.]Merrill)* was published in Botanical Gazette (1979). The study classified the 'Smooth Cayenne' pineapple as a quantitative short-day plant.

Bramibilla and Fornara (2013) studied the molecular control of flowering in response to day length in rice. Carr (2001) said the flowering of Arabidopsis plants is accelerated by long-day photoperiods and that recent genetic studies have identified elements of the photoperiodic timing mechanism. Studies by Soladoye and Adebisi (2004), Adebooye and Oloyede (2005) documented that there was little information in the literature on the agronomic practices for *Trichosanthes cucumerina.*

This work therefore is a study on the flowering rate of snake tomatoes *(T. cucumerina,*

Linn.) as affected by day length. It is aimed at determining other ways of improving and increasing crop productivity.

The objectives of this study are:

i. To determine how photoperiodic is snake tomato.

ii. To determine the effect of day length extension on flowering rate of snake tomatoes.

2.0 MATERIALS AND METHODS

The study was carried out at Ikembara in Ikeduru Local Government Area of Imo State located on latitude 5° 35'N, longitude 7° 09'E and 151meters above sea level. The soil type upon which the crops were planted is sandy loam. Ten stands spaced 1m apart were used at both ends of the 18 meter length house and the test was replicated four times alternatively for four rain-fed planting seasons. The light extension is for one end of building only per season while the other end was blacked out (control). Sixty (60) Watts bulbs of 710 lumen spaced at 1.5m apart was used for the day length extension. The day extension lasted 6 hours daily throughout the period of the test. The power supply was gotten from the public power supply and a private 3KVA generator to ensure constant and uninterrupted power supply to the plants as required. The bulbs were replaced every four (4) weeks when their illumination value must have dropped to below 70% (Gustafon and Morgan, 2004). The plants were staked during growth to prevent the tendrils crossing over to another stand.

The flowers were counted every week when they started flowering (6 weeks for day extended and 8 weeks for control) and tagged. The next counting started from the last tag. The test lasted for four (4) months. The rate of flowering was calculated from the number of flowers produced during the flowering period for both control i.e 56 days (8 weeks) and day length extension i.e 70 days (10 weeks).

3.0 RESULTS AND DISCUSSION

The average number flowers produced by the snake tomatoes with extended day length and the control for the four seasons is given in Table 1.

Table 1 show that the day extension had an effect on the flowering of the snake tomatoes as the number of flowers produced was about five times more than those of the control. It was also observed during the test that those with extended day length started flowering two (2) weeks earlier.

F-test was conducted for the homogeneity of the number of flowers produced with and without day length extension i.e. $s^2_{Extension}$ and $s^2_{Control}$. The result showed that F_{value} =12.29 while F_{tab} = 3.15 at 5% level. This means that the difference is highly significant at 5% level. Therefore day length extension has a high significant effect on the number of flowers produced.

From Table 1, the average number of flowers is 326.1 for day length extension and 62.2 for control. The number of days from start of flowering to the end of flowering for those with extended day length and control care 70 days and 56 days respectively. This brings the flowering rate for extended day length and control to 4.66 flowers per day and 1.11 flowers per day respectively. The number of flowers produced also determines the number that will translate from flowers to pods (fruits), hence those with extended day length will produce more yield. This therefore implies that the snake tomato *(T. cucumerina, Linn)* is a long day plant or conversely, a short night plant.

Therefore, for increased flower production which by extension implies more yield, the snake tomato should be grown under an extended day length or the periods when the day length is long and the night lengths short.

4.0 CONCLUSION

From this study, the following conclusions were arrived at:

i. The snake tomato *(Trichosanthes cucumerina)* is a long day plant producing about five (5) times more flowers for a 6-hour day length extension than the control.
ii. Day length extension made the snake tomato flower two weeks earlier than the control.

ACKNOWLEDGEMENT

Special thanks to Mr. Victor C. Ohanyere for his assistance in switching on/off the generator during public power outages at night.

REFERENCES

Adebooye, O. C. (2008). Phyto-constituents and anti-oxidant activity of the pulp of snake tomato *(Trichosanthes cucumerina, L.)*. African Journal of Traditional, Complementary and Alternative Medicines (AJTCAM) 5(2); 173 – 179.

Adebooye, O. C., F. M. Oloyede, J. T. Olabode and O. O. Onagoruwa (2005). Fruit characteristics and nutrient composition of three landrace morphotypes of snake tomato *(Trichosanthes cucumerina L.)*. Journal of Vegetable Science Vol. 11 (4): 5 – 16.

Adebooye, O. C. and F. M. Oloyede (2006). Response of fruit yield and quality of *Trichosantes cucumerina* landraces to phosphorus rate. Journal of Vegetable Science 12(1): 5 – 19.

Adebooye, O. C., G. J. Noga and C. Lankes, (2009). Root zone temperature affects emergence and growth traits of snake tomato *(Trichosanthes cucumerina L.)*. Journal of Central European Agriculture Vol. 10 (3): 239 – 244.

Barnes, C. and N. Poore, (1998). Crop productivity and light In: Plant Science in Action, a Focus on Biology, University of Nottingham. Pp. 21 – 28.

Bartholomew, D. P. and S. B. Kadzimin, (1977). Pineapple in P. T. Alvin and T. T. Kozlowski, eds. Ecophysiology of Tropical Crops. Academic Press, New York. Pp: 113-156

Botanical Gazette (1979). Published by the University of Chicago Press Vol. 140(3): 280 – 283.

Article stable URL: http://www.jstor.org/stable/2474576.

Brambilla, V. and F. Fornara, (2013). Molecular control of flowering in response to day length in rice. Journal of Integrated Plant Biology Vol. 55(5); 410 – 418.

Burkill, H. M., (1985). The useful plants of tropical West Africa, Vol. 1. Families A – D. Royal Botanic Gardens Kew P. 604.

Carr, I. A., (2001). Day-length perception and the photoperiodic regulation of flowering in Arabidopsis. Journal of Biological Rhythms, Vol. 16(4): 415 – 423.

Chukwu, E. C., D. N. Ogbonna, B. A. Onuegbu, and M. T. V. Adeleke, (2008). Comparative studies on the fungi and bio-chemical characteristics of snake gourd *(Trichosanthes cucumerina Linn)* and tomato *(Lycopersicon esculentus Mill)* in Rivers State, Nigeria. Journal of Applied Sciences 8(1): 168 – 172.

Currey, C.J. and R.G. Lopez, (2011). Flower Induction of Annuals: Commercial Greenhouse and Nursery Production. Purdue Extension Publication. Pp. 1-10.

ECHO, (2000). Snake gourd. ECHO Plant Information Sheet, USA. http://www.echonet.org.

Erwin, J., R. Warner and N. Mattson (2002). How does day length affect flowering of spring annuals? University of Minnesota Commercial Flower Growers Bulletin. Pp. 6 – 10.

Gustaton, R. J. and M. R. Morgan, (2004). Fundamentals of Electricity for Agriculture. 3rd Ed. American Society of Agricultural Engineers. Pp. 301 – 341.

Izawa, T., (2007). Daylength measurements by rice plants in photoperiodic short-day flowering. Int. Rev. Cytol. 256: 191 – 222.

Kessler, Jr.J.R.,(2013). Light duration. Downloaded from http://www.ag.auburn.edu/landscape/lightduration.html.

Mbah, B. N., (1987). Flowering phenology of selected trees important in Southern Nigerian Landscape. Proceedings of the 9th Annual Conference of the HORTSON, held at FUTO., Pp. 131 – 133.

Ojiako, O. A. and C. U. Igwe, (2008). The nutritive, anti-nutritive and hepatotoxic properties of *Trichosanthes anguina* (Snake tomato) fruits from Nigeria. Pakistan Journal of Nutrition, Vol. 7 (1): 85 – 89.

Okeke, E. A. C., O. A. Oyetola, J. B. Owolabi, P. P. Udofia, M. A. Abubakar, C. W. Ayabam, (1983). Science Teachers Association of Nigerian Biology. Addison – Wesley Publishers. Pp. 179 – 193.

Olarewaju, J.D., (1987). The effects of shoot pruning on flowering and fruit set in sweet pepper (Capsium annuum L.). Proceedings of the 9th Annual Conference of the Horticultural Society of Nigeria held at Federal Univ. of Tech., Owerri.

Oloyede, F. M., and O. C. Adebooye, (2005). Effect of season on growth, fruit yield and nutrient profile of two landraces of Trichosanthes cucumernia L. African Journal of Biotechnology. Vol. 4(10):1040 – 1044.

Purseglove, W. (1977). Tropical Crops Dicotyledons ,Vol. 1 and 2. English Language Book Society, Pp. 137 – 533.

Putterill, J. (2001). Flowering in time: genes controlling photoperiodic flowering in Arabidopsis. Transactions of the Royal Society of London. B. 356: 1761 – 1767.

Soladoye, M.O. and A.A. Adebisi, (2004). *Trichosanthes Cucumerina L.* in: Plant Resources of Tropical Africa (PROTA) 2: Vegetables. PROTA Foundation, Netherlands.

Backhuys Pulishers, Leiden, Netherlands/ Technical Centre for Agricultural and Rural Co-operation (CTA) Wageningen, Netherland. Pp. 532-534.

Stone, R.H., and A.B. Cozens, (1976). New Biology for West African Schools. Longman Group Limited, London. Pp 127-167.

Thomas, B. and D. Vince-Prune (1997). Photoperiodism in plants, 2nd Ed. Academic Press, New York, N. Y. Pp. 1 – 26.

Table 1: Number of Flowers Produced by the Snake Tomatoes With Extended Day-Length and control

Stake	Number of flowers	
	Extended day-length	Control
1	313	68
2	346	63
3	373	72
4	322	55
5	302	62
6	273	76
7	318	56
8	330	51
9	333	57
10	351	62
Average	**326.1**	**62.2**

TOWARDS TAKING AGRICULTURAL ENGINEERING IN NIGERIA TO THE NEXT LEVEL: THE ROLE OF COMPUTER-BASED SIMULATION MODELS

Henry E. Igbadun
Department of Agricultural Engineering, Ahmadu Bello University,
P.M.B. 1044, Zaria, Nigeria
(Presently on Sabbatical Leave to Department of Agricultural and Bio-resources Engineering,
Federal University of Technology, Minna, Niger State)
Email address: igbadun20@yahoo.com, +2348064189575

ABSTRACT
The advent of information and communication technology (ICT) has thrown wide the doors of opportunity for Agricultural Engineers in Nigeria to move research and training in all aspects of agriculture and environment to the next level. While many countries of the world have recorded much success in the area of development and application of computer-based simulation models in different aspect of agriculture and environment, not much have been reported of such feat in Nigeria yet. Most of the modelling works reported are empirical- and theoretical- based models developed using statistics or dimensional analyses. Although such models have significantly improved our knowledge, research and training, their applications are always limited by the fact that they are hardly useful beyond their sphere and conditions of development. The objective of this paper is to create some level of awareness, to sensitize and encourage Agricultural Engineers, (and other Scientist at large), towards development and application of simulation models in agricultural engineering researches and training. The paper explains what computer-based simulation models are, usefulness in different fields of agricultural engineering, steps involved in development and use of simulation models, and limitations of computer-based simulation models

Keywords: Models, Simulation, Computer, Agricultural Engineering.

1.0 INTRODUCTION

The new dawn in the world of computer technology must be seen as a wide door of opportunity for research and capacity building in all fields of science and science-related courses. Agricultural Engineering, a profession that seek to apply engineering principles to agriculture, must also take up the challenge of introducing computer technology into all processes involved in agricultural production chain, from the field to the dining table, in order to turn a new page for agriculture in this nation. One of the ways of accomplishing the task is to provide the leadership both in research and capacity building towards developing computer-based simulation models for all the different processes and operations involving agricultural production and natural resources management.

While a lot of breakthrough in development and use of computer-based simulation models for different aspect of agriculture and environment have been achieved in many countries of the world, not much of such works has been heard in Nigeria yet. A survey of the Journal of Agricultural Engineering and Technology (JAET) and the Nigerian Institution of Agricultural Engineering conference (NIAE) Proceedings in the last 10 recent years shows scanty reports on development and application of computer-based simulation models in the different aspect of agriculture and

environment. Most of the modelling works reported are empirical- and theoretical- based models developed using statistics or dimensional analysis. Although such models have significantly improved our knowledge, research and training, there application is always limited by the fact that they are hardly useful beyond their sphere of development. There is a need for a paradigm shift from theoretical and empirical modelling to dynamic and process-based modelling and simulation. This article is a review of the processes involved in modelling and simulation. The objective of this paper is to create some level of awareness, to sensitize and encourage Agricultural Engineers towards development and application of simulation models in agricultural engineering researches and training. The paper aimed at explaining what computer-based simulation models are, their applicability in different fields of agricultural engineering, steps involved in development and use of simulation models, and limitations of computer-based simulation models. It is interesting to note that in some Nigerian Universities, computer modelling and simulation has been introduced into the Agricultural Engineering undergraduate curriculum. Some others are yet to do so. This paper is also aimed at contributing towards enhancing the teaching and understanding of subject.

2. TYPES OF MODELS

A model is a representation of a real-world which is defined as a system. Models can be broadly classified into two: physical and conceptual models. Conceptual models can be classified into graphical/schematic models and mathematical models. Mathematical models may also be classified into empirical and simulation models. Figure 1 shows a schematic diagram of a general classification of models.

2.1 Empirical Versus Simulation Models

An empirical model is a mathematical expression which shows input-output relationships of the system. Gregory and Walling (1973) classified empirical models as: black box (where only the main input and outputs variables are studied); grey box (where few input variables that influences the output are studied); white box (where most of the input variables that influences the output are captured in the model equation). Empirical models do not explain the processes that go on in the system they represent. They are only mathematical functions that capture the trend of the relationship between input and output data. The data obtained from series of experimentation are used to suggest the models, to estimate its parameters and to test the models; so empirical models are data based. They can only be used to predict behaviours (final response) of the system but cannot simulate the dynamic processes in the system. More so, their use cannot be extended to domains outside the conditions in which they were developed and the levels of variables used in the experimentation. Extrapolation in empirical modeling therefore must be taken with great caution.

Simulation models on the other hand usually take the form of a set of assumptions about the operation of the system, expressed as mathematical or logical relations between the objects of interest in the system. Simulation models are mechanistic models. They are built based on the understanding of the physical and physiological processes in a system, considering causes and effects at the process level. They are regarded as processed-based models because they can respond to daily (or even more frequent) changes in the system's environment. Simulation models are built by arranging the set of mathematical expressions that explains the identifiable and selected processes in the system in a hierarchical manner and they produce a set of quantifiable output, similar to and can be compared with the output of the real-world.

There are two types of simulation models: static model, which is a representation of a system at a particular point in time, and dynamic model, which is a representation of a

system as it evolves over time. Within these two classifications, a simulation may be deterministic or stochastic. A deterministic simulation model is one that contains no random variables; a stochastic simulation model contains one or more random variables.

Simulation models are regarded as process-oriented because they include elements which occur in defined patterns. The logic associated with such a system or events can be generalized and defined by a single statement. A simulation language could then translate such statement into the appropriate sequence of events describing the processes through which the entities in the system flow. Simulation models have greater advantage over empirical models. While empirical models simply predict system's outputs from the given inputs data, simulation is used to better understand the expected performance of the real system and to test the effectiveness of the system design. Simulation models can be used for various performance measures, have greater realism, easier to understand, and are able to model the steady state as well as the transit behavior of the system. The only disadvantages are that it may not provide you with optimal solution, and the time to construct will be longer compared to empirical models.

3.0 COMPUTER SIMULATION MODEL (CSM)

When a computer program is developed to handle the computation and dynamic iterations of the processes in the modeled system, the model built is referred to as computer simulation model. So, a computer simulation model is a numerical integration of the constituent processes in a system with the aid of a computer. This implies a computer program describing the dynamic processes involved in the system. Such a program should operate on a time step in order of magnitude below the duration of the process being simulated takes place. The model should have the capacity to output variables describing the state variables of the system at different point in time.

Tumbo et al. (2006) referred to the CSM as Virtual Laboratory. CSM can be used to carry out experiments and investigations that would have been carried on the field without the researcher going to the site. They can be used to perform impossible or undesirable experiments; provide a safe and controlled environment for experimentation; focus on subject matter without interference; observe obscure processes; substitute for time, finance, and physical resources; synthesizing diverse discipline and fragmented knowledge. They can be used for games, distance and self learning. Overall, the application of CSM is generally less costly. The major disadvantage is greater realism associated with it.

There are quite a number of CSM for different aspects of agriculture and environment in use: crop growth, irrigation, soil erosion, drainage, groundwater and surface hydrology, evapotranspiration, meteorology, processing and storage, pesticide application, etc. A number of these models can be found in the website of Register Ecological Model: http://www.eco.wiz.uni-kassel.de/. A few examples of simulation models in area of soil and water management option of Agricultural Engineering are given in Table 1.

3.1 A Tool For Research

Research involves developing a theory of the real-world and testing it with observations, then perhaps using the outcome to explain and predict further phenomena. With a simulation model representing that real-world, we can generate and test hypotheses: How will this system behave under the imposed conditions? For example, we may want to know what will be the crop yield if given amounts of irrigation water is applied; how given feed rates affects the cleaning efficiency of the thresher? We can assess the extent to which our theory (as captured in the model) explains the real system observation by comparing model simulated outputs with real system outputs (model

validation), e.g., drying rate vis-a-vis thermal, humidity and moisture dynamics in a solar drying system. We can determine the most influential parameters of the system (sensitivity analysis), e.g., determining the most influential parameter among flow rate, infiltration, hydraulic sheer stress, furrow width and bed slope under furrow irrigation-induced erosion.

We can also test and evaluate modeled system performance, so that the scientist can go on to improve on those parts of the system relevant to his research purpose (system/process optimization). We can also use model to provide a medium for better communication between researchers in different disciplines. We can predict intermediate processes such as instantaneous or daily responses in the system which ordinarily cannot be measured due to spatial and temporal variations or lack of tools; e.g., daily transpiration, changes in soil moisture content, rate of flow of grains in a combine harvester, etc. We can identify gaps in our knowledge, providing new insight to areas for future research, e.g., We can evaluate yield potential relative to weather, identify and evaluate desirable plant and animal characteristics (aspect of breeding); Soil erosion effect on crop performance and the environment, etc.

3.2 A Tool for Decision Making

We can use simulation models to investigate the influence of management practices (soil, plant, water, tillage, cropping system, etc) on the crop and its environment; influence of conservation measures (e.g. terracing, bunding, contouring, etc) on erosion control; influence of force convection on drying of crop produce; etc. This type of investigation could provide the basis for deciding on best management practices. CSM are also useful in system/process optimization; for prediction and forecasting.

3.3 A Tool for Education, Training and Technology Transfer

CSM can be used for virtual experimentations, demonstrations, research, consultancy, extension services, policy making, etc. One aspect of education and training in CSM is the act of building simulation model. It must be understood that the task of building CSM that address agricultural and environmental challenges are better carried out by Agricultural Engineers. This is because only the agricultural engineering training relates engineering knowledge to agricultural and environmental interactions.

4. STEPS INVOLVED IN DEVELOPMENT AND USE OF COMPUTER SIMULATION MODELS

A computer model refers to the algorithms and equations used to capture the behaviour of the system being modelled. However, a computer simulation refers to the actual running of the program which contains these equations or algorithms. Simulation, therefore, refers to an instance where you ran a model. In other words, you wouldn't "build a simulation" you would "build a model", but you could either "run a model" or "run a simulation". Although, model and simulation are often used interchangeably and the difference between them may be trivial, the act of developing a model is referred to as modelling. Simulation is the study of the model over time. We use the model in simulation in order to try to understand the real system behaviour under different circumstances.

There are three options available when deciding to use simulation models for research, decision making or training: Use an already developed model; modify an existing model, or develop a new model altogether.

4.1 Using an Already Developed Model

There are few advantages in using an already developed model compared with developing a new one. It saves time; easy to justify the choice of such model especially if

it has been calibrated and validated under various conditions; documentation, examples and technical assistance may be easily available. But the disadvantages include instances where existing model does not actually describes the phenomena of interest at the right level of sophistication or simplicity desired; non-availability of the specific input data required by the models; insufficient understanding of how the model was developed (especially the theory on which it is based). If existing model is to be used, the user must be clear minded of what he want to do and select possible models which addresses the problem; review literatures relevant to the model selected; get familiar with the model (the input data required, how to enter the data, how to run the model, the nature of the output); test-run the models; evaluate the models against the requirements. If more than one candidate model meets the selection criteria, then choose the simplest; calibrate the model for the study environment (this is necessary if the model has been widely tested in your environment of study) before applying it for the study.

4.2 Modifying an Already Existing Model

It is possible that available models do not exactly meet your requirement but that some may come close. Therefore, it may be desirable to modify a model. Modifying a model may mean anything from changing the way the input files are handled to adding or changing some of the underlying theory. Often, modification will mean adding a description of further components and processes to address a specific situation.

If the plan is to modify an existing model, selecting the candidate model; get access to the original computer code and description of the theory behind it; understand them fully, and know how to modify it for the intended use. You must be good in computer programming to be able to do this (or get assistance from those who know how). Some models are much easier to adapt than others. If they were originally designed and produced with adaptation in mind then the task may be straightforward. After the modification, the modeling processes, that will be discussed later has to be observed.

4.3 Developing a New Model

Situations that may necessitate developing a new model include, working in an area where no existing model can be found (although this is rarely true); where the outputs generated and/or inputs required in the system or experiment of interest are not catered for in the existing models; existing models are too clumsy or complicated, or have a poor track record. Building and using your own model could be sometimes that takes a few hours, if you are looking at a few interacting components and are familiar with a suitable computing environment. It could also take several years.

4.4 Simulation Modeling Processes: Steps Involved in Developing a Model

The steps involve in developing and applying a simulation model includes the following:

Step 1: Problem statement:

Setting realistic and detailed objectives for your modeling will determine the whole nature of the task. It will help you decide the characteristics of the model. What is the fundamental goal of the model; e.g., what do I want the model to address and what information is to be derived from the model? What is the intended end-product, and who is the intended end-users of the model? What type of model best address the problem at hand (simplified or detailed model?). What time scale is appropriate; daily, monthly?

Step 2: Determine the key variables in the system:

The components to be included in the study (including the inputs and outputs) and the system boundary should be defined. This will help you to determine the key variables

in your study that will be represented by variables in the computer programme. Key variables are the few most important, significant factors that affect the system and their relationships. The cause-and-effect connections in the real system will be represented by the interconnections among the variables in the computer model. Note that by adding more and more interconnections the model becomes complex. A determinant of model usefulness is the ability of the modeller to leave out unimportant factors and capture the interactions among the important factors. A model is too complex when there are too many assumptions and relations, and too simple when it exclude factors known to be very important.

Step 3: Model development:

Prior to building the model, a review of information availability is needed in order to assess the possibility of meeting the objectives as stated in step 1 and 2. Develop the conceptual model; diagrams may be used to represent the components in the system, and summarize their relationships. Develop the mathematical representation of the system, including specific functions and relationships to be used in the model. Translate the conceptual diagram into computer code. Computer flowcharts are helpful in translating the model to computer code and documenting the relationships between the model and the code. Note that building a model is an interactive, trial and error process. A model is usually built in steps of increasing complexity until it is capable of describing the aspects of the system of interest.

Step 4: Model testing and evaluation:

This involve procedures necessary to ensure that the model is working and produces expected outputs which are similar to those of the real world (the system) it is designed to represent.

The four very important procedures include verification, calibration, validation, and sensitivity analysis.

Model verification: involves the evaluation of the accuracy with which the computer codes represent the model. Do the programming logic and codes represent our model of the system? Is the model 'accurately' doing what it is intended to do?

Calibration: refers to the adjustments made to the model parameters so as to give the "most accurate" comparison between simulated results and results obtained from a real-system (through field experiments). In other words, calibration involves the adjustment of certain model parameters by systematically comparing simulated results to field observations of state variables. Calibration should be conducted only within the confines of a given data set. The model is said to be more accurate when the simulated results closely reflects observed data. Calibration can also be used to estimate the values of some parameters used in the model that are not easily measured. The calibration need to be verified by obtaining output data from the model and comparing it to what is expected from the input data.

Validation: is the process by which a simulation model is compared to field or historical data not used previously in the development or calibration process. The purpose of validation is to determine if the model is sufficiently accurate for its application as defined by the set objectives.

To validate a model, simulated states variables are compared with measured values of same variables. Graphical comparison and statistical tests are used to determine whether the model-behaviour is different from real system behaviour to some stated level of significances. Some statistical indices include: Student't' test; Root mean square error

(RMSE), Coefficient of variation (CV), Modelling efficiency, Index of agreement, coefficient of residual mass. The implications of these indices vis-a-vis model performance have been explained in Igbadun et al. (2011). Krause et al. (2005) has also made a comparison of the efficiency of some of these statistical indices in evaluating model performance.

Although, the coefficient of determination (r^2) is commonly used by many to compare model performance, a high R-squared value does not necessarily mean the model fits the data well. R-squared indicates the measure of dispersion. A value of Zero means no correlation at all between the measured and predicted data whereas a value of 1 means that the dispersion of the prediction is equal to that of the measured. According to Krause et al. (2005), the fact that only the dispersion is quantified is one of the drawbacks of r^2. A model which systematically over- or under- predict all the time will still result in good r^2 value close to 1 even if all the prediction is wrong. It is therefore not encouraged to be used as the only indices to prove the validation of a model. Another tool used to validate models is graphical residual analysis. If model output values are drastically different than historical values, it probably means there's an error in the model. This is an important step to verify before using the model as a base to produce additional models for different scenarios to ensure each one is accurate.

It must also be noted that validation is a subjective judgment. First, the state variables to be compared must be selected based on the objective of study. Then a measure of accuracy or closeness of fit must be established. The choice of criteria and important states variables for comparison should be based on model objectives. Although a formal process of validation is always recommended in model development, the process of gaining confidence in the model is generally a slowly emerging one over the period of model construction, through formal validation, to application of the model. During this time, essentially, two sets of judgments are being made: (1) That the model is not different from the real existing system to a degree that will detract from the value of the model for the purposes for which it was designed; (2) That if the model is accepted as being adequate, then the decisions made with its assistance will not be measurably less correct than those without the benefit of the model. Such an exact assessment is extremely difficult and cannot be other than subjective in nature, howbeit, with values. When we are confident that the behaviour of the model is satisfactory, formal validation process is over. The model can then be put to use. If the outputs do not reasonably match historic/field measured values during the validation process, the model should be reviewed and updated to produce results more in line with expectations. It is an iterative process that helps to produce more realistic models.

Sensitivity analysis: involves exploring the behaviour of the model for different values of parameters within the range used in building the model. This is done to determine how much change in the value of a parameter influences the important outputs from the model. The model is sensitive to a parameter if a major change in the output occurs when the parameter is changed. Sensitivity analysis can also be structured to determine the important subsystems, relationships and inputs. Sensitivity analysis should be designed with respect to the objectives of the study

Step 5: Model application:

At this point, the model may be viewed as 'complete' and its use may be by those who did not participate in its development. The application may be related to management of a system, research, or training. The model can be used for varieties of scenarios to generate non-obvious discussions. Documentation of the model and the computer code is very essential.

It is worth noting that the five steps in modeling mentioned above should not be seen as strictly sequential. Rather, in most systems modeling and simulation studies, these steps are repeated in an interactive fashion as information is gained.

5 LIMITATIONS OF COMPUTER SIMULATION MODELS

Models are simplified representations of the real-life systems. Although, they may be substitute of the real-life for certain purposes, they are not real-life systems. They should never be expected to perform perfectly and produce similar results as real-life systems. Whether or not a model is an adequate substitute for the system it is designed to represent is determined only in relation to its purpose. The extent at which a model represents the real-life system is a function of the system variables included in building the model and the degree at which the mechanism and dynamism (the sets of mathematical expressions and logics) of the model reflect the principles and workings of the real-life system. Therefore, the results of models should always be taken with caution and examined to see if in reality they reflect the real-life system.

Simulation models should not be:

Too complex: so many input data, input data not easily obtainable, cumbersome in application, model outputs not easily understood and interpreted;

Too detailed: so many state variables of the real system reflected in the model such that the model becomes bogus and unstable (However, detailed models have the advantage of increased versatility);

Too simple: such that very basic state variables of the modeled system are not captured/reflected in the model.

6. CONCLUSION

Computer-based simulation models are valuable tools in research, management technology and decision-making. Indeed, in the developed and some developing nations, computers and system modeling have become tools of most scientific disciplines, rather than being reserved for computer information specialist and mathematician. Simulation models which address agricultural and environmental interactions are the cheapest means to answer the numerous research questions which requires a lot of fund, time and energy to answer. The agricultural engineer, by virtue of his training, is best positioned to develop simulation models and to apply them to answer these questions.

REFERENCES

Ciat (2002). Marksim: A computer tool that generates simulated weather data for crop modelling and risk assessment. International Centre for Tropical Agriculture.

Donatelli M., Bellocchi G., Fontana F., 2003. RadEst3.00: Software to estimate daily radiation data from commonly available meteorological variables. Eur. J. Agron., 18, 363-367.

Gregory, K. J. and Walling, D. E., 1973. Drainage Basin form and Process. Edward Arnold.

Igbadun, H.E., Oyebode, M.A. and Mohammed A.S., 2011. Evaluation of a simulation

model for predicting soil-water characteristics of selected agricultural fields. Nigerian Journal of Technological Development (NJTD). Vol.8 (1): 61-73. Publisher: Faculty of Engineering, University of Ilorin.

Igbadun, H.E., 2012. Irrigation scheduling impact assessment model (ISIAMOD): A decision tool for irrigation scheduling. *Indian Journal of Science and Technology.* Vol.5 (8):3090-3099

Jetten, V., 2002. LISEM User Mannual version 2.X. Draft version January 2002. Utrecht Centre for Environment and Landscaping Dynamics. Utrecht University, The Netherland. pp 44.

Jones, C.A. and Kiniry, J.R., 1986. *CERES-Maize: A Simulation Model of Maize Growth and Development*. Texas A & M University Press, College Station, Texas, 150 pp.

Jones, J.W., Hoogenboom, G., Porter, C.H., Boote, J., Batchelor, W.D., Hunt, L.A., Wilkens, P.W., Singh, U., Gijsman, A.J. and Ritchie, J.T., 2003. The DSSAT cropping system model. *European Journal of Agronomy* 18:235-265.

Kiniry, J.R., Williams, J.R., Gassman, P.W. and Debaeke, P., 1992. A general process-oriented model for two competing plant species. Transactions of the American Society of Agricultural Engineers (ASAE) 38: 801-810.

Krause, P; Boyle, D.P. & Bäse. F., 2005. Comparison of different efficiency criteria for hydrological model assessment. Advances in Geosciences. European Geosciences Union, 5:89-97.

Matthews R.B., 2002. Models as research tools. In: Crop-Soil Simulation Models Applications in Developing Countries (Edited by Matthews, R.B. and Stephens, W.), CABI Publishing, New York, pp. 9-11.

McCown, R.L., Hammer, G.L., Hargreaves, J.N.G., Holzworth, D.P. and Freebairn, D.N., 1996. APSIM: A novel software system for model development, model testing, and simulation in agricultural research. *Agricultural Systems* 50: 255-271.

Morgan, R.P.C., Quinton, J.N., Smith, R.E., Govers, G., Poesen, J.W.A., Auerswald, K., Chisci, G., Torri, D. and Styczen, M.E., 1998. The European Soil Erosion Model (EUROSEM): A dynamic approach for predicting sediment transport from fields and small catchments. Earth Surface Processes and Landforms, 23: 527-544

Raes, D., Steduto, P., Hsiao, T.C., and Fereres, E., 2009. AQUACROP: Reference Manual. FAO Land and Water Division, Rome Italy.

Saxton, K. E. and Willey, P. H., 2006. The SPAW Model for Agricultural Field and Pond Hydrologic Simulation. Chapter 17 in: *Mathematical Modelling of Watershed Hydrology*, V. P. Singh and D. Frevert, (Ed.); CRC Press LLC.

Skaggs, R. W., 1982. Field evaluation of a water management simulation model. *Transactions of the ASAE*, Vol. 25(3):666-674.

Smith, M., 1992. CROPWAT: A computer program for irrigation planning and management. FAO Irrigation and Drainage Paper 46. FAO, Rome, 89

Stockle, C.O. and Nelson, R., 1996. *Cropping System Simulation Model. User's Manual*. Biological System Engineering Dept., Washington State University, Pullman WA 99164-6120, 165pp.

Stöckle C.O., Bellocchi G., Nelson R.L., 1999. Evaluation of the weather generator ClimGen for several World locations. 7th *International Congress for Computer Technology in Agriculture*, 15-18 November 1998, Florence, Italy, 34-41.

Supit, I., Hooijer, A.A. & Van Diepen, C.A., 1994. System description of the WOFOST 6.0 crop simulation model implemented in CGMS, vol. 1: Theory and Algorithms, Luxembourg: Joint Research Centre, Commission of the European Communities.

Tumbo, S.D., Mahoo, H.F. and Kihupi, N.I. (Eds.), 2006. *A Manual for Virtual Laboratory Experiments in Agriculture. The Use of PARCHED-THIRST Software in Agricultural System Simulation*. Soil-Water Management Research Group. Sokoine University of Agriculture, 131pp.

USDA-NSERL, 1995: Technical Document. USDA-Water Erosion Prediction Project (WEPP). National Soil Erosion Research Laboratory (NSERL) Report No. 10.

van Dam, J.C., Huygen, J., Wesseling, J.G., Feddes, R.A., Kabat, P., van Waslum, P. E. V., Groenendjik, P. and van Diepen, C.A., 1997. *Theory of SWAP version 2.0: Simulation of Water Flow and Plant Growth in the Soil-Water-Atmosphere-Plant environment.* Technical Document 45. The Netherlands: Wageningen Agricultural University and DLO Winand Staring Centre, 90pp.

Williams, J.R., Jones, C.A., Kiniry, J.R. and Spanel, D.A., 1989. The EPIC crop growth model. Transactions of the American Society of Agricultural Engineer (ASAE) 32: 497-513.

Yang, H.S., Dobermann, A., Lindquist, J.L., Walker, D.T., Arkebauer, T.J. and Cassman, K.G,. 2004. Hybrid-maize- a maize simulation model that combines two crop modelling approaches. *Field Crops Research*. 87: 131-154.

Young, M.D.B., Gowing, J.W., Wyseure, G.C.L. and Hatibu, N., 2002. PARCHED-THIRST- development and validation of a process-based model of rainwater harvesting. Agricultural Water Management 55: 121- 140.

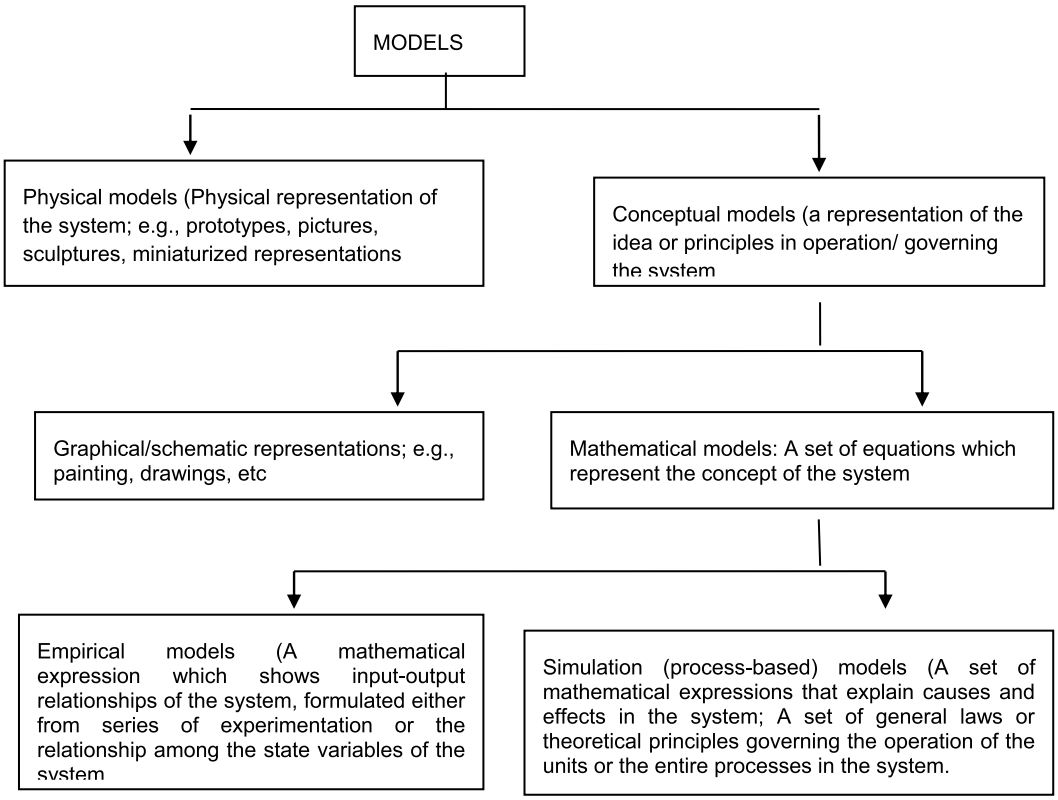


Fig.1: A Schematic Diagram of Model Classification

Table 1: List of Some CSM in the Area of Soil and Water Management Option in Agricultural Engineering

Type of model	Name	Author
Crop growth models	❍ Decision Support System Agro-technology Transfer (DSSAT) family models, e.g., CERES-Maize, SOYGRO-bean	Jones and Kiniry (1986), Jones et al. (2002)
	❍ Cropping System (CropSyst)	Stockle and Nelson (1996)
	❍ AquaCrop	Raes et al (2009)
	❍ World Food Studies (WOFOST)	Supit et al. (1994)
	❍ Agricultural Production System Simulator (APSIM)	(McCrown et al (1996)
	❍ Hybrid-Maize	Yang et al. (2004)
Land management/Erosion models	❍ Land Management Alternatives with Numerical Assessment (ALMANAC)	Kiniry et al. (1992)
	❍ European Soil Erosion Model (EUROSEM)	Morgan et al. (1998)
	❍ Erosion Production Impact Calculator (EPIC)	Williams et al. (1989)
	❍ Water Erosion Prediction Project (WEPP)	USDA-NSERL (1995)
	❍ Limburg Soil Erosion Model (LISEM)	Jetten (2002)
Irrigation models	❍ Irrigation scheduling Information System (IRSIS)	(Raes et al., 1986)
	❍ Soil–Water–Atmosphere –Plant model (SWAP)	van Dam et al (1997)
	❍ Crop Water model (CropWat)	(Smith, 1992)
	❍ Irrigation Scheduling Impact Assessment Model (ISIAMod)	Igbadun (2012)
Drainage/Hydrology Models	❍ Drainage Model (DRAIMOD)	Skagg (1982)
	❍ Soil-Plant- Air-Water (SPAW)	Saxton and Willey (2006)
Rain water harvesting/crop growth model	❍ PARCH-THIRST (PT) model	(Young et al., 2002)
Agro-meteorology models	❍ CLIMGEN ❍ MARKSIM ❍ Radiation estimation model (RadEst)	Stockle et al.(1999) CIAT (2002) Donatelli et al. (2003)

DESIGN AND DEVELOPMENT OF AUTOMATIC MICROCONTROLLER BASED ELECTRONIC GARDEN DRIP IRRIGATION SYSTEM

K. Ahmad, M. M. Jibrin; Y. A. Shaaban, A.M.S Tekanyi, A. Muhhamad
Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT
This paper presents a new approach of irrigating gardens automatically without human intervention. It uses PIC microcontroller PIC16F877A for controlling the operation of electronic circuit that controls DC pumps for supplying water to plants in garden. The microcontroller is programmed using assembly language. It is programmed to periodically turn on DC pumps to supply water to different zones of the garden. Each zone has PVC pipes network with holes punched along their length to supply drips of water for a period of one hour and then turn off the pumps for a period of twelve hours and then repeat the cycle. Sensors are placed in each zone of the garden to monitor the moisture content of the zones. When the sensors sense dryness in a zone a signal is sent to the microcontroller to supply water for selected period of one hour. The microcontroller also monitors level of water in reservoir tank. When the level of water is below certain point a pump is started to supply water to the tank. When the tank is full the microcontroller sends command to stop the pump. The pumps are controlled by microcontroller via transistor relay driver circuits to drive 25W, 12V DC pumps. The designed system was simulated using FLOWCODE 4 for PIC, professional version was found working as expected. Using bigger pumps and higher current relays, this system can be used in commercial irrigation farming.

Keywords: Automatic, Microcontroller, Electronic, Garden, Drip Irrigation.

1.0 INTRODUCTION

Gardens are commonly found in houses and other places like schools. The gardens usually are used for growing flowers and sometimes fruits. For normal growth of these plants in the garden, water supply on regular basis is very necessary. The water is mainly supplied through irrigation which is done manually by gardeners. Due to limitations of human operators which include forgetfulness and tiredness sometimes the garden is not irrigated consistently and this have great negative impacts on the well-being of the plants in the garden. The electrical engineering as a dynamic field of technology plays very important roles of solving diverse problems of life including those that involve agricultural issues. The microcontrollers are key components of modern day electronics systems for they can be programmed to tackle any problem based on the need and expertize of the programmer. The PIC microcontrollers and ATMEGA microcontrollers are two major classes of the microcontrollers (Han-Way, 2005).

A microcontroller, or MCU, is a computer implemented on a single large scale integrated (VLSI) circuit. In addition to those components contained in a microprocessor, an MCU also contains some of the following peripheral components:
Memory, Timers (real-time interrupt, and watchdog timer), Pulse-width modulation (PWM), Analog-to-digital converter (ADC), Digital-to-analog converter (DAC), Parallel I/0 interface, Asynchronous serial communication interface (UART),

Synchronous serial communication interfaces (SPI, I2C, and CAN), Direct memory access (DMA) controller, Memory component interface circuitry and Software debug support hardware (Ionive, 2000).

The amount of current that can be supplied or drained by the microcontrollers is very small. Therefore, to control a large power device like pumps, a relay driver circuit is used to control the system. Fig. 1.1 shows the simplified block schematic of PIC16F877A architecture (Ionive, 2000).

2.0 MATERIALS AND METHODS

This work is carried out using the fundamental components that made up the complete system and adopting a suitable methodology to enhance the success of the work. The major components used in doing this work include: PIC Microcontroller PIC16F877A, Moisture sensor LPA12, General purpose NPN transistor C945, Electromagnetic Relay of 12V, 10A, Free Whirling Diode 1N4007, DC pumps of 25W, 12V, Transformer of 240V/15V, Bridge Rectifier, Regulator LM7812 and Backup Battery of 100AH.

2.1 Design of Power Supply for the System

The system is powered using a 12V regulated supply for the pumps and a 5V for microcontroller which are obtained from the mains together with a backup DC battery of 75W, 12V.

This combined power supply is used to ensure the continuity of the system's operation even in the event of mains power failure. The complete power supply circuit for the system is as shown in Fig. 2.1.

The transformer used is 240V/15V, 2.5A step down type. The rectifier diodes selected are based on the peak inverse voltage (PIV) calculated as (Servant, 1981):

$$PIV = \sqrt{2}V_{max} \qquad (2.1)$$

The V_{max} from the transformer is 15V so,

$$PIV = \sqrt{2}\ x\ 15 = 21.21V$$

Therefore, diodes 1N4007 with PIV of 50V are used as D_1 to D_5.

The filter capacitor C1 is selected using relation (Link, 1996):

$$C_1 = \frac{V_{max}}{\Delta V f_p R_L} \qquad (2.2)$$

The Vmax is 15V, fp is twice the power frequency (50Hz) and RL is maximum load resistance selected (1k?) and maximu ripple factor (?V) is taken as 5% of V_{max}. So C is obtained using (2.2) as:

$$C_1 = \frac{15}{0.75\ x\ 100\ x\ 1000} = 2000\mu F$$

A 2200μF is used as the filter capacitor (C_1) here for better filtering.

A 12V regulator (LM7812) is used to obtain regulated 12V for powering the pumps and 5V regulator (LM7805) is used to obtain 5V for powering the PIC microcontroller and the relay driver circuits.

2.2 Design of the Main Control Circuit

The general circuit used for controlling the automatic garden drip irrigation system is shown in Fig. 2.2.

The system as shown in Fig. 2.2 has microcontroller PIC16F877A as the main brain that monitors and controls the operations of other segments of the system. Six

moisture sensors (LPPA12) is used in six zones of the garden detects the level of moisture and sends report to the microcontroller in digital form. There are two other sensors placed in water reservoir for watering the plants.

Six pumps (pump 1 to pump 6) driven by six relay driver circuits are used for supplying water to the six zones on periodic basis and on request for dry zones detected by the sensors. One other pump (pump 7) is used for supplying water to the water reservoir tank. The two major parts of the circuit are designed in the following subheadings.

2.2.1 Design of relay driver circuit

Each relay drive uses an NPN transistor (C945) which is general purpose as the active component for controlling the relay. The base current to the transistor is regulated by current limiting resistor (R_1 to R_7). The transistor is protected from damage by back voltage generated due to self-induction of the relay coil. The freewheeling diodes (D6 to D12) have peak inverse voltages of 50V and current rating of 1.5A.

The specifications of the NPN transistors (C945) used are as follows:
Maximum power (P_D) = 0.5W, Collector Current (I_C) = 1000mA, Supply Voltage (V_{CC}) = 5V – 18V. Cut – In Voltage (V_{BE}) = 0.7V. Minimum current gain (β) = 100.
The base current for the transistor is obtained as (Horowitz and Hill, 1995**):**

$$I_B = \frac{I_C}{\beta} \qquad (2.3)$$

$$I_B = \frac{1000}{100} = 10mA$$

Based on this design value a 1k? ± 20% tolerance is used as value of base resistors (R_1 to R_7).
The anti – flickering capacitors (C_4 to C_{10}) are used across relays terminals to make the relay triggering very smooth. The suggested value for these capacitors as suggested in the data sheet can take any value between 10µF and 100µF (Motorola, 2009). In this work 47µF is used.

2.2.2 Design of PIC16F877A external oscillator circuit

An external oscillator (XT1) is connected between pins 13 (OSC1) and 14 (OSC2) to complete in – built oscillator circuit of PIC16F877A. All instructions are executed within one single instruction cycle, except for program branches which are two-cycle. In this case, the execution takes two instruction cycles with the second cycle executed as a NOP (No operation). One instruction cycle consists of four oscillator periods. Thus, the oscillator frequency of the crystal is related with instruction cycle time as (Micro

$$Instruction\ Cycle\ Time = \frac{4}{Oscillator\ Frequency} \qquad (2.5)$$

The recommended instruction cycle by the manufacturer is from 0.4µs to DC (infinity) (Microchip Technology Inc.). If a 4MHz crystal oscillator (XT2) is used, the instruction cycle time is obtained using equation (2.5) as:

$$Instruction\ Cycle\ Time = \frac{4}{4\ x\ 10^6}$$

$$Instruction\ Cycle\ Time = 1\mu s$$

The instruction cycle time of 1µs calculated is within the accepted range.
Capacitors C_2 and C_3 connected between crystal oscillator and ground are used to improve the stability of oscillation. The recommended values for these capacitors are given by the manufacturer as shown in Table 2.1 (Microchip Technology Inc.).
Recommended values of C_2 and C_3 should be identical. Higher capacitance increases the stability of the oscillator but also increases the start-up time. Therefore, for the 4MHz

crystal oscillator used in this work, 33pF capacitors are selected as C_2 and C_3.

2.2.3 Configuring the ports of PIC16F877A

The microcontroller PIC16F877A has five ports. Port A has six pins: RA0 to RA5. Port B has eight pins: RB0 to RB7. Port C has eight pins: RC0 to RC7. Port D has eight pins: RD0 to RD7 and port E has three pins: RE0 to RE2.
Six pins of port A are configured as input for six moisture sensor. Pins of port B are used for driving six pumps for watering six zones of the garden. Pins of port C are used as inputs for two sensors of tank water levels while port D is used as output for driving the pump 7 for filling the water storage tank. The Table 2.2 shows the ports configurations of the microcontroller PIC16F877A.

2.2.4 Programming the PIC16F877A

The microcontroller, PIC16F877A is programmed using Assembly Language. The design begins by developing a program flowchart that described the main function to be performed by the microcontroller. The program flowchart is given by Fig. 2.3.

The PIC16F877A when powered it first check the status of the pins and confirms that they are active. It would then put ON the pins of port B to start the pumps 1 to 6 to supply water for a period of one hour (3600Sec) and then turn OFF the pumps for a period of twelve hours (43200Sec). While in this state it would continuously check the status of sensors in the six zone. When any of the sensors detects dryness in its zone the pump in that particular zone is put ON to supply water to the zone. When the microcontroller is started it simultaneously check the status of water level sensors in the reservoir tank. When the low level sensor is high, the pump 7 is started to supply water to the tank. The pump continues to work until the high level sensor becomes high to stop the pump.
The assembly language program is compiled into hex version and is given on the appendix.

2.2.5 System block diagram and pipe layout in the garden

The home garden for which the proposed system is designed has dimension of 40feet by 20feet. The length (40feet) of the garden is divided into six parts each representing a zone. Pipes are arranged in each zone across the breadth (20feet) and length of the garden. This pipe arrangement is given by Fig. 2.4.

3.0 RESULTS AND DISCUSSION

The developed system was simulated using Flowcode ® 4, professional version. Eight (8) toggle switches are used in the software to serve as the six moisture sensors in the garden and the remaining two switches were used as the low level and high level water sensors in the storage tank. Light Emitting Diodes (LEDs) were used to represent the seven pumps. The Source code was developed using the flow chart of the Flowcode software and the developed program was loaded to the PIC microcontroller used (PIC16F877A). When the simulated project was run the circuit was functioning well by responding the sensors signal and this confirms the normal operation of the proposed system.

4.0 CONCLUSION

The importance small and medium size garden in our homes and schools is common known fact. The wellbeing of plants in the garden is mainly dependent of the quality of the water supply process for the garden. The most common practice in irrigation of gardens is the manual method. This method has many disadvantages which

include lack of consistency due to either forgetfulness or fatigue from the side of the person responsible for watering the plants.
This proposed automated watering system would actually help to maintain a good garden by eliminating the problems that are associated with the human shortcomings. The system would also help in making the maintenance of gardens very cost effective since no labourers are needed to be hired for this purpose. It can therefore be concluded that this system would generally help to improve the irrigation system of gardens by eliminating the need of manual labour as well as cost improvement. The system is easy to implement for the fact that all the components needed are readily available in local markets at reasonable costs.

REFERENCES

Han-Way, H., (2005) "PIC Microcontroller: An Introduction to Software and Hardware Interfacing" Thompson Delmar Learning, USA

Horowitz P. and Hill W. (1995) "The Art of Electronics", Cambridge University Press, Second Edition,

Ionive, J., (2000)"PIC Microcontroller Project Book" McGraw – Hill, New York

Link J. D. (1996) "Hand book of simplified solid state circuit design", McGraw Hills, New York.

Microchip Technology Inc. PIC16F877A Datasheet. Retrieved March 2012 from http://www.microchiptechnology.com/PIC16F84Adatasheet

Motorola Semiconductors Data Manual (2009). Volume I, First Edition. PP. 87 -102.
Savant C. J. Roden M.S and Carpenter G., (1981) "Electronic Design". Benjamin/ Cumming publishing co.

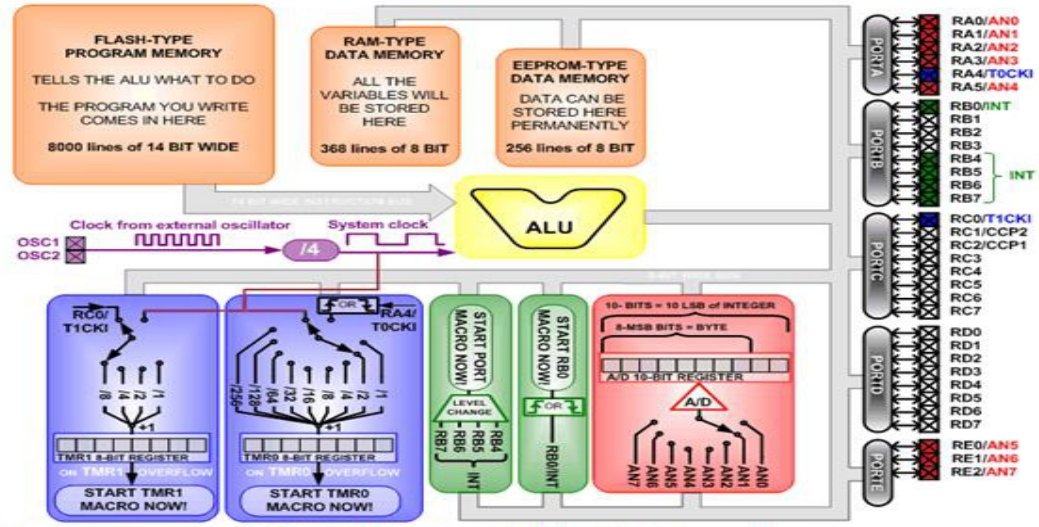


Fig. 1.1 simplified block schematic of PIC 16F877 Architecture

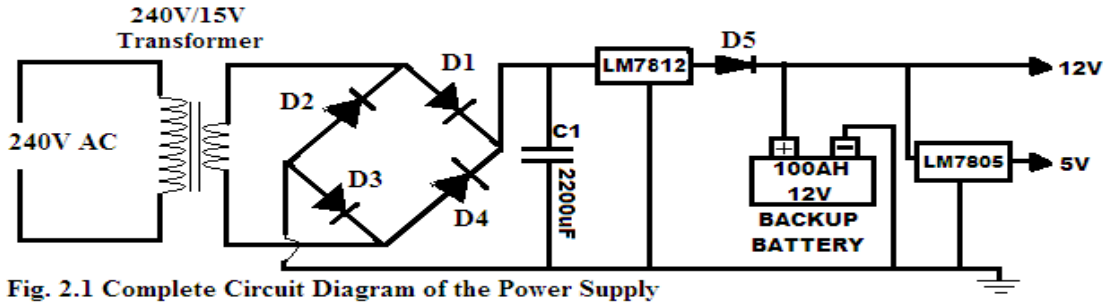


Fig. 2.1 Complete Circuit Diagram of the Power Supply

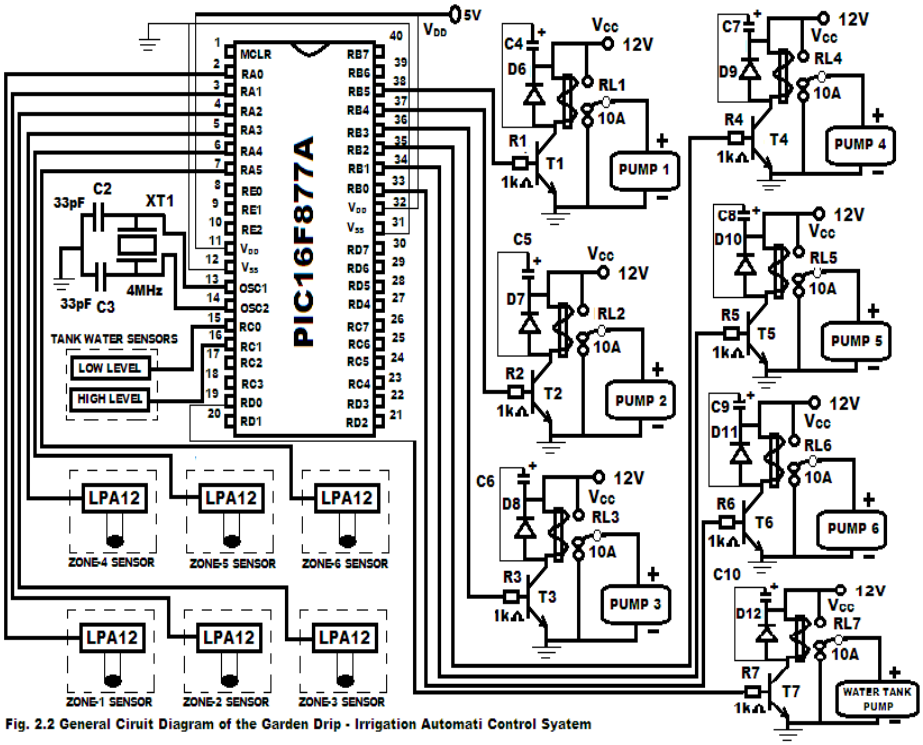


Fig. 2.2 General Ciruit Diagram of the Garden Drip - Irrigation Automati Control Syatem

Table 2.1 Recommended Values of Capacitors C_2 and C_3

Ranges Tested			
Oscillator Type	Frequency	C_2 (OSC1)	C_3 (OSC2)
Crystal	455kHz	47 – 100pF	47 – 100pF
Oscillator	2.0MHz	15 – 33pF	15 – 33pF
	4.0MHz	15 – 33pF	15 – 33pF
High Speed	8.0MHz	15 – 33pF	15 – 33pF
Resonator	10.0MHz	15 – 33pF	15 – 33Pf

Table 2.2 PIC Ports Configurations of PIC16F877A

Sensors	Port A pins	Port B pins	Relay Driver Circuits	Water Level Sensor	Port C
LPA12 ZONE 1	→ RA0	RB0	→ Pump 1	Low Level	→ RC0
LPA12 ZONE 2	→ RA1	RB1	→ Pump 2	High Level	→ RC1
LPA12 ZONE 3	→ RA2	RB2	→ Pump 3		
LPA12 ZONE 4	→ RA3	TB3	→ Pump 4	**Port D**	**Relay Driver Circuit**
LPA12 ZONE 5	→ RA4	RB4	→ Pump 5		
LPA12 ZONE 6	→ RA5	RB5	→ Pump 6	RD0 →	Pump 7

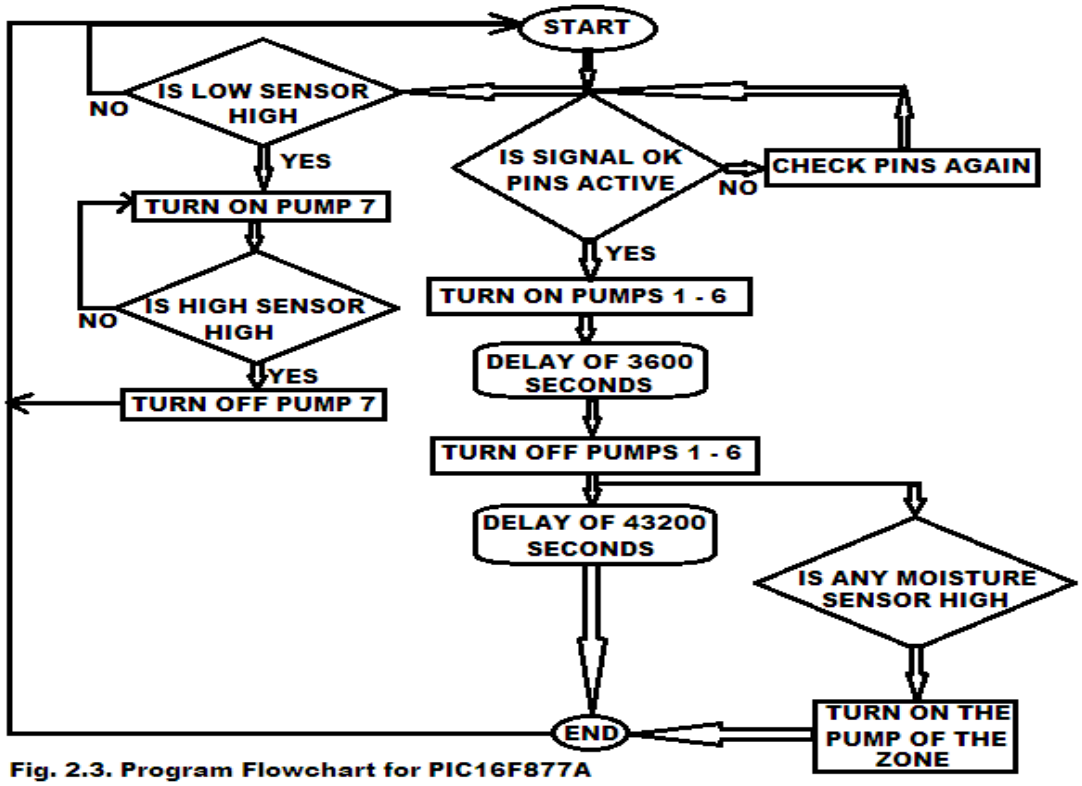


Fig. 2.3. Program Flowchart for PIC16F877A

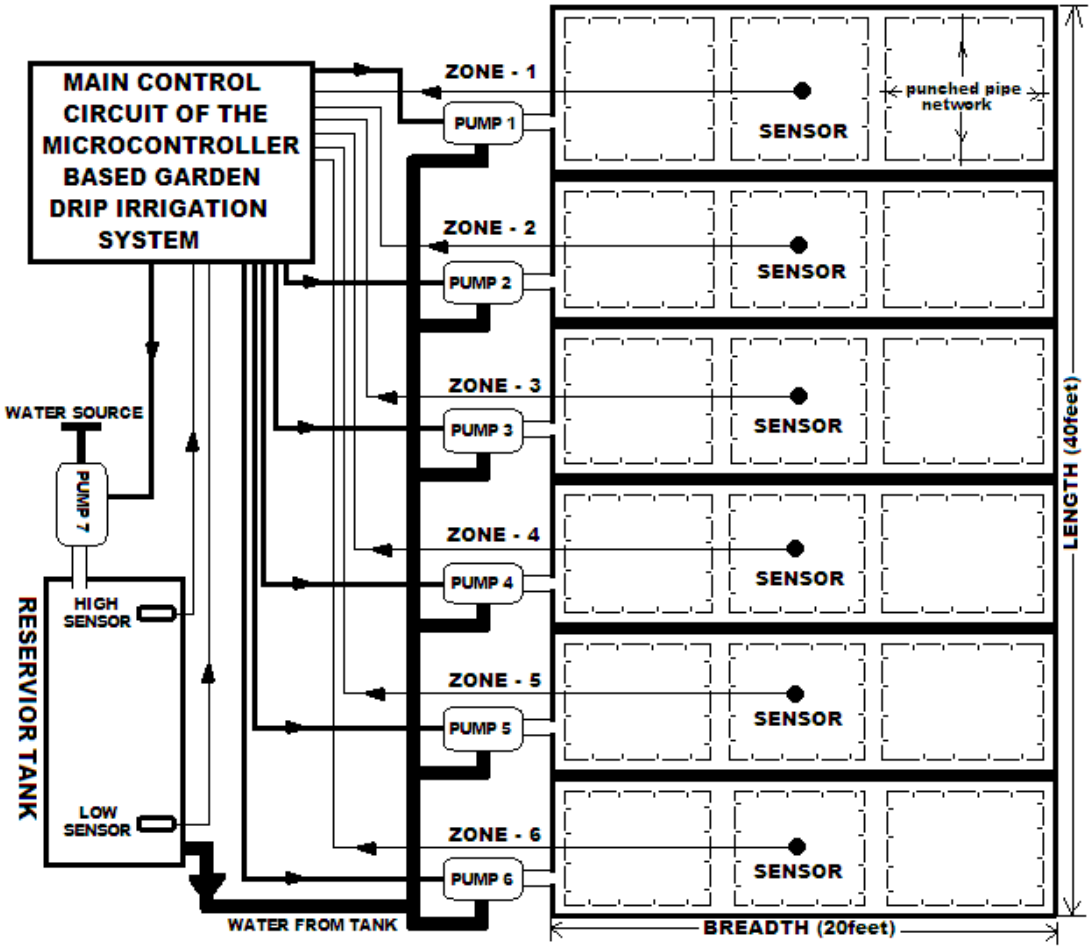


Fig. 2.4. General Block Diagram and Pipe Layout of the System

COMPARATIVE EVALUATION OF PRODUCTIVITY AND PROFITABILITY OF RICE-FISH CULTURE AND RICE MONO CULTURE IN AKWA IBOM STATE, NIGERIA.

Augustine, C. Ubong[1] and C.C. Mbajiorgu[2]
[1] International Fund For Agricultural Development (IFAD)-Community Based Natural Recourses Management Programme, Ministry of Agriculture, Uyo. Akwa Ibom State. Nigeria.
E-mail: alleybury @ yahoo.com
[2] Eco-Hydrological Systems Research Unit (EHSRU),
Dept of Agricultural and Bioresources Engineering, University of Nigeria Nsukka,
Enugu State, Nigeria.
E- mail: const.c.mbajiorgu@talk21.com

ABSTRACT
Aquacultural production, in addition to the rice crop itself, is a critically important resource for rural livelihoods in developing countries; its local consumption and marketing are particularly important for food security as it is the most readily available, most reliable and cheapest source of animal protein and fatty acids both for farming households as well as for the landless. This work describes the various production systems, including modifications of the rice fields necessary for integrating fish farming, and the agronomic and aquaculture management are examined. It proves to be environmentally and economically sound farming practices.
Concurrent rice-fish culture and rice mono culture experiments were conducted in Mbiabet, Ini Local Government Area of Akwa Ibom State, Nigeria, to compare and evaluate the profitability and productivity (yields) of two species of fish, Catfish (*Clarias gariepinus*) and tilapia *(Oreochromis noliticus*.) which were grown with rice, on the one hand, and paddy rice yields from monoculture on the other hand.
Mechanization and technical operation requirements for rice-fish, rice-alone and fish-alone situations were also evaluated. Survival and specific growth rate, condition factor and yields were found better with the *Clarias* spp the larger- sized (47.0-53.0cm) than the smaller-sized (12.75cm- 15.17 cm) *O. noliticus* when grown with rice. The net fish yield mean was 183 kg plot^{-1} crop^{-1} with *Clarias gariepinus* in a 99 days culture, significantly higher than *Oreochromis* spp. which was 80kg plot^{-1} crop^{-1} ($P < 0.05$). Paddy yields were 50.5kg plot^{-1} crop $^{-1}$ and 45.5kg plot^{-1} crop $^{-1}$ in rice-fish and 40.05kg plot^{-1} crop $^{-1}$ in rice-alone culture with no significant differences between the yields ($P > 0.05$). Water quality parameters were, within the acceptable range for aquaculture.

Keywords: Rice-Fish Culture, Ponds, Mechanization, Yields.

1. INTRODUCTION

The aim of the study is to investigate the desirability, or otherwise, of introducing the rice- fish culture as a farming system in Nigeria. Specific objectives of the study are;

i. To introduce rice-fish culture technology to conventional lowland (swamp) rice cultivators.
ii. To demonstrate the comparative rice yield of rice-fish culture with rice mono-culture in the local environment.
iii. To demonstrate the comparative yield of fish in rice –fish culture and conventional fish ponds in the local environment, and
iv. To compare the mechanization and technical operational requirement, of rice-fish, fish pond and sole rice cultures.

2. RESEARCH METHODOLOGY

2.1 Experimental Site.

The experiment was conducted at Mbiabet Ikot Udo Community, in Ini local Government Area of Akwa Ibom State, Nigeria.

The average annual rainfall in Uyo the state capital is between 238cm to 250cm. The mean monthly temperature varies between 25.5°C in August and 28°C in February. Wind direction is predominantly between south and west. During the dry season the influence of harmattan can be felt and the winds are variable between south – west and northerly. In the wet season average wind speeds from the south – West direction were recorded between 5.5km/hr in November and May and 8.2km/hr in March and July. The area in question lies between latitudes 4°33' and 5°33' North and longitudes 7° 35' and 8° 25' East of the Equator and fall within the tropical zone. Enyong Creek swamp rice study, (1993). Soil particle size distribution analysis showed the soil to be sandy loam.(sand-80%,silt-12% and clay 8%).

2.2 Experimental Treatment and Design.

2.2.1 Rice farming

Two plots of rice field were subdivided into three experimental units (between 50ft x 50ft , with a 2 m high dike on four sides) having a longitudinal refuge canal (0.3m width X 0.5 m height) along the side. There was a single replication for the two rice-fish treatment (rice + *Oreochromis spp.* and rice + *Clarias spp*.), and a single replications of rice-alone. The experimental units of each plot were separated by a median dike. In one case when two different treatments were contained in the plot, it was block by mud to prevent exchange. Allocation of plots to each treatment and their replications were done in a complete randomized block design (CRBD) fashion using the table of random digits (Zar, 1984).

The ploughing, harrowing and field preparation were done according to the farmers' conventional practice (Haroon et al., 1989). Immediately after land preparation and fertilization, one month old paddy seedlings of 'Suakoko 8' (a locally improved variety of Orza *sativa* which attains a size of 100- 125 cm, matures in 100- 120 days, is comparatively disease resistant, and is popular because of smaller grain size) procured from the local market were transplanted in puddle fields. Transplanting spaces were 20cm between rows, 15-20 cm between plants and 3-4 seedlings per hill (groups of seedlings) . Weeding was done at low levels only to maintain but not to impede fish grazing. Each rice season generally lasts 90-120 days, during which time algal mats and aquatic macrophytes (mostly submerged and emergent) often grow sufficiently large to impede swimming of the stocked fish.

2.2.2. Fish Stocking and Culture Tenure

Oreochromis niloticus and clarias gariepinus:

Once the seedlings were rooted and the tillers growing, water depth was about 0.25 m in the paddy field and 0.75 m in the refuge canal (30 days after transplanting). Average sizes of 2.70g of ***O. niloticus***, procured from Akwa Ibom State ADP, ponds,and average sizes of 11.0g of *Clarias gariepinus*, procured from Department of fisheries, Ministry of Agriculture Uyo, Akwa Ibom State ponds were separately stocked in two experimental units at a density of 150 plot-^{1} on 24th August, 2009. A total of 63 individuals in the rice + *O. niloticus* fish treatment and a total of 150 numbers in the rice + *Clarias gariepinus* fish treatments were stocked. The *O. niloticus* fish ranged from 4.5 -5.6 cm in length and from 5.1-6.1g in weight; the *Clarias gariepinus* fish ranged from 9.5-13cm in length and from 39.4 - 40.1g in weight at stocking (Table 11). Before stocking in the rice field, the fish were kept in a flow-through tank for 48 h to completely empty their guts. Rain was the main source of water but additional water was pumped-in to maintain a depth 0.75 m in the paddy field. Culture period was until 9th December 2009, 99 days after stocking (DAS), there was supplemental feeding and necessary supervision.

2.2.3. Fish sampling

Fish were sampled at 30, 60 and 99 DAS in both pond by draining water into the refuge canal and capturing fish with a knotless nylon hapa net of (3 x2 x1.5 m, mesh 0.5 cm) for analysis of weight and length from each unit of both treatments. The fish were sampled at 1300-1400h, corresponding to maximum feeding period as determined by earlier studies (Haroon and Pittman,

1997a,b).
Growth and condition factor was measured from 20-30% of the stock from each unit at 30 and 60 DAS, and from all individuals at stocking and at harvest.

2.2.4 Water quality

Weekly records were kept of air and water temperatures (^{O}C), dissolved oxygen and carbon dioxide (mg l^{-1}), total alkalinity and hardness (mg l^{-1} as CaCO,), ammonia nitrogen (mg l^{-1}) (HACH water kit, FF-2, USA) and pH (portable meter, Janeway 3060) at 1300-1400 h of each sampling day from the day of fish stocking until paddy and/or fish harvesting. Surface to sub-surface (0.02 m) water samples from the same three places as for plankton were analyzed and the means calculated. Water-quality data from the units of rice-fish treatment were pooled. The water-quality characteristics were similar (not strikingly different) both in rice-alone and rice-fish. Hence water quality from rice-alone were not monitored beyond 30 DAS.

2.3. Harvesting and Data Analyses

2.3.1. Paddy

The paddy was harvested one week before the fish to facilitate retrieval of every surviving fish from the rice-fish plots. Grains were separated from the straw, sun-dried repeatedly, weighed and the mean paddy yields expressed in kg $plot^{-1}$ $crop^{-1}$ for rice-alone, rice + *O. niloticus* and rice + *Clarias gariepinus*.

2.3.2. Fish harvesting

Fish were harvested by pumping the rice field dry. Each fish was counted to get overall survival. Fish were measured (mm) and weighed (g) for specific growth rate (SGR), condition factor (K) and both gross and net fish yield under each rice-fish treatment. Mean gross and net fish yields (deducting weight of the biomass at stocking) were expressed as kg $plot^{-1}$ $crop^{-1}$.
SGR was calculated using the following formula (Hopkins, 1992):

$$SGR = G \times 100 \quad (1)$$

where G is the instantaneous growth rate.

$$G = \frac{\ln(Wt) - \ln(Wj)}{t} \quad (2)$$

where ln(Wt) is the natural logarithm of the weight at time t and ln(Wt) is the natural logarithm of the initial weight.
Fulton's condition factor *K* was used at stocking and at 30, 60 and 99 DAS (Bagenal and Tesch, 1978):

$$K = -\frac{100w}{I^3} \quad (3)$$

where w and I are the total weight and total length of the fish.

2.3.3. Data analyses

Both nonparametric, Mann-Whitney and Kruskal-Wallis (Zar, 1984) and parametric (two-way, ANOVA) tests were done to compare yields of paddy and fish among the treatment groups. Significant differences found by ANOVA were subjected to a Fisher's Least Significant Difference test (F-LSD).

2.4. Pond Design.

2.4.1 Design consideration

Consumptive Use Determination:

Consumptive Use commonly known as Evapotranspiration mainly determine on the water requirement of crop. The Blaney morin –Nigeria evapotranspiration using Model estimates best the potential evapotranspiration using Climatologically data in Nigeria (Duru 1984). It is given as the relation

$$Etp = rf(0.45t + 8)(530 - R^{1.31})/100 \quad (5)$$

Where; Etp = Potential evapo transpiration (mm/day)
r f = Radiation factor
t = Air temperature ^{o}C

R = Relative humidity %

CU = K Etp (6)

CU = Crops consumptive use (mm/day)

K = Crops consumptive use coefficients.

Etp = Potential evapo transpiration (mm/day)

Model using the average value of monthly air temperature with corresponding average values of mean monthly relative humidity in table A1,A2 & A3 respectively.

The following calculations were done and values obtained.

For January;

$Etp = rf(0.45t + 8)(530 - R^{1.31})/100$

$= 0.0807(0.45 \times 25.71 + 8)(520 - 61.75^{1.31})/100$

$= 4.7$mm/day

Similarly all the values of pontential evapotranspiration were calculated and the result tabulated as in table 1.

The K values of rice crop was used in the computation. The field was divide into three different plots of 50ft x 50ft (15.24m x 15.24m) for the three experimental units.

In April, CU = K Etp

$= 0.85 \times 3.93 = 3.34$mm/day

Similarly, all the values of the designed consumptive Use for rice were calculated and the result tabulated as in table 4.

2.4.2. Determination of flow rate and time of application

Using the border irrigation to grow rice and stocking fish.

Water holding capacity of sandy loam - 8cm/m depth

Rooting depth of rice = 60cm= 0.6m

Available moisture at root depth = 8x 60/ 100 = 4.8cm

Assuming Management allowable Deficiency of 60%,

The ready available moisture = 4.8 X 60/100 = 2.88cm =28.8mm.

Maximum Consumptive use rate = 4.45mm/day

Hence readily available moisture will be used up in 28.8mm/ 4.45mmday^{-1} = 6days.

Therefore supply of water to pond should be after every 6days.

Since the soil is sandy loam, borders slope of 0.4%, width of 15.24m, length of 15.24m and an irrigation stream size of 5l/s perimeter width will be adequate for preliminary design (Micheals, 1978).

Given 3 plots borders field (15.24mx 15.24m) with the borders width along one side as in figure 1, this gives approximately 15m border strips each 5m wide.

Flow into each border = 5 x 5 L/s, which is = 25L/S. Hence total flow to be carried by secondary channel while irrigating 4 borders at a time (with gate along the secondary channels to control flow at the end of every 4 borders strips)

$= 25$L/s x 4 borders $= 100$L/s $= 0.1 m^3/s$

Now, Total volume of water required per irrigation of 4 borders = readily moisture x borders width x borders length x No. of borders (7)

$= 28.8\text{mm} \times 10^{-3} \times 5\text{m} \times 15.24\text{m} \times 4$

$= 8.778 m^3 = 8.778 \times 10^3$ litres

Time to apply this Volume:

$$\frac{8.778 \times 103 \times \text{seconds} \times \text{minutes}}{1000 \times 60 \text{ seconds}} = 0.146\text{mins}$$

Note, 4 borders will control the border take –out, with less labour

2.4.3. Design of supply channel (fish refuge in pond)

The element of an open channel are employed in these design

T= top width of the channel

t = width of surface when the water is at depth d

D = depth of channel after free board is added.

d = depth of flow in refuge

cc = wetted side of channel.

Design parameter:

Data needed for channel capacity includes the mannings roughness coefficients of 0.025 (a constant), the side slope of 1:1 and bed slope of 0.3%, these values were gotten from Booher (1974).

The flow rate =Q= $0.1m^3/s$. But due to application efficiency of 65%, the flow will be = $0.1m^3/s./0.65 = 0.15\ m^3/s$.

Design approach and assumption:

The design of supply channel or refuge for fish was based on the maximum amount flow that will pass through the supply channel at any time of irrigation, then slow rate cannot exceed $0.15\ m^3/s$.

A bed slope of 0.3% is assumed to avoid siltation of the channel and at the same time over scouring of the channel.

The design of the supply channel and the secondary channel for the borders will be the same since the same flow rate will be used.

Fish refuge dimension:

Design discharge = $0.15\ m^3/s$., for 4 borders strip.

Applications efficiency of 65%, will result to flow rate or design discharge of $0.15\ m^3/s$.

Available design discharge = $0.15\ m^3/s$.

Manning's roughness coefficient = 0.025

Side slope = 1:1 ; Bed Slope = 0.3%

Using manning's formula to determine the section factor of the design , if the section factors agree with the calculated section factors the design is good and okay.

Given that $Q = A/n\ R^{2/3}\ S^{1/2}$ ---------- 8

This Quantity Q is in m^3/s, when the Area (A) is in m^2, R is in m and k = 1 and S = Side slope

$Qn/S^{0.5} = AR^{2/3}$ ---------- Section factor

$AR^{2/3} = Qn/S^{0.5}$

$0.15 \text{ X } 0.025 / 0.003^{0.5} = 0.068 = 0.1$

For channel section;

$A = bd + Zd^2$ ---------- 9

$$P = b + 2d\sqrt{Z^2 + 1} \quad \text{---------- 10}$$

Where;

A = Area of channel

b = bottom width of channel (fish refuge)

d = depth of flow in fish refuge

P= wetted perimeter

Z = channel side slope =1

Substituting Z =1 in equation 9 & 10

$A = bd+d^2$

$P = b + 2d\sqrt{2}$

$R^{2/3} = (A/P)^{2/3}$

$= [bd+d^2/b+2d\sqrt{2}]^{2/3}$

$AR^{2/3} = (bd+d^2)\ [bd+d^2/b+2d\sqrt{2}]^{2/3}$

Given bottom width (fish refuge) b = 0.25m and depth of flow d = 0.3m (koesoemadinata and Costa-Pierce, 1992)

Then; $AR^{2/3} = (0.25 \text{ x } 0.3 + 0.3^2)[0.25 \text{ x } 0.3 + 0.3^2/\ 0.25 + 2 \text{ x } 0.3\ \sqrt{2}]^{2/3} = 0.175$

$A = bd + Z\,d^2$
$= 0.25 \times 0.3 + 1 \text{ xx } 0.09$
$A = 0.165m^2$
$P = b + 2d\sqrt{2}$
$= 0.25 + 2x\ 0.3\ \sqrt{2}$
$P = 1.098m$
$R = A/P = 0.165/1.098 = 0.1502$
$R^{2/3} = 0.2861$
$V = 1/n\ R^{2/3}\ S^{½}$
$V = 1/0.025 \times 0.2861 \times \sqrt{0.003}$

$V = 7.5$ m/s
$Q = AV$
$Q = 0.165 \times 7.5$
$Q = 1.2375 m^3/s$
But, with 20% loss to conveyance;
$Q = 0.2475\ m^3/s$
$Q = 0.21\ m^3/s$
With the calculated value of Q of $0.21m^3/s$ and the designed Q of $0.15m^3/s$. Our design dimension is correct and okay. Adding free board of 20%.
$D-d = 0.2D$
$D = d/0.8$
$D = 0.3/0.8 = 0.375$
$t = b + 2\,d\,Z$
$t = 0.25 + 2 \times 0.3 \times 1 = 0.85$
$T = b + 2\,D\,Z$
$= 0.25 + 2 \times 0.375 \times 1 = 1m$
$T = 1m$
$A = 0.165m$
$P = 1.098m$ $T = 1m$ $t = 0.85m$ $b = 0.25m$ $d = 0.3m$
$D = 0.375m$

Design of fish refuge (pond):
The maximum design flow rate for rice is $0.15m^3/s$. But the main / supply channel will carry maximum flow of $0.15m^3/s$. The dimension of the main channel would also form the dimension of the fish refuge (pond), due to the fact that they would carry the same amount of flow. It is this fish refuge channel that will distribute water to the borders take–out structure.
Therefore channel dimensions of bottom width $b = 0.25m$
Depth of flow $d = 0.3m$ are okay
Dimension used for the supply channel were used for the fish refuge (pond channel).

3.0 RESULTS AND DISCUSSION.

3.1 Fish

Oreochromis niloticus attained a final mean size of 15.17 cm and 46.71 g and *Clarias gariepinus* attained a final mean size of 53 cm and 1.25 kg (Table 2). *Oreochromis niloticus* had a mean condition factor of 1.10 at stocking and 1.32 at harvest, and an SGR which increased from 0.5% day^{-1} at 30 DAS to 1% day^{-1} at harvest (Table 3). The *Clarias gariepinus* fish had a condition factor of 2.79 at stocking which decreased to 0.77 at harvest. The overall condition factor was reduced by 55% at harvest. The SGR increased from 0.1% day^{-1} at 30 DAS to 3.4% day^{-1} at harvest (Table 3). Mean survival rates (Table 2) were slightly better for the *Clarias gariepinus* fish (92.65%) than the *Oreochromis niloticus* fish (89.8%). Similarly, gross fish yields were better with the *Clarias gariepinus* fish (187.5 kg $plot^{-1}$ $crop^{-1}$) than with the *Oreochromis niloticus* fish (31.5 kg $plot^{-1}$ $crop^{-1}$). However, net fish yields were better with the *Clarias gariepinus* fish, 183 .0 kg $plot^{-1}$ $crop^{-1}$ than with the *Oreochromis niloticus* 80 kg $plot^{-1}$ $crop^{-1}$ (Table 2). There were significant differences in fish yield between the two treatments of rice + *Clarias gariepinus* and rice+ *Oreochromis niloticus* *(P > 0.05;* both nonparametric, Mann-Whitney and parametric,

two-way ANOVA) (Table 4-8).

3.2 Paddy Rice

Paddy rice yields ranged between 40.05kg plot^{-1} crop^{-1} in rice-alone and between 45.5kg and 50.5kg plot^{-1} crop^{-1} in rice-fish condition regardless of fish size (Table 5).

Stocking rate 150Plot^{-1} with supplemental feeding, and ^{a} figures with superscripts do not differ significantly at 0.05 level of significance.

Stocking rate 150Plot^{-1}, with supplemental feeding
DAS =days after stocking.

There were significant differences *(P* > 0.05) in the paddy yield between the of rice + *Clarias gariepinus* , rice+ *Oreochromis niloticus and the rice-alone* treatment groups (both nonparametric, Kruskal-Wallis and parametric, two-way ANOVA). (see table.4-7, T-test and ANOVA result using GENSTAT Micro Soft ware Package to run the experimental Design.)

3.3 Water Quality

Average annual precipitation in this region is around 238cm-250cm, most of which occurs during July-September. Water quality parameters were within the acceptable ranges for aquaculture at all times in all treatments.

3.4. Analysis.

From table 4. above, the difference between two mean are statistically significant at 5%, it therefore means that the introduction of fish in the paddy rice farm, have significantly affect the yield of rice positively, that is, it has enhance rice production.
The decision rule is that at 30 DAS, since the difference between the two treatment means is greater than the calculated F-$LSD_{.05}$, then the two fish yield are declared statistically different , meaning that at 30 DAS, the weight of the fish increased significantly, in respective of it being stocked in a paddy rice field.
The two fish yield are declared statistically different , meaning that at 60 DAS, the weight of the fish increased significantly, in respective of it being stocked in a paddy rice field.
The decision rule is that at 99 DAS, since the difference between the two treatment means is greater than the calculated F-$LSD_{.05}$, then the two fish yield are declared statistically different , meaning that at 99 DAS , the weight of the fish increased significantly, in respective of it being stocked in a paddy rice field.

3.5 Discussion

Average final weights attained at harvest for *Clarias gariepinus* irrespective of their size at stocking were larger than the final weights attained by of the *Oreochromis* spp. The *Clarias gariepinus* had a reduction of condition factor at harvest while the *Oreochromis* spp maintained a slight increase in their initial condition. A similar phenomenon was observed in sepat Siam, *Trichogaster pectoralis* and sepat kedah, *T. trichopterus* from Malaysian rice fields (Ali, 1990).
The *Clarias gariepinus* were found to maintain the highest SGR and the *Oreochromis spp* were found to have increased feeding until 60 DAS but all decreased at harvest. Poor survival, lower condition factor and SGR with *Oreochromis* might be due to the factor below.
(a) The slower-swimming *Oreochromis* were often entangled in aquatic macrophytes and were vulnerable to predation by frogs, snakes and birds in this shallow habitat. Hence, their survival rates were poor in contrast to the *Clarias gariepinus* Little et al., there was higher recovery rates of *Clarias gariepinus* than *Oreochromis* in rice-fish systems.

This factor may have contributed to a lower SGR in *Oreochromis* spp. Poor survival and yield of *Oreochromis* have also been reported earlier from rice-fish culture in Bangladesh (Haroon and Alam, 1992) and in the Philippines (Sevilleja et al., 1992). Fish sampling may have been biased due to capture methods as mean attained size calculated from 15 fishes of large tilapia collected at 99 DAS were smaller than the mean final size calculated from all retrieved fish. Net fish yields of 183 kg plot $^{-1}$crop^{-1}, with the *Clarias gariepinus* and 80 kg plot $^{-1}$ crop^{-1}, with the large *O.noliticus ,* is achievable in rice-fish culture with supplemental feeding in Mbiabet.

Fish yields from rice-fish culture need to be expressed as net fish yields to have a clear understanding of the yield potential. Gross fish yields vary widely from 50 kg ha^{-1} to 2.25 t ha^{-1} depending unsystematically on country, fish species, density, fish diets, culture tenure and a variety of other factors (Leelapatra et al., 1992; Li, 1995).

Paddy yields were a little lower in the rice+ *O. noliticus* due to high fish disturbances. We found significant increase in paddy yield in rice-fish culture as compared to rice-alone in the present work, supporting previous reports from Bangladesh (Hossain and Chowdhury, 1985; Haroon et al., 1989, 1992, 1993, 1994); from the Philippines (Arce and dela Cruz, 1978; Torres et al., 1992) and from Korea (Kim et al., 1990).

4.0 CONCLUSIONS.

Since rice yield is not impaired by fish culture, nor is production area lost to fish refuge, and ecological conditions are favorable, concurrent rice-fish integration should be encouraged. Rice yield in the plots cultured with fish was observed to be better, than that of the sole rice plot. The yield of fish in rice –fish culture is more advantageous to the conventional fish ponds grazing, this is so because the culture environment, which is the paddy rice field is suitable for the species of fish that was cultured.

Clarias gariepinus was better for stocking in paddies because of better survival, growth and feeding habits on aquatic macrophytes than the *Oreochromis* spp. or other native carps. Net yield of small *Clarias gariepinus* was about 50kg $plot^{-1}$ greater than with *Oreochromis spp.* The operational and mechanization requirement are not cumbersome in the culturing of rice-fish, because rice field modification, irrigation and drainage were achieved using minimal labour requirement, when compared to conventional fish pond construction.

Finally, culturing of rice –fish is more productive and profitable as an agro business to practice than the sole rice system in Akwa Ibom State and the entire Nigeria.

REFERENCES

Ali, A.B., 1990. Some ecological aspects of fish population in tropical rice fields. Hydrobiology. 190, 215-222.

Arce, R.G. AND C.R. Dela cruz, 1978. Improved rice - fish culture in the Philippines. Paper presented at the Afro-Asian Conference of the International Commission on Irrigation and Drainage, Manila, Philippines, September, 1978. Tech. Pap. 10, 10p.

Booher, L.J. 1974. Surface irrigation. Food and Agriculture Organization of United Nations , Rome. 1974.

Cagauan, A.G., dela Cruz, C.R., Lightfoot, C., 1994. Nitrogen models of lowland irrigated ecosystems with and without fish using Ecopath II. In: dela Cruz, C.R. (Ed.), Role of Fish in Enhancing Rice fieid Ecology and in Integrated Pest Management. ICLARM Conf. Proc. 43, Manila, Philippines, p. 36.

Duru, J.O. 1984. Blaney Morin – Nigeria, Evapotranspiration model:Elservier Science publishers B.V . Nathalie 1984

Haroon, A.K.Y., Alam, M., 1992. Integrated paddy-cum-fish/shrimp farming. Final report. Fisheries Research Institute, Mymensingh-2201, Bangladesh, 41 pp.

Hossain, M.A., Chowdhury, D.P.N., 1985. Benefit of paddy-cum-prawn culture in Khulna. Abstract published in 10th Bangladesh Sci. Conf., Dhaka. Bangladesh Assoc.

Advan. Sci., Section III, p. 55.

Kim, Y.H., Kim, H.D., Kim, B.H., Lee, W.W., Ree, D.W., 1990. Studies on the raising four fish species in paddy field with grown rice. Research reports of the Rural Development Administration, 32 (2 Rice), 49-54 (in Korean with English abstract).

Leelapatra, W., Thongpan, N., Sollows, J., Chapman, Cl., 1992. Participatory research and extension in Thailand. World Aquacult. 23 (11, 58-60.

Li, D., N. Wu and T. Zhou. 1995. Effect of fi sh on growth and development of rice, p. 209-212. ***In*** K.T. MacKay (ed.) Rice-fi sh culture in China. International Development Research Centre (IDRC), Ottawa, Canada, 276 p.

Little, D.C., P. Surintaraseree and N. Innes-Taylor, 1996. Fish culture in rainfed rice fi elds of northeast Thailand. Aquaculture 140 (1996):295-321.

Micheal, A,M. 1985. Irrigation theory and practices 3rd edition. Vikas publishing house PVT. New York.

Schuster, W.H. 1955. Fish culture in conjunction with rice cultivation. World Crops 7:11-14; 67-70.

Sevilleja, R.C., A.G. Cagauan, E.A. Lopez, C.R. de la Cruz and A.A. van Dam. 1992. Component technology research in rice-fi sh systems in the Philippines, p. 373-384. ***In*** C.R. De la Cruz, C. Lightfoot, B.A. Costa- Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Torres, J., N.A. Macabale and J.R. Mercado. 1992. On-farm rice-fi sh farming systems research in Guimba, Nueva Ecija, Philippines, p. 295-300. ***In*** C.R. De la Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fi sh research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Zar, J.H., 1984. Bio-statistical Analysis. Prentice-Hall, Englewood Cliffs, NJ, USA, 718 pp.

Table 1: Radiation Ratio for the B.M.N. Evaporation Model from (Duru, 1984)

Lat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
04^0	.081	.077	.0886	.085	.085	.079	.085	.085	.085	.086	.080	.080
00^1	9	8		3	1	9	2	9	2	6	2	3
04^0	.081	.077	.0886	.085	.085	.083	.080	.086	.085	.086	.079	.079
30^1	6	5		3	5	6	3	2	2	3	8	7
05^0	.081	.077	.0886	.085	.085	.080	.084	.086	.085	.086	.079	.079
00^1	2	3		7	9	8	1	5	2	1	4	2
05^0	.080	.077	.0885	.086	.086	.081	.085	.087	.085	.085	.079	.078
30^1	7	1		1	6	8	0	1	3	9	0	7
06^0	.080	.076	.0885	.086	.086	.081	.085	.087	.085	.085	.078	.078
00^1	3	8		1	6	8	0	1	3	7	6	2
07^0	.079	.076	.0884	.086	.087	.082	.085	.087	.085	.085	.077	.077
00^1	4	3		5	7	7	9	7	4	3	8	2
07^0	.079	.076	.0884	.086	.087	.083	.086	.087	.085	.085	.077	.076
30^1	0	0		5	4	2	3	9	4	2	5	7
08^0	.078	.075	.0883	.086	.087	.083	.086	.088	.085	.085	.077	.076
00^1	5	8		7	7	6	7	2	5	0	1	2
09^0	.077	.075	.0883	.086	.088	.084	.087	.088	.085	.084	.076	.075
00^1	7	3		9	1	5	6	8	5	6	4	3
09^0	.077	.075	.0882	.087	.088	.085	.088	.089	.085	.084	.070	.074
30^1	2	3		2	9	0	0	1	6	4	0	8
10^0	.076	.074	.0881	.087	.089	.085	.088	.089	.085	.084	.075	.074
00^1	8	8		4	6	4	5	4	6	2	7	4
10^0	.076	.074	.0881	.087	.089	.085	.088	.089	.085	.084	.075	.073
30^1	4	5		5	0	9	9	7	7	0	3	9

Table 2: Values of Mean Monthly Relative Humidity%

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	68	70	75	76	80	79	80	78	80	78	76	65
1989	63	62	63	72	76	77	80	80	86	79	70	64
1990	60	58	72	76	78	79	79	80	80	76	70	62
1991	68	60	75	78	78	78	-	78	78	80	78	62
1992	68	70	71	78	82	81	87	80	86	86	83	65
1993	59	68	65	75	77	77	84	84	84	81	78	65
1994	60	69	72	78	80	79	80	83	83	80	79	68
1995	48	53	67	80	81	82	84	85	82	85	80	78
AVE.	61.7	63.	70.0	76.	79.0	79.	82.	81.0	82.	80.	76.8	66.
%	5	75	6	63		0	0		38	6		1

Table 3: Values of Mean Monthly Air Temperature ^{0}C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	27.0	27.2	26.8	26.5	27.0	25.4	26.0	27.2	27.0	27.1	26.8	27.1
1989	26.3	26.0	27.0	26.4	26.1	26.0	25.2	27.0	26.5	26.2	27.0	27.5
1990	26.5	24.5	27.3	27.0	27.0	25.1	25.2	27.0	26.3	25.2	26.5	27.0
1991	26.3	27.5	26.4	27.5	27.8	27.7	28.0	27.3	26.5	25.5	27.0	26.0
1992	27.0	27.0	27.5	28.5	28.9	27.8	27.1	26.3	27.3	26.4	27.3	27.5
1993	20.5	22.5	25.8	28.0	27.5	27.4	25.4	26.1	27.5	26.5	27.8	27.0
1994	255.5	26.5	27.0	27.5	26.3	26.5	26.4	26.5	26.3	25.1	26.5	25.9
1995	27.2	28.0	29.0	26.5	26.5	26.8	25.3	26.5	25.5	25.6	26.0	26.5
1996	26.0	27.0	26.5	27.2	26.5	25.0	26.0	26.8	26.0	26.1	27.0	27.0
1997	24.5	26.0	26.2	26.8	26.2	26.0	25.8	20.5	26.3	26.8	27.2	26.5
Ave.	25.71	26.2	26.9	27.1	27.0	26.3	26.0	26.7	26.5	26.1	26.9	26.8
		2	5	9	3	8	4	2	2			

Table 4: Designed values of Potential Evapo-Transpiration (Etp) and Consumptive Use of Rice (Cu) Obtained by Calculation.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Etp (mm/day)	4.7	4.4	4.6	3.93	3.73	3.47	3.32	3.56	3.34	3.48	3.5	4.38
K				0.85	1.00	1.15	1.30	1.25	1.10	0.90		
Cu (mm/day)				3.34	3.73	3.99	4.31	4.45	3.67	3.1		

Table 5: Fish Stocking, Harvest and Yield of Fish and Paddy In 99days Rice–Fish Culture Experiments From Mbiabet, Akwa Ibom State, Nigeria

Treatment	Culture area (ft^2) = Plot	Initial Length (cm)	Wt (g)	Final Length (cm)	Wt (g)	Fish retrieval (%)	Fish yield		Paddy yield (Kg/plot)
							Gross (Kg/plot)	Net (kg/plot)	
Rice alone	50								40.05[a]
Rice +O. noliticus	50	4.5-5.6	5.1-6.1	12.75-15.17	30.5-46.71	89.8	31.5	80	45.50 [a]
Rice + Clarias gariepinus	50	9.5 -13	39.4-40.1	47- 53	1050-1250	92.65	187	183	50.50 [a]

Table 6: Condition Factor (K) and Specific Growth Rates B (SGR) of Fish From Rice-Fish Culture Experiments In Mbiabet, Akwa Ibom State.

Year and Treatment	Culture tenure (days)	Condition Factor (K)			Final reduction of K (%)	Specific Growth Rates		
24^{TH} August 2009		Initial	30 DAS	60 DAS	99 DAS		30 DAS	60 DAS	99 DAS
Rice + O. noliticus	99	1.10	1.80	1.62	1.32	0	0.5	1.5	1.0
Rice + Clarias gariepinus	99	2.79	1.70	1.45	0.77	55.0	0.1	3.0	3.4

Table 7: Analysis of Variance For Rice Yield (Kg/Plot) in Sole Rice Plot and Rice–Fish Plots.

Source of variation	Degree of freedom	Sum of squares	Mean square	Variances ratio	Fisher Probability
Among treatment	6	0.143	0.023	5.44	
Within treatment	2	385.3	192.7	44071	0.001*
Error	12	0.052	0.004		
Total	20	385.3			

*highly significant at 5% probability level.

Table 8: Analysis of Variance For Fish Yield At 30 Days After Stocking (30DAS)

Source of variation	Degree of freedom	Sum of squares	Mean square	Variances ratio	Fisher Probability
Among treatment	4	0.3926	0.0982	0.96	
Within treatment	1	4.1474	4.1474	40.64	0.003*
Error	4	0.4082	0.1021		
Total	9	4.9482			

*Significant at 5% probability level.

Table 9: Analysis of Variance For Fish Yield At 60 Days After Stocking (60DAS)

Source of variation	Degree of freedom	Sum of squares	Mean square	Variances ratio	Fisher Probability
Among treatment	4	0.084	0.21	21.0	
Within treatment	1	654.4	654.4	6.54	0.001*
Error	4	0.004	0.001		
Total	9	654.56			

*Highly Significant at 5% probability level.

Table 10: Analysis of Variance For Fish Yield at 99 Days After Stocking (99 DAS)

Source of variation	Degree of freedom	Sum of squares	Mean square	Variances ratio	Fisher Probability
Among treatment	4	6.40	1.60	2.67	
Within treatment	1	291.6	291.6	486.0	0.001*
Error	4	2.40	0.60		
Total	9	300.4			

*Highly Significant at 5% probability level.



Plate A1: Pictorial View of the Demonstration Plot Showing the Fish Refuge and the Matured Rice Paddy.

SUBSURFACE DRAINAGE SYSTEM DESIGN USING FUZZY CONTROL

A.M. Adewara[1], I.I. Ahuchaogu[2] and A.O. Ogunlela[3]
[1&3]Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Kwara State, Nigeria.
[2]Department of Agricultural and Food Engineering, University of Uyo, Uyo, Akwa Ibom State, Nigeria.

ABSTRACT
An expert system based on fuzzy logic to predict the uncertainties in subsurface drainage systems at Lower Niger River Basin Development Authority (LNRBDA), Basin road, Ilorin, Kwara-State, Nigeria and twenty other drainage data given the uncertain design parameters of hydraulic conductivity, drainage coefficient and depth of impermeable layer which determined the position of water table height in drainage system to give a conservative design. Hooghoudts was used which represent steady state condition. Fuzzy Logic Control and first and second order solution were used to evaluate the uncertainties in twenty one subsurface drainage systems, Fuzzy Logic Control gave narrower drain spacing, so that the amount of head lost in horizontal and radial flow is insignificant, also reduces the risk of yield loss due to excess water and it drain faster, with subsurface drainage system DSN 21 (measured LNRBDA) of drain spacing of 17.1 m while FSOS drain spacing of 30.7 m. The permissible midspan water table height of the twenty-one subsurface drainage systems were maintained for FLC and FSOS respectively because they fell between the range of expected water table heights. The two approaches validated in which FLC gave a higher degree of efficiency 70.9 % than FSOS 37.5 % for the three design parameters combined (k, d and R). Fuzzy Control was found to give a more conservative design due to it flexibility and ability of it expert system in the model.

Keyword: Fuzzy logic, Hydraulic Conductivity, Drainage Coefficient, Hooghoudts Method, Uncertainties.

1.0 INTRODUCTION

Agricultural drainage system is the removal and disposal of excess water and salt from above and below the soil surface to enhance effective crop production and soil management. It is a system that behaves in an unusual manner due to the variation in climatic factor, environmental factor, soil physical properties and others. The need for subsurface drainage system is related to water table elevation, permeability of the soil and crop requirements (Todds, 2005).

Hooghoudts in 1940, solved drainage problem such as water table height, depth of drain, spacing of drain, hydraulic conductivity, drainage co-efficient and depth of impermeable layer (Luthin, 1978). Failure in drainage system can be traced to uncertainties in the soil physical properties, climatic factors and environmental factors. If these factors are considered properly and are incorporated into the drainage design, a sustainable drainage system awaits us.

Conventional design of agricultural land drainage system needed to be improved on by making proper provision for uncertainties in the parameters concern such as hydraulic conductivity, drainage coefficient and depth of impermeable layer.

Luthin (1978) stated that the position of water table depends on the drainage coefficient, soil hydraulic conductivity, depth of impermeable layer and drain spacing.

These are the major problems in drainage system which determines the position of the water table.

Various methods can be used to analyzed and evaluate uncertainties in all field of studies such as Euler equation, first order analysis, first-second order analysis , DRAINMOD, kirchoff network, simulation method, kriging model, stochastic technique, deterministic model and Bayesian method.

Another approach which has gained wider acceptance is Fuzzy logic control with the aid of graphical user interface. There is therefore need to search, evaluate and apply other approaches that can provide designer with a simpler and yet more accurate way of evaluating uncertainties in subsurface drainage system design.

2.0 METHODOLOGY

Fuzzy Logic (FL) was used to carry out the optimization of subsurface drainage system and first and second order solution (FSOS) used as a check. They were evaluated based on their ability to give a more conservative design. These methods were applicable to the design of subsurface drainage system assuming steady state (Hooghoudt, 1940). Twenty –one subsurface drainage systems were considered in uncertainty in hydraulic conductivity, drainage coefficient, depth of impermeable layer and the three parameters combined.

In computation of the measured data from the 21 subsurface drainage systems, Information about the first and second statistical moment (mean and variance) of the data was considered.

Russel, 1996 an expert in the area determined the lowest (L), the most probable (P) and highest (H) value of specific measured data as expressed below:

$$\text{Mean} = \frac{L + 2.5P + H}{4.5} \quad (1)$$

$$\text{Variance} = \left(\frac{H - L}{2.56}\right)^2 \quad (2)$$

Where L, P and H are lowest, the most probable and highest respectively of the uncertain parameters.

Principles of Hooghoudt equation has gained confidence of experience the drainage design engineers (Michael et al, 2006).

Hooghoudt Equation expressed below as:

$$S^2 = \frac{(8Khd + 4K h^2)}{R} \quad (3)$$

where S= drain spacing (cm); K = Saturated hydraulic conductivity (cm/day); R = Drainage coefficient (cm/day); h = Permissible midspan water table height above the drains (cm); d = Equivalent depth to the impermeable layer (cm)

With the assumption that most of the flow takes place below the drains, as simplified below: $S^2 = \frac{8Khd}{R}$ *(4)*

Note: $h^2 \approx 0$

Considering h as the dependent variable, as simplified below:

$$h = \frac{S^2 R}{8Kd} \quad (5)$$

For a normal distribution, 90% of confidence interval of midspan water table height (h)

an equivalent value of 0.1 as obtained using normal distribution approach to be ± 1.28.

$$h = [E(h) \pm 1.28\ SD] \qquad \sqrt{Variance} \qquad (6)$$

Where E (h) = expected water table height and SD =

Fuzzy logic control:

Fuzzy logic was first proposed by Zadeh 1965. He developed his ideas in 1973 paper that introduced the concept of "linguistic Variables" as Fuzzy set.

Fuzzy logic is a logic that makes computers behaves like human being. It is closer to human thinking and by natural language it is easier to use in many field (Lee, 1991).

Membership function is functions that specify the degree to which a given input belongs to a concept. It is of various forms triangular, trapezoidal, Gaussian, linear shapes. Fuzzy logic involved three steps, namely: fuzzification of input variables, fuzzy rules and defuzzification of the output variables.

First and second order solution:

First and second order analysis is a good tool in the field of research especially in estimation of uncertainties. It was used in assessing the uncertainties in local sensitivity analysis of air quality (Laurent et al., 1997). It was also used by Alexander (1997) in the analysis of non linear semi definite programs. Ravi et al. (2007) explored it in the analysis of lighting, shading & shadowing. Its result in analysis of uncertainty in drainage system (Hooghoudts equation) yields more accurate results (Prasher et al., 1984). Prasher et al. (1984) method of first and second order equation was incorporated as a check for this study using Hooghoudt equation as expressed below:

For Hydraulic conductivity

From equation 5

$$h = \frac{S^2R}{8} \qquad K \qquad d$$

Using Taylor series to obtain first and second order solutions

$$\frac{?h}{?k} = -\frac{S^2RK^{-2}}{8d} \qquad (7)$$

$$\frac{?^2h}{?k^2} = \frac{S^2RK^{-3}}{4d} \qquad (8)$$

Expected value and variability of h were obtained respectively:

$$E(h) = \left[\frac{S^2R}{8Kd}\right] + \left[\frac{1}{2}\left[\frac{S^2R\overline{K^{-3}}}{4d}.Var(K)\right]\right] \qquad (9)$$

$$Var\ (h) = \left[\frac{-S^2R}{8dk^2}\right] Var\ (d) \qquad (10)$$

The same were calculated for depth of impermeable layer and drainage coefficient respectively.

Model efficiency:

Nash and Sutcliffe (1970) (R^2) model efficiency test was used to evaluate the performance of the approach and establish the relationship between the model and FSOS. The value of R^2 ranges between -1.0 to 1.0. The higher the value of R^2 the better the model (Tran et al., 2001). The coefficient can be calculated as follow:

$$R^2 = 1 - \frac{\{\sum_{i=1}^{N}(Qmi - Qci)^2\}}{\{\sum_{i=1}^{N}(Qmi - Qm)^2\}} \qquad (11)$$

where, Q_{mi} and Q_{ci} are the measured and computed values respectively , of event *I* and $\overline{Q_m}$ is the mean of the measured values.

3.0 RESULTS AND DISCUSSION

3.1 Model Development

Fuzzy Logic Toolbox by Math Works Inc was used in the study to develop the model. The methodology of the model developed includes basically three components which include fuzzification of the input parameters in table 1, writing of inference rules and defuzzification of output parameters.
The procedure for the designing of the graphical user interface of the model and the codes are as follows.

3.2 Fuzzy Input and Output

The input variables entered into the model are the measured uncertain parameters in order to obtain a result which is our expectation from the model. The fuzzy inputs of this model subsurface Drainage fuzzy Logic (SDFL) include hydraulic conductivity (K), the depth of impermeable layer (d) and drainage coefficient (R) as in table 1. The output of the model is the fuzzy outputs which were incorporated into the Hooghoudts equation to give a conservative design.

3.3 Fuzzification Inference System (FIS)

Fuzzy inference system is the process that create mapping from a given input to an output, uploading from Fuzzy logic toolbox by typing tipper.fis at its command window. Input variable on the left and output variable on the right. There are two types of FIS; Mamdani and Sugeno-type inference. Mamdani-type inference was used for this model. FIS was loaded with the generic untitled FIS Editor, with one input, labeled **input1**, and one output, labeled **output1**. The input1 was renamed as HydraulicCon., estimate while Output 1 was named as FuziHCEstimate The same was done when designing for Depth of Impermeable Layer and Drainage Coefficient with inputs named as DepthOfImperLayer and DrainageCoef., and their outputs as FuziDOILEstimate and FuziDCEstimate respectively (Figure 1).

3.4 Membership Function Editor (MF) Membership Function is a curve that defines the shape of all membership function of each parameters. The membership value between the universe of discourse (0 & 1). Membership function is loaded from the FIS editor menu by selecting the Add MFs…. Showing the MF plots by the right with the FIS variables by the left. The MFs types are trimf, gaussmf, trapmf functions respectively. In this study the MFtype selected for K, d, and R is Trimf.

MF type:
For drainage coefficient, Hydraulic conductivity and depth of impermeable layer are trimf, gaussmf, trapmf respectively. The params were left at default. The MFs names for three variables are Low, Probable and High. The same process was followed to create the output variable membership function. The triangular membership function type was used for the three variables. **Range** (and the **Display Range**) set for drainage coefficient is [0 10] while for hydraulic conductivity and depth of impermeable layer were the same [0 200]. This is done by ensuring that the range covers the output range. The MFs names of the output variable are Low, Medium and High.

Rule editor:

After the variables have been named, and the membership functions have appropriate shapes and names, Rule editor was loaded from Edit menu of MFs window.

Clicking on Rules from Edit menu displayed rule editor window. Based on the descriptions of the input and output variables defined with the FIS Editor, the Rule Editor construct the rule statements automatically, by clicking on and selecting one item in each input variable box, one item in each output box, and one connection item. **None** as one of the variable qualities that exclude variable from a given rule and choosing **Not** under any variable name negate the associated quality. Rules may be changed, deleted, or added, by clicking on the appropriate button. The resulting rules for the three variables are as given below.

Drainage Coefficient Uncertainty Fuzzy Rules
1. If (DrainageCoef. is Low) then (FuziDOILEstimate is Low) (1)
2. If (DrainageCoef. is Probable) then (FuziDOILEstimate is Medium) (1)
3. If (DrainageCoef. is High) then (FuziDOILEstimate is High) (1)

Hydraulic Conductivity Uncertainty Fuzzy Rules
1. If (HydraulicCon. is Low) then (FuziHCEstimate is Low) (1)
2. If (HydraulicCon. is Probable) then (FuziHCEstimsate is Medium) (1)
3. If (HydraulicCon. is High) then (FuziHCEstimate is High) (1)

Depth of Impermeable Layer Uncertainty Fuzzy Rules
1. If (DepthOfImpLayer is Low) then (FuziDOILEstimate is Low) (1)
2. If (DepthOfImpLayer is Probable) then (FuziDOILEstimate is Medium) (1)
3. If (DepthOfImpLayer is High) then (FuziDOILEstimate is High) (1)

Rule viewer:

The Rule Viewer displays a roadmap of the whole fuzzy inference process. The rule viewer is loaded from edit menu. The interface consists of rows and columns components. Each rule is a row of plots in yellow color which indicate the MF referred to as antecedent the if- part of the rule, while each column is a variable in blue color which indicate the MF referred to as consequent the then- part of each rule. The last row after the rules plots which is the fourth plot in the third column of plots represents the aggregate weighted decision for the given inference system. This decision depends on the input values for the system. The defuzzified output value is shown by the thick line passing through the aggregate fuzzy set. The Rule Viewer allows for the interpretation of the entire fuzzy inference process at once.

3.5 Uncertainties in Subsurface Drainage Systems Design

The Fuzzy logic control and First and Second Order differential analysis were used to analyze the uncertainties in the drainage systems. The methods were used on the Hooghoudt's drainage system steady flow equation to obtain the uncertainties in drainage system due to the effect of variability in the soil physical characteristics such hydraulic conductivity (K), drainage coefficient (R) and depth of impermeable layer (d). Luthin, 1978 stated that the above uncertain parameters are the major problems in drainage system which determines the position of the water table. The two approaches were used to estimates the uncertainties on the twenty one subsurface drainage systems data as represented in tables 3 and 4.

3.6 Model Validation

Degree of efficiency was also calculated to determine the ratio of the accuracy between the two approaches. The result indicated that FLC model has higher efficiency than FSOS approach except at the uncertainty in the depth of impermeable layer which the degree of efficiency was very close (table 5.0). The level of efficiency of FLC in the measurement of uncertainty in hydraulic conductivity was 9times efficient than if FSOS was used. Using the model to measure uncertainty in drainage coefficient, FLC was 26times efficient while in the combine uncertainties it was 38times efficient than that of

FSOS.

3.7 Conservative Design

For a drainage system design, it means that the design drain spacing would be narrower with the FLC approach, conserving less land space, the amount of head lost in horizontal and radial flow is insignificant, also reduces the risk of yield loss due to excess water and it drain faster. Determining the optimal drain spacing for a soil is critical when evaluating the economics of a drainage system. Although narrower drain spacings remove more water from the field, they do not always produce the best crop growth and yield Schwab et al., 1957. Therefore, it will result in a safer design than the design obtained by FSOS. The variance in output can be regarded as the risk in the drainage system design. Hence, a more conservative design can be done by considering the increased risk with FLC approach. As their drain spacings are presented in table 5.

4.0 CONCLUSION

Subsurface drainage is an important water management practice on naturally poorly drained soils, and recommendations for appropriate drain spacings for particular soils continue to evolve. On the basis of the validation results it is concluded that the model FLC performed well in the analysis of the uncertainties in subsurface drainage system. The fuzzy model possesses the additional capability to manipulate the input membership function and adjust the fuzzy parameters without requiring rigorous computation. The FLC approach was also found to be more flexible and which gave a narrower drain spacing resulting to insignificant head lost in the horizontal and radial flow in drainage system, improved crop yield and drain excess water faster. it can be implemented easily in most designs with the availability of this model, Fuzzy Logic Control. FSOS resulting in larger drain spacing which may well act as bottleneck in drainage system Lambert, 1983.

REFERENCES

Alexander S. (1997). First and Second Order Analysis of Nonlinear Semidefinite Programs. School of Industraial and Systems Engineering, Georgia Institute of Technology, Atlanta, USA. Published by Elsevier Science B.V.

Hooghoudt, S.B. (1940). General consideration of the problem of field drainage by parallel drains, ditches, watercourses, and channels. Publ. No.7 in the series Contribution to the knowledge of some physical parameters of the soil (titles translated from Dutch). Bodemkundig Instituut, Groningen, The Netherlands.

Laurent Vuilleumier, Robert A. Harley, and Nancy J. Brown (1997). First and Second Order Sensitivity Analysis of a Photochemically Reactive System (a Green's Function Approach), Published by Environ. Sci. Technol.,), pp 1206–1217

Lee C.C. (1991). Fuzzy logic in control systems: Fuzzy logic controller, IEEE Transactions, Man, and Cybernetics, vol.20, nr.2, p.404-410

Luthin J.N. (1978). Drainage Engineering. Published by Robert E. Krieger publishing CO. New York,,pp 122.

MathWorks, (2002). Fuzzy Logic Toolbox for with MATLAB. Published by The

MathWorks, Inc. 3 Apple Hill Drive Natick, MA 01760-2098.
Michael A.M. and Ojha T.P. (2006). Principles of Agricultural Engineering Vol. II. Published by Sunil Kumar Jain for Jain Brothers, New Delhi.

Prasher, S. O., Russell, Podmore, T. H. and Chieng, S. T.(1984). First and Second order analysis of parameter uncertainty in drainage design. Transaction of ASAE 27 (4): 1081-1086.

Todd, D. K., and Mays, L.W. (2005).Groundwater Hydrology. John Wiley and Sons, New York.

Tran, L.T., Ridgely, M.A., Nearing, M.A, Duckstein, L. and Sutherland, R. (2001). Using Fuzzy Logic base modeling to improve the performance of the Revised Universal Soil Loss Equation. International Soil Conservation Organization. USDA-ARS, West Lafayette. USA.

Zadeh, L.A. (1973). "Outline of a new approach to the analysis of complex systems and decision processes," IEEE Transactions on Systems, Man, and Cybernetics, Vol. 3, No. 1, pp.28.

Table 1: Summary of the Subsurface Drainage data Used

DSN	Drain Spacing, S (cm)	Saturated Hydraulic Conductivity, K (cm/day)	Drainage Coefficient, R(cm/day)	Permissible Midspan water table head above drain, h(cm)	Equivalent depth to the impermeable layer,d(cm)
1	2400	49	0.89	76	211.1
2	5500	50	0.12	180	150
3	1800	30	0.13	30	60
4	1400	35	0.37	33	75
5	2000	40	0.27	26	128
6	2500	114	0.32	17	133
7	2800	119	0.25	15	133
8	2700	84	0.19	15	133
9	5880	122	0.61	90	210
10	11250	366	0.24	195	240
11	1600	62	1.6	75	110
12	1850	90	2.1	67.5	147.5
13	1750	51	1.5	82.5	137.5
14	5000	60	0.5	50	500
15	6500	14	0.1	100	480
16	9500	30	0.1	100	480
17	3800	200	0.7	70	400
18	9000	100	0.23	30	770
19	9000	100	0.1	30	463
20	10000	100	0.17	60	200
*21	3000	50	1	100	160

Note: * =Measured

Table 2: Data Used and Their Respective Sources

Drainage System Number (DSN)	Source
1	**Perret, et al. (1997).**
2-3	**Schwab et al. (1993).**
4- 8	**www.google.com, Accessed March, 2009**
9 –10	**Soil Water Conservation Service (SWCS) (1999)**
11 –13	**www.google, Accessed March, 2009.**
14	**FAO (1996)**
15 -19	**Ritzema, et al. (1994).**
20	**Dieleman et al. (1996)**
*21	**LNRBDA (2008)**

Note: *DSN 021 = Measured by Lower Niger River Basin Development Authority (LNRBDA) Basin Road, Ilorin, Kwara-State, Nigeria.

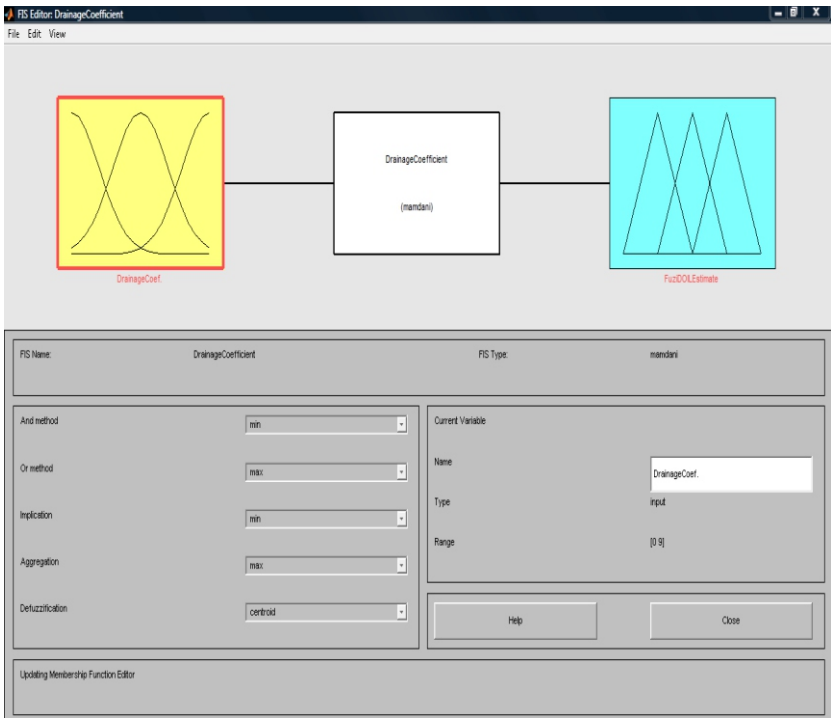


Figure 1; Fuzzy Inference Systems (FIS) Graphical User Interface for Uncertainty in Drainage Coefficient

Source: Math Work (2002)

Table 3: Fuzzy Subsurface Drainage Results

DSN	Drain Spacing,S (cm)	Saturated Hydraulic Conductivity, K (cm/day)	Drainage Coefficient, R(cm/day)	Permissible Midspan water table height above drain, h(cm)	Equivalent depth to the impermeable layer,d(cm)
1	1558.7	22.000	0.991	76	142.000
2	4060.564	22.400	0.403	180	116.000
3	990.7813	18.500	0.403	30	74.100
4	926.5452	18.500	0.516	33	74.200
5	1062.785	18.500	0.402	26	105.000
6	814.5341	18.500	0.438	17	107.000
7	795.1814	18.500	0.402	15	107.000
8	867.1449	22.000	0.402	15	107.000
9	3652.012	39.400	0.402	90	144.000
10	8994.883	82.900	0.402	195	154.000
11	1241.662	26.200	1.350	75	94.900
12	1215.057	32.900	1.790	67.5	115.000
13	1295.584	22.700	1.350	82.5	110.000
14	1914.91	26.100	0.689	50	217.000
15	3054.184	18.500	0.403	100	204.000
16	3054.184	18.500	0.403	100	204.000
17	2813.138	50.200	0.849	70	204.000
18	2688.883	34.800	0.402	30	333.000
19	2130.418	34.800	0.403	30	204.000
20	2630.97	34.800	0.403	60	137.000
*21	1711.354	23.2	1.09	100	122.000

Table 4: FSOS Subsurface Drainage Results

DSN	**Drain Spacing, S (cm)**	**Saturated Hydraulic Conductivity, K (cm/day)**	**Drainage Coefficient, R(cm/day)**	**Permissible Midspan water table head above drain, h(cm)**	**Equivalent depth to the impermeable layer,d(cm)**
1	2490.66	40	0.80	76	200
2	6101.89	46	0.12	180	145
3	2057.64	30	0.14	30	50
4	1650.95	31	0.35	33	71
5	2482.73	40	0.07	26	126
6	3138.73	11	0.3	17	120
7	3515.38	11	0.05	15	120
8	3389.83	65	0.13	15	120
9	6438.25	122	0.06	90	210
10	12077.85	335	0.18	195	240
11	1663.31	60	1.5	75	110
12	2061.72	95	2.0	67.5	140
13	2027.04	50	1.5	82.5	130
14	6169.43	55	0.5	50	450
15	7656.71	15	0.1	100	450
16	11190.58	30	0.1	100	450
17	4531.07	180	0.7	70	350
18	10560.34	100	0.23	30	750
19	10851.81	100	0.1	30	434
20	11690.13	100	0.17	60	180
*21	3070.26	50	1	100	170

Table 5: Model Efficiency Evaluation of First and Second Order Solution and Fuzzy Logic Control Model

S/N	Parameter	Method	No of Drainage System	Nash& Sutcliffe Model Efficiency	Degree of Efficiency
1	Hydraulic Conductivity, K	FSOS	21	0.319	1.00
		FLC	21	2.861	8.97
2	Depth of Impermeable Layer, d	FSOS	21	0.652	1.00
		FLC	21	0.630	0.966
3	Drainage Coefficient, R	FSOS	21	0.039	1.00
		FLC	21	0.997	25.56
4	Combine K, d, R	FSOS	21	1.89	1.00
		FLC	21	70.87	37.50

SYSTEM DEVELOPMENT OF LOW CARBON BIOPROCESS TECHNOLOGIES FOR ECONOMIC TRANFORMATION IN NIGERIA

Oladipo Ajayi[1], Olugbemide A.D[2], Adebayo A.A[1], and Atanda E.O[1]
[1]Department of Agricultural & Bio-environmental Engineering Technology, Auchi Polytechnic, Auchi, Edo State. P.M.B 13, Edo State.
[2]Department of Basic Sciences, Auchi Polytechnic, Auchi, Edo State.
Corresponding author E-mail: oladipo_aj@yahoo.com 08052127818

ABSTRACT
The 1992 convention on climate change by the United Nations conference on Environment and Development (UNCED) in Rio de Janeiro galvanized the driving force for global strategic energy mix development was to stabilize greenhouse gas concentration levels in the atmosphere for combating global warming and related environmental challenges. The rate of carbon-dioxide (CO_2) emissions from the combustion of fossil fuels is directly linked to fuel consumption. An analysis of the Nigerian oil-driven manufacturing and industrial sectors reveal high rate use of carbon based fuels. Industrial activities increase the concentration of carbon dioxide in the atmosphere against the global concern. The need to join the league of nations seeking substantial changes to their energy production methods in order not to exceed the level of CO_2 concentrations in the atmosphere has necessitated attempts to harness the potential of integrating renewable energy in electricity development with emphasis on biomass energy resource utilization of Nigeria's rich natural energy. The abundant energy resources available in Nigeria have not been properly harnessed to satisfy the nation's energy needs in the face of its growing population and industrial needs. This paper addresses the need to provide a scope of technologies and system development required for the conversion process in the emerging bioprocess industry sector for a sustainable transformation of Nigeria. Bioenergy technologies (BETs) involving thermo-chemical, bio-chemical and physico-chemical conversion of biomass into secondary energy forms such as electricity production are presented as potential carbon abatement methods for substitution for fossil fuel. Improvement of the present critical energy situation in Nigeria can be achieved through such flexible energy mix which integrates untapped biomass as a renewable energy source. In conclusion, the paper provides the road-map for short and long term strategies for implementation in the energy sector towards capacity utilization in order to meet its developmental targets of becoming one of the twenty most developed economies in the world by 2020.

Keywords: Bio-Energy, Biomass, Bioprocess, Greenhouse Gas, and Technology.

1.0 INTRODUCTION
Energy is fundamental to sustenance of life in present day energy-based society. Every activity towards the satisfaction of human needs such as lighting, housing, industry, transportation, agriculture, provision of water, health and education which are indices of development is dependent on energy either directly or indirectly. An energy system consists of a sequence of elaborate and complex processes for the extraction, conversion and distribution of useful energy to the user for provision of goods and services (Grubler *et al*, 2012). Energy services are the result of a combination of various inputs such as technologies, infrastructure, materials, manpower know-how, energy carriers and users specifically during the conversion of energy to fuels and electricity and distribution to final use. The energy sector therefore is a very strategic part of any national economy as the productivity index of any nation measured in terms of Gross Domestic Product (GDP) is a function of the electricity consumption during various conversion processes for industrial, commercial, private and national wealth creations. GDP and per capita income are development indices used to measure the economic well-being of a country and its people. Sesan (2008) defined GDP as the total market value of all final goods and services produced within a given country in a given period of time (usually a calendar year). Per

capita income refers to what each citizen would receive if the yearly income generated by a country from its productive activities were divided equally among everyone.

Presently global energy requirements are mostly dependant on fossil fuel obtained from primary energy sources which may eventually lead to a foreseeable depletion of the finite resources. Energy consumption globally is on the rise due to rapid population growth and economic development. In Nigeria, the return to democratic governance since 1999 has induced significantly economic productions and income levels making government to introduce reforms in the oil and gas sectors which is the mainstay of the economy. The reform became necessary to meet increasing energy demand and also maximize income opportunities arising from oil prices at the international oil market. Rising earnings would ensure massive infrastructural development and realization of the targeted goal of Nigeria becoming one of the twenty most industrialized economies in the world by 2020. Nigeria is a developing country currently experiencing rapid economic transformation, industrialization and population expansion. The main challenges facing the country presently is how to increase energy supplies to meet the needs of its growing population and also repair and upgrade existing infrastructure especially for non-hydrocarbon energy sources (Nwasike, 2005). Meeting these challenges is very critical to improving the nation's economy and raising the standard of living in Nigeria. Energy production and supply in Nigeria currently is provided mainly from fossil fuels.

Most of the CO_2 emissions come from fossil fuels consumption from primary energy sources such as coal, oil and gas. Table 1 reveals that major share of electricity production is from gas and hydropower. The consumption of fossil fuels in both rural and urban sectors in Nigeria have increased over the years and electricity demand is expected to increase for the next couple of decades to meet increasing population and industrial needs. The drive for increased human activities for economic growth and social development are leading to a large gap between energy demands and demands across the globe and Nigeria. Energy shortages have affected Nigerian economy as almost all manufacturing and industrial organizations as well as the private consumers have to rely on generators which use fossil fuel to augment. Peixoto (2012) reported that electricity production places considerable pressure on the environment, because it is mostly produced from nuclear reactions, burning of fossil fuels and in dams. These pressures include the emission of greenhouse gases and air pollutants, land-use, and waste generation and these contribute to climate change, damaged natural ecosystems with adverse effects on human health. The environmental concern of these sources of power coupled with depleting fossil fuel sources fueled demand for alternate costless biochemical energy resources globally. In Nigeria investment in energy and power infrastructure is expected to rise and this requires careful planning to ensure greenhouse gas mitigation while meeting the energy needs for development aspirations of the nation.
The aim of the paper is therefore to promote a broad development and utilization of Nigeria's biomass energy resources as a viable environmentally friendly energy resource for electricity production through appropriate technology development for the reduction of carbon emissions. It also seek to provides a guide for incorporating energy and carbon dioxide issues as one of the core parts in energy planning process to achieving a low carbon sustainable energy development in Nigeria.

2.0 ENERGY RESOURCE USE AND CARBON DIOXIDE CO_2 EMISSIONS

Modern overall energy resource availability and transformation into useable form are often analyzed in terms of anthropogenic greenhouse gas (GHG). Energy is central to global environmental change as emissions from energy use contribute significantly to the human component of climate change (Cleveland and Christopher, 2007). Emissions of CO_2 arise from a number of sources, mainly fossil fuel combustion in the power generation, industrial, residential and transportation sectors. According to Hossain (2012) atmospheric CO_2 concentrations have increased by almost 100 ppm in comparison to its pre-industrial level, reaching 379 ppm in 2005, with mean annual growth rates in the 2000-2005 period that were higher than those in the 1990s. The total equivalent concentration of CO_2 is currently estimated to be about 455 ppm CO_2 although the effect of aerosols, other air pollutants and land-use change reduces the net effect to

levels ranging from 311 to 435 ppm CO_2. Despite continuous improvements in energy intensities, global energy use and supply are projected to continue to grow, especially as developing like Nigeria countries pursue industrialization.

Nearly one-third of the world's energy consumption and 36% of its carbon dioxide emissions are attributable to manufacturing industries. However, the adoption of advanced technologies already in commercial use, could provide technical energy savings in industry of 27–41 exajoules (EJ), along with a reduction in CO_2 emissions of 2.2–3.2 gigatonnes (Gt) per year, about 7–12 % of today's global CO_2 emissions (Gielen *et al*, 2008). Rault et *al* (2012) opined that there is a positive correlation between CO_2 emissions and energy consumption: a 1% increase in energy consumption per capita increases CO_2 emissions per capita by 0.47 % in the Middle east and North African countries region. Grubler et al (2012) stated major source of energy-related carbon emissions as coal with 48 %, oil 39 %, and natural gas with 18 %. He also cited carbon dioxide emissions from fossil energy consumption in 1990 estimated at about 6 (±0.5) Gt C [(billion tons) or Pg C (10^{15} grams) elemental carbon], of which about 2.3 Gt C were emitted by the energy sector during the conversion to fuels and electricity and distribution for final use while the remainder 3.7 Gt C was emitted at the point of end use. A CO_2 emission was given as the mass of the actual molecule with 1kg C corresponding to 3.67 kg of CO_2. The increases in primary energy GHG emissions contributed from every country to the atmosphere will continue to grow unless they are mitigated.

Presently global mean temperatures have already risen to above pre-historic levels resulting in melting of glaciers and rising sea levels. To redress the challenge, a convention on climate change came into force in March 1994 following the 1992 UN Conference on Environment and Development (UNCED) held in Rio de Janeiro. Its long-run stated objective is to mitigate and stabilize greenhouse gas concentration levels in the atmosphere. The stabilization of atmospheric concentration will take at least 100 years going by the rapid growth of global population and consumption, slow change in economies and energy technologies and slow removal of greenhouse gases from the atmosphere. In 1997, the Kyoto Protocol was signed to achieve practical reductions and limitations of the GHG emissions within a specified commitment period (2008-2012) towards achieving the same level as in 1990. Among the proposals made was switching to less carbon-intensive energy sources to replace fossil fuels by renewable energy sources (Wihersaari, 2005).

While many countries have achieved energy conservation and reduction of carbon dioxide emissions, effective planning framework in Nigeria is still lacking in this aspect. Although there are some planning policies that indirectly promote energy conservation, there are still no measures that directly emphasize or promote less carbon dioxide emissions from energy provision. Energy and carbon dioxide issues are core parts in modern energy planning process towards achieving the desired socio-economic developments. It is necessary and possible to create a low energy consumptions and low carbon sustainable society in Nigeria. Specifically, the development of non-carbon based industries in Nigeria will redress environmental challenge as well as simultaneously solve energy production challenge and reduce CO_2 emissions. This would definitely involve many ideas and methods of sustainable energy production. The drive for sustainable energy is not propelled by concerns over energy security alone. Fossil fuels have been a major cause of adverse environmental and social consequences such as climate change, air pollution, and flooding. Sustainability is therefore a cardinal factor influencing long-term viability of any energy resource, and it comes as no surprise that it is at the forefront of the global campaign to abandon the use of fossil fuels (Sesan, 2008). New electricity production from renewable resources without a net carbon dioxide emission is much desired (Zhuwei *et al,* 2007). The current rate of use of carbon fuels for industrial growth in Nigeria is increasing the concentration of carbon dioxide in the atmosphere. There is urgent need to join the league of nations seeking substantial changes to their energy production methods in other not to exceed the level of carbon-dioxide (CO_2) concentrations in the atmosphere. Globally, countries are developing strategies and policies to enable the sustainable development of their energy resources so as to fuel economic and social development while reducing air pollution and the greenhouse-gas emissions. There are two ways of reducing CO_2 emissions. One is to reduce the consumption of energy preferably while maintaining or even increasing utility and performance.. A second is to replace fossil fuels by new types of energy sources which either have lower CO_2 intensities (CO_2 per energy output) than current sources such as renewable energy sources (Alfredsson, 2002) .

3.0 PRESENT ENERGY SCENARIO IN NIGERIA AND NATIONAL RENEWABLE ENERGY POLICY

Energy demand in Nigeria is higher than supplies and this create an energy gap with about 40% of the population having access to electricity supply (Nnaji, 2011). The energy shortages have affected Nigerian economy as almost all manufacturing and industrial organizations rely on generators which use fossil fuel to augment electricity production. Power sector challenges in Nigeria include inadequate power generation, transmission and distribution capacities, and obsolete infrastructure resulting in high losses and low access to electricity grid (Kupolokun and Mohammed, 2009). The inadequacy of the power sector made the government to embark on the power sector reform agenda. The vision statement by the National Technical Working Group on energy for the power and energy industry toward year 2020 maintain that the energy sector will be the major engine for the nation's sustainable, social, economic and industrial growth which should deliver affordable and constant energy supply efficiently to other sectors of the economy.
One of the seven strategic plans encapsulated in the report for achieving energy security is by utilizing the nation's renewable energy resources (including wind, solar, hydro and biomass) for a diverse energy mix that would meet the demand for energy in all sectors of the economy, in all parts of the country with safe, clean and convenient energy at an affordable cost. This must be done in a technically efficient, economically viable and environmentally sustainable manner using different conventional, non-conventional, as well as emerging energy sources to ensure electricity supply at all times with minimal disruption. According to the Presidential Task Force on Power, about 30 MW will be required in the next couple of years to meet demand as envisioned in the Vision 20:2020 target. Consequently, an annual growth of approximately 3,000 MW is required to meet the energy gap. A shift in energy planning and provision is required to achieve this objective.

However, in spite of plethora of policies and actions, the government lacks a practical strategy for low carbon and clean energy development. In that light, it is the candid submission of this paper that current methods to produce energy in Nigeria are not sustainable, and concerns about climate change and global warming require developing and adopting new technologies using renewable and carbon-neutral sources (Patil *et al*, 2011, Fatemi *et al,* 2012). For the country to attain the Vision 20:2020 development targets, energy poverty has to be addressed urgently in a carbon-constrained manner. Globally, energy crisis have led to a vast research on various alternative sources of energy to cope with the growth in standard of living of people across the world. Sambo *et al*, (2012) reported government recent need recognition for more electricity through a National Energy Master Plan (NEMP) developed by the Energy Commission of Nigeria and approved by the Federal government in 2007 which incorporate Renewable Energy Master Plan (REMP).The key objectives of the National Energy Policy are to:

- Ensure the development of the nation's energy resources, with a diversified energy resources option, for the achievement of national energy security and an efficient delivery system with an optional energy resource mix
- Guarantee increase contribution of energy productive activities to national income.
- Guarantee adequate, reliable and sustainable supply of energy at appropriate costs and in an environmentally friendly manner, to the various sectors of the economy, for national development
- Guarantee an efficient and cost effective consumption pattern of energy resources
- Accelerate the process of acquisition and diffusion of technology and managerial expertise in the energy sector and indigenous participation in energy sector industries, for stability and self reliance
- Promote increased investments and development of the energy sector industries with substantial private sector participation
- Ensure a comprehensive, integrated and well informed energy sector plan and programmes for effective development
- Foster international co-operation in energy trade and projects development in

both the African region and the world at large
- Successfully use the nation's abundant energy resource to promote international cooperation

Sustainable Energy Planning is a new trend in energy planning which is driven by three planning drivers: energy access, energy security and climate change (Sambo *et al*, 2012).The fundamental principle of the energy policy is for the optimal utilization of the nation's viable energy resources for sustainable development and their utilization to foster regional and international cooperation. The energy master plans for Nigeria envisage a guided implementation action plans on set targets within the timelines - short term (2006-2009), medium term (2010-2015), and long term (2016-2030). These targets are still policy documents presently particularly with regards to the biomass resource utilization. The framework policy though seems promising, but there is a discontinuity, however, between policy and Implementation.

Boimass renewable energy is an alternative energy medium that can be used with oil and gas to give the nation the desired mix that will ensure a reliable, affordable and environmentally friendly energy medium. A renewable energy system converts the energy found in sunlight, wind, falling-water, sea waves, geothermal heat, or biomass into a form such as heat or electricity. The focus of the this paper is the development of bioenergy for electricity generation. Bioenergy refers to energy derived from the conversion of biomass into liquid or gaseous fuel. Nigeria is relatively well endowed with biomass resources. In summary there are three main potential sources of bioenergy in Nigeria, namely:

Natural occurring biomass such as wood from trees and other plants to produce energy;
Biomass wastes from processes of agro-industries; and,
Commercially grown crops solely grown for modern energy production.

Nigeria has significant reserves of conventional and renewable energy resources (Table 2). The biomass energy resources are estimated to be 144million tones/year while about 43.4x109kg of fuel wood is consumed annually. Nigeria has significant potential for bioenergy development for both liquid biofuel as well as for electricity generation.

3.1 Barrier to Bioelectricity Development in Nigeria

Major barrier to the exploitation and use of biomass renewable energy, especially for power generation in Nigeria is the absence of institutional framework in terms of legislative and regulatory policies strong enough to promote the adoption of bioenergy technologies and specific directives that can make it practicable. For a start Nigeria being a market oriented economy could adopt her bioenergy policy for private investors in the development of biorenewable electricity generation plants in rural areas.

Lack of specialized funding and financial mechanisms such as investment credit policy and loan, taxation (e.g. priority incentive or exemption), technology, market etc is another factor. This places restrictions on the establishment, operation and trading of bioenergy enterprises. Crucial issues and difficulties in the ownership pattern for biorenewable energy projects (public or private) as well as provision of necessary infrastructural base to support the technologies for its development needs to be resolved.

Research and development currently are few to generate relevant data on resource inventory and assessment such as would have determined land area required to grow biomass energy crop plantation size, and relevant technical data base,. These data are necessary to optimize the selection of technologies for bioelectricity generation from biomass.

Institutional and human resources barriers have also militated against the overall success of the Nigerian effort to provide information on emissions and mitigation options. Energy supply where biorenewables would play a role necessitates the creation of appropriate policy framework of legal, fiscal and regulatory instruments that can attract domestic and international investments.

3.2 Technology for Conversion of Biomass Energy Resources

Biomass resources include diverse varieties of renewable organic materials, including forestry and agricultural wastes and residues, food processing wastes, woody weeds, oil bearing plants, animal manures and sewage, energy crops and the organic fraction of municipal solid waste. A number of technologies have been developed for extracting energy from the energy-rich

biomass. These may be based on the combustion of the solid fuel, or by converting them into other useful forms of stored energy, as biogas or liquid fuels such as methanol and ethanol. Among the renewable energy technologies, bioenergy has a large diverse portfolio including efficient biomass stoves, biomass combustion and gasification, and process heat and power, and pyrolysis; anaerobic digestion to produce a combustible gas; and fermentation to produce ethanol (Das, 2011). Nowadays, a lot of modifications and pre-treatment of biomass have resulted into various efficient technologies. The advanced technologies are more focused on converting biomass into secondary energy forms such as electricity, gaseous and liquid fuels, hydrogen, etc. There are basically three principal methods of conversion of biomass: thermo-chemical conversion, physical-chemical conversion and bio-chemical conversion. Also, Microbial fuel cells (devices that utilize bacteria as the catalyst to oxidize organic and inorganic materials via energy-producing respiratory processes) have emerged as a potentially viable technology for the direct generation of electricity from soluble wastes like wastewater (Gregoire, 2009).

The agro-food sector in Nigeria offers possibilities for the recovery of organic components for recycling and reuse in agriculture..This opens several research opportunities for Nigeria researchers particularly the Agricultural Engineering Professionals for generating data towards a transition to a Low-carbon economy. Such areas of research include but not limited to:

- Characterization of the physical properties and chemical compositions of biomass fuels and ashes.
- Behaviour of ash-forming elements in biomass combustion/gasification processes and their influencing variables
- Chemical analysis of biomass fuels and biomass ashes
- Technological and ecological optimization of biomass combustion plants
- Characterization for efficient aerosol precipitation in biomass combustion and gasification plants
- Development of innovative computer-aided process control system for biomass combustion plants
- Simulation of flow and combustion in biomass furnaces
- Development of innovative biomass CHP (Combined Heat and Power) technologies
- Research and Development concerning the production and utilization of biogas
- Biomass briquette technologies
- Biogas from organic waste
- Bio-fuels for transportation and mobility
- Biorefineries for plant based chemicals etc.

There are other, larger scale biomass technologies such as cogeneration, biofuel production, pyrolysis and gasification. With the exception of biofuels, there is currently no indication of the implementation of these large scale technologies in Nigeria.

4.0 CONCLUSION

Biomass renewable energy has shown tremendous potentials to supplement the energy requirements in a growing population and developing nation as Nigeria if exploited. The need for a diversified power generation mix utilizing agricultural-based biomass energy resources to produce biofuel, heat and bioelectricity as a technological basis for transition to a sustainable bioenergy system has been canvassed in this paper. Bioenergy is globally accepted as one of the means to redress the threat of global warming as well as its application in electricity production. Higher demand for energy and global environmental concerns on emission of global warming gases such as CO_2 from carbon-based fossil fuels are part of the current drivers for low carbon bioprocess technologies for the alternative energy development. This has induced significant increase in annual investments in new energy infrastructure while simultaneously scaling down fossil-fuel based energy systems. Transforming to clean energy technologies in Nigeria would however require an increased investment in the development and use of bio-renewable energy resources. Conclusively, Nigeria needs to adopt more energy conservation policies and environmental considerations in its energy planning in order to reduce its carbon dioxide emissions as it seek to meet its developmental targets in energy and power sectors.

5.0 RECOMMENDATION

There is a need for the establishment of National Renewable Energy Research Agency and a Trust Fund dedicated for the research and development of technologies and processes to utilize the biomass resource efficiently.

Massive manpower training and human capacity development is required through collaboration with relevant local and international stakeholders, and non-governmental organizations (NGOs) with the active participation of the private industrial organizations. This would assist in developing relevant technical and economic studies, as well as increasing public awareness for information provision, dissemination and assistance to interested stakeholders.

There is also a need to achieve adequate synergy and collaborative efforts between renewable energy research centres in Enugu and Sokoto states, tertiary institutions and the industry in Nigeria to achieve the energy mix master plan.

REFERENCES

Alfredsson E., (2002). Green Consumption Energy Use and Carbon Dioxide Emission , Doctoral thesis submitted to the Department of Social and Economic Geography, Spatial Modelling Centre Umeå University GERUM 2002:1 http://www.smc.kiruna.se

Bureau of Public Enterprises (BPE). Electric Power Investors' Forum, Power Generation: Status and Outlook, Publication of Presidential Task Force on Power.

Cleveland, C.J. and Christopher, M., (2007). Dictionary of Energy, Publication of Elsevier, Oxford, Britain.

Das B., (2011). Estimation of Power Generation Potential of Non-woody Biomass and Coal-biomass Mixed Briquettes, B.Tech thesis submitted to the Department of Mechanical Engineering National Institute of Technology Rourkela, India.

Fatemi S., Ghoreyshi A.A., Najafpour G., and Rahimnejad M., (2012). Bioelectricity Generation in Mediator-Less Microbial Fuel Cell: Application of Pure and Mixed Cultures Iranica Journal of Energy & Environment 3 (2): 104-108, Pp 104 – 108.

Grubler, A., Johansson T. B., Mundaca L., Nakicenovic N., Pachauri S., Riahi K., Rogner H.-H. and Strupeit L., (2012): Chapter 1 - Energy Primer. In Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 99-150.

Hossain S., (2012). An Econometric Analysis for CO_2 Emissions, Energy Consumption, Economic Growth, Foreign Trade and Urbanization of Japan Low Carbon Economy, 2012, 3, 92-105 doi:10.4236/lce.2012.323013.Published Online November 2012 (http://www.SciRP.org/journal/lce).

Kupolokun M. F, & .Mohammed S.A.,. (2009). Report of the Vision 2020 National Technical Working Group on Energy Sector. July, 2009.

Nnaji B., (2011). Power Sector Outlook in Nigeria: Governments Renewed Priorities, Chairman, Presidential Task Force on Power, Presentation at Securities and Exchange Commission, June.

Nwasike O.T., (2005). Opportunities and Challenges of an Integrated Energy Policy for Nigeria: Perspectives from a Competing Energy Product –Coal.

Patil D., Patil D.B., Deshmukh M. B., and Pawar S. H.,(2011). Comparative Study of Bioelectricity Generation along With the Treatment of Different Sources of Wastewater,

International Journal of Chemical Sciences and Applications ISSN 0976-2590.Vol 2, Issue 2, June-2011, pp 162-168 http://www.bipublication.com

Peixoto L., (2012). Microbial Fuel Cells for Autonomous Systems:Kinetics and Technological Advances in Wastewater Treatment and Sensor Applications, Doctoral Dissertation in Chemical and Biological Engineering, Universidade do Minho Escola de Engenharia,

Rault C., Arouri M.E., Youssef A.B., M'henni H., (2012). Energy Consumption, Economic Growth and CO_2 Emissions in Middle East and North African Countries, Forschungsinstitut zur Zukunft der Arbeit Institute for the Study of Labor, IZA Discussion Paper No. 6412, Bonn, Germany

Sambo, A.S., Bala, E. J., Ojosu, J O., Zarma. H.I. and Dawuda A.A.,(2012). Implementation of Energy Plans: A Solution to Nigeria's Energy Crisis, A Presentation at the 5th NAEE/IAEE International Conference, Energy commission of Nigeria, Abuja, 23rd – 24th, April.

Sesan T. (2008). Status of Renewable Energy Policy and Implementation in Nigeria, Institute for Science and Society, Faculty of Social Sciences, Law and Education, University of Nottingham, United Kingdom.

Wihersaari M., (2005). Aspects on Bioenergy as a Technical Measure to Reduce Energy Related Greenhouse Gas Emissions. PhD Dissertation presented to the Department of Mechanical Engineering, Helsinki University of Technology.

Zhuwei D, Haoran L , Tingyue G. (2007). A State of the Art Review on Microbial Fuel Cells: A Promising Technology for Wastewater Treatment and Bioenergy ,Elsevier Science Direct, Biotechnology Advances 25 (2007) 464–482

Table.1. Table. Current Status of Power Generation Capacity In Nigeria

	Total Installed Capacity (MW)	Total Available Capacity (MW)	% Difference	% Difference on Total
Existing FGN owned Power Station				
Hydro	1900	1380	27.4	72.6
Thermal	5005	1,978	60.5	39.5
Independent power projects	1759	1,484	15.5	84.5
National Integrated power project	4,775	--	--	
	13,439	4,842	64	36

Source: Bureau of Public Enterprises, (BPE).

1. FGN owned Power Station.
2. IPP – Non – funded Investment in the Nigeria Power generation Industry.
3. NIPP – Funded and owned by the three tiers of government (Federal, states and LGAs)

Table 2. Nigeria's Energy Reserves/Capacity as at December 2005

ENERGY SOURCE	RESERVES
Conventional crude oil	36. 5 billion barrels
National Gas	187. 44 TCF
Tar Sands	30 billion barrels of oil Equivalent
Coal and Lignite	Over 4 billion tonners
Renewable	
Large Hydropower	11, 235 MW
Small Hydropower	3,500 MW
Fuel wood	13,071,464 Hectares
Animal waste	61 million tonnes/Yr
Crop Residue	83 million tonnes/Yr
Solar Radiator	3.5 – 7.0 kWh/m^2 day
Wind	2.4 ms^{-1} at 10m height.

Source: Kupolokun & Mohammed, (2009).

PERCEIVED CONSTRAINTS IN AGRICULTURAL ENGINEERING COURSES IN OUR HIGHER INSTITUTION

***Kayode A.K, Adedire O, Amusa T, Duro K.O, Ojo M**
Federal College of Forestry Mechanization, Afaka,Kaduna State. Nigeria,
*(Corresponding Author Email- kayodeakk@gmail.com) Mobile no 07063224511

ABSTRACT
A study was conducted to determine the perceived constraints in Agricultural Engineering courses in our higher institution. Agricultural engineering, is simply defined as the application of science and engineering principles into agriculture for the production of food and fibre with the aim of making it better, less tedious, more efficient and perhaps more attractive. This paper examines the challenges faced by the students in the process of acquiring knowledge. Recommendations for the way forward include; access to latest information in their area of field, industrial trainings, excursions and seminars.

Keywords: Constraints, Engineering, Challenges, Courses, Agriculture.

1.0 INTRODUCTION
Agricultural Engineering does not have a specific definition, as there are different authors. Agricultural Engineering is a very important sector to the growth of economy. The economic progress of a nation depends directly upon availability of energy and its consumption for fruitful utilization (Jagdishwar, 2005).

Agricultural engineering is simply defined as the application of science and engineering principles into agriculture for the production of food and fibre with the aim of making it better, less tedious, more efficient and perhaps more attractive. According to the American Society of Agricultural Engineers, "Agricultural Engineering is the application of any and all branches of engineering to the extent that they be used in farming, in rural living, rural processing of farm products, and such allied activities as malaria control and wildlife conservation". Agricultural Engineering may also be defined as the application of theories, principles and models from any of all the branches of engineering in the production, processing, preservation, marketing and utilisation of agricultural produce (plants, animals and fishes) (Thompson, 1999)

There is no doubt that Agricultural Engineering is a profession in itself but it is so wide that in the course of solving engineering problems on the farm, it utilizes the knowledge of many other engineering professions especially Civil, Electrical, Mechanical and Structural Engineering. Agricultural Engineering can rightly be described as a 'Jack of all engineering professions and master of all.' This is why the Agricultural Engineering Curriculum is very wide, broad and contains subjects from both other engineering and non-engineering disciplines.

Agricultural Engineering courses have low students intake into the tertiary institutions in Nigeria because the prospects of the courses have not been sufficiently highlighted.

2.0 HISTORY OF ENGINEERING
The concept of engineering has existed since ancient times as humans devised fundamental inventions such as the pulley, lever, and wheel. Each of these inventions is consistent with the modern definition of engineering, exploiting basic mechanical principles to develop useful tools and objects.

The term engineering itself has a much more recent etymology, deriving from the word engineer, which itself dates back to 1325, when an engine'er (literally, one who operates an engine) originally referred to "a constructor of military engines." In this context, now obsolete, an "engine" referred to a military machine, *i. e.*, a mechanical contraption used in war (for example, a catapult). The word "engine" itself is of even older origin, ultimately deriving from the Latin *ingenium* (c. 1250), and meaning "innate quality, especially mental power, hence a clever invention.

Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specializing in the construction of such non-military projects and those involved in the older discipline of military engineering (the original meaning of the word "engineering," now largely obsolete, with notable exceptions that have survived to the present day such as military engineering corps, *e. g.*, the U.S. Army Corps of Engineers).

2.1 Ancient Era

The Acropolis and the Parthenon in Greece, the Roman aqueducts, Via Appia and the Colosseum, the Hanging Gardens of Babylon, the Pharos of Alexandria, the pyramids in Egypt, Teotihuacán and the cities and pyramids of the Mayan, Inca and Aztec Empires, Cities of Indus Valley Civilization, Asokan pillar at Vaishali (india) the Great Wall of China, among many others, stand as a testament to the ingenuity and skill of the ancient civil and military engineers. The earliest civil engineer known by name is Imhotep. As one of the officials of the Pharaoh, Djosèr, he probably designed and supervised the construction of the Pyramid of Djoser (the Step Pyramid) at Saqqara in Egypt around 2630-2611 BC. He may also have been responsible for the first known use of columns in architecture. Ancient Greece developed machines in both in the civilian and military domains. The Antikythera mechanism, the earliest known model of a mechanical computer in history, and the mechanical inventions of Archimedes are examples of early mechanical engineering. Some of Archimedes' inventions as well as the Antikythera mechanism required sophisticated knowledge of differential gearing or epicyclic gearing, two key principles in machine theory that helped design the gear trains of the Industrial revolution and are still widely used today in diverse fields such as robotics and automotive engineering.

2.2 Middle Era

An Iraqi by the name of al-Jazari built five machines to pump water for the kings of the Turkish Artuqid dynasty and their palaces. Besides over 50 ingenious mechanical devices, al-Jazari also developed and made innovations to segmental gears, mechanical controls, escapement mechanisms, clocks, robotics, and protocols for designing and manufacturing methods.

2.3 Renaissance Era

The first electrical engineer is considered to be William Gilbert, with his 1600 publication of De Magnete, who was the originator of the term "electricity".

The first steam engine was built in 1698 by mechanical engineer Thomas Savery. The development of this device gave rise to the industrial revolution in the coming decades, allowing for the beginnings of mass production.

With the rise of engineering as a profession in the 18th century, the term became more narrowly applied to fields in which mathematics and science were applied to these ends. Similarly, in addition to military and civil engineering the fields then known as the mechanic arts became incorporated into engineering.

2.4 Modern era

Electrical Engineering can trace its origins in the experiments of Alessandro Volta in the 19th century, the experiments of Michael Faraday, Georg Ohm and others and the invention of the electric motor in 1872. The work of James Maxwell and Heinrich Hertz in the late 19th century gave rise to the field of Electronics. The later inventions of the vacuum tube and the transistor further accelerated the development of Electronics to such an extent that electrical and electronics engineers currently outnumber their colleagues of any other Engineering specialty.

The inventions of Thomas Savery and the Scottish engineer James Watt gave rise to modern Mechanical Engineering. The development of specialized machines and their maintenance tools during the industrial revolution led to the rapid growth of Mechanical Engineering both in its birthplace Britain and abroad.

Chemical Engineering, like its counterpart Mechanical Engineering, developed in the 19th century during the Industrial Revolution. Industrial scale manufacturing demanded new materials and new processes and by 1880 the need for large scale production of chemicals was such that a new industry was created, dedicated to the development and large scale manufacturing of chemicals in new industrial plants. The role of the chemical engineer was the design of these

chemical plants and processes.

Aeronautical Engineering deals with aircraft design while Aerospace Engineering is a more modern term that expands the reach envelope of the discipline by including spacecraft design. Its origins can be traced back to the aviation pioneers around the turn of the 20th century although the work of Sir George Cayley has recently been dated as being from the last decade of the 18th century. Early knowledge of aeronautical engineering was largely empirical with some concepts and skills imported from other branches of engineering. Only a decade after the successful flights by the Wright brothers, the 1920s saw extensive development of aeronautical engineering through development of World War I military aircraft. Meanwhile, research to provide fundamental background science continued by combining theoretical physics with experiments.

3.0 AREAS OF SPECIALISATION IN AGRICULTURAL ENGINEERING

Agricultural Engineering profession is sub-divided into about five specializations with each of the specializations dealing with related problems on the farm. There are five major areas of specialisation common in Nigeria's universities and polytechnics,

a. Farm Power and Machinery
b. Farm Structures and Environment
c. Agricultural Processing and Storage
d. Soil Conservation and Water Resources/ Irrigation
e. Farm Electrification

There are different sources of farm powers on the farm. For any farming process to be mechanised, a source of energy must be harnessed. Power is needed on the farm for a variety of operations which may be either mobile or stationary. Examples of mobile operations are the transportation of produce, and field operations such as ploughing, spraying and so on. Stationary applications include operations like threshing, extracting and raising water and so on.

The power produced by human beings continues to be the main sources of farm power in most developing countries. Human power is an important source for operating small implements and tools. Stationary operations like threshing, extracting and raising water and so on. An average man can develop a maximum power of about 75 Watts but this, of course, varies with environmental conditions and type of food intake, however, human power is generally a source of supplementary power in conjunction with other power sources.

Animal power is still widely used in several countries, and may be derived from oxen, buffalo, donkeys, camels or horses. Special harnesses and yokes are used to hitch various equipment to the animal. The output available from animal is dependent on the food intake, the breed of animal, the training given and the yoke used for hitching.

The third important farm power is mechanical power, is available through tractors, power tillers, oil engines (diesel engines & petrol or kerosene engines), self-propelled combines, oil engine (internal combustion engine) is a good device for converting fuel into useful work

Electrical power is used mostly in the form of electrical motors on the farms, which converts the electric power into mechanical power to run different machines. Electric power is extremely useful for a number of operations. Electricity is used for (a) Heating, for instance in poultry sheds and so on (b) Refrigeration (c) Water supply

Biomass energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices. It can be used for lighting, cooking, water heating, food processing, water pumping, diesel engine operation and electric generation. Renewable energy is inexhaustible in nature.

a. Farm Machinery

A machine is a device or mechanical contrivance consisting of two or more relatively constrained

components which are energised by a power source to transmit or modify force and motion to accomplish some desired kind of work. (Mijinyawa, 2000). Farm operation can be classified according to the type of operation and the source of power.

b. Farm Structures and Environment

This is an aspect of Agricultural Engineering that deals with the provision and maintenance of buildings and structures within and occasionally outside the farm environment. The study of farm structures required the knowledge about the climatic conditions of the environment, the behaviour of crops in storage, the response of animals to environmental conditions.

A farm structures engineer is a specialist in the fields of agricultural and civil engineering whose interests, education training and experience have developed the knowledge of scientific principles, construction materials, construction procedures, and economic necessary to direct design, construction, utilization and maintenance of farm houses, barns, sheds, silos and related structures. Farm structures may be grouped into earth, wooden, concrete, plastic and steel buildings or structures.

c. Agricultural Processing And Storage

Agricultural processing may be defined as an activity which is performed to maintain or improve the quality or change the form or characteristics of an agricultural product. A processing job consists of a series of 'unit operation'. The sequence of processing operations may broadly be classified as-cleaning, grading and sorting, drying and dehydration, Storage, Milling, Handling, packaging and transportation and Agricultural waste and by-products utilisation. The knowledge of grain structure and composition is desirable for selecting the specific operation to be performed for processing into various products.

d. Soil And Water Conservation Engineering

Soil and water conservation comprises of several areas of Agricultural Engineering, ranging from drainage engineering, irrigation engineering, water resources, etc. Water conservation is the management of available water resources, where by soil conservation is carried out with the aim of not losing the soil to the erosion. Soil conservation is protection of soil against erosion or deterioration, also soil conservation can also be referred to as the preservation and careful management of the environment and of natural resources. The principles involved in the conservation and/or improvement of soil and water resources for economic and recreational purposes. Typical learning activities include erosion control, land use planning, site surveying and profile levelling techniques, drainage and irrigation systems, constructing and maintaining ponds and dams.

e. Farm Electrification

Electricity serve as a source of energy for farm lighting and processing. The drive to make electricity accessible to all the people of Nigeria includes the electrification of households occupied by the farm dwellers. To show commitment to universal access for electrification, government contributes considerably towards the cost of connection and these connections are reported as part of government's electrification achievements.

4.0 CONCLUSION

Though the constraint of Agricultural Engineering is well known, more efforts are needed from the government to review their policy for the development of Agricultural sector, especially the field of Engineering. To provide enabling environment and infrastructure. There is the need for more enlightment to the students and the general public through organizing workshops, seminars, excursions, and workshop in order to improve the attitude of the students and the general public towards development of Agricultural Engineering sector.

REFEERENCES

Jagdishwar . S (2005). Elements of Agricultural Engineering. Standard Publisher Distributors. Reprint Edition.

Mijinyawa, Y. (2000). Introduction to Agricultural Engineering. Stirling-Horden Publishers, Oyo State Nigeria.

Mijinyawa, Y. (2010). Farm Structures. Ibadan University Press. 2nd Edition
Sahay, K.M and Singy K. K(1994). Unit operation of Agricultural Processing.

CONTROL AND MONITORING OF GREEN HOUSE ENVIRONMENT MICROCONTROLLER-BASED APPROACH

M. J. Musa[1], K. Ahmad[1], I. Umar[2], M. A. Aminu[3] and A. Ahmed[3]
[1]Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria, Nigeria
[2]Samaru College of Agriculture. Division of Agricultural Colleges. Ahmadu Bello University, Zaria, Nigeria
[3]Department of Agric. Technology, School of Agriculture, Abubakar Tatari Ali Polytechnic, Bauchi, Nigeria

ABSTRACT
Appropriate environmental conditions are necessary for optimum plant growth, improved crop yields and efficient use of water and other resources. Automating the data acquisition process of the soil conditions and various climatic parameters that govern plant growth allows information to be collected at high frequency with less labor requirements. The existing systems employ PC or SMS-based systems for keeping the user continuously informed of the conditions inside the greenhouse; but are unaffordable, bulky, difficult to maintain and less accepted by the technologically unskilled workers. This paper presents the design of microcontroller based circuit to monitor and record the values of temperature, humidity; soil moisture and sunlight of the natural environment that are continuously modified and controlled in order optimize them to achieve maximum plant growth and yield. The controller used is an ATMEL chip having 8K bytes of on-chip memory. It communicates with the various sensor modules in real-time in order to control the light, aeration and drainage process efficiently inside a greenhouse by actuating a cooler, fogger, dripper and lights respectively according to the necessary condition of the crops. An integrated Liquid crystal display (LCD) is also used for real time display of data acquired from the various sensors and the status of the various devices. The design is quite flexible as the software can be changed any time. It can thus be tailor-made to the specific requirements of the user. This makes the design system to be an economical, portable and low maintenance solution for greenhouse applications, especially in rural areas for small scale agriculturists.

Keywords: Greenhouse; Control; Plant; Growth; Microcontroller

1.0 INTRODUCTION
We live in a world where everything can be controlled and operated automatically, but there are still a few important sectors in our country where automation has not been adopted to a full-fledged use, perhaps because of several reasons one such reason is cost. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Greenhouses form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum growth. Automating a greenhouse envisages monitoring and controlling of the climatic parameters which directly or indirectly govern the plant growth and hence their output.

Savant et al (1981) described the benefit of using light dependent resistors (LDR) in applications that need high precision in sensing light level like in agriculture. Ryder, (1989) illustrate the properties of sensitive temperatures sensors like LM35 which is base on solid state semiconductor technology. Such sensors work well in areas like agriculture where variation of temperature is usually small. Hughes, (2004) suggested suitable

techniques of adapting moisture sensors which work on the principle of water conductivity to accurately work in farms and gardens for sensing the soil moisture content. Ronald and Tossinial (1997) outlined the basic steps to be taken in designing electronic based humidity sensing circuits. Most of the commonly used electronic components for sensing humidity give reading in percentage. Driscoll (1996) presented different electronic circuits that can be used to maintain the pumping rate of electric pumps and the speed of electric motors both AC and DC versions of pumps and motors. Link (1996) in his book "Hand book of simplified solid state circuit design" itemized the fundamental aspects that must be considered in choosing electric based sensor.

2.0 MATERIALAND METHODS

2.1 Materials

The materials used for the design are purely solid state electronic components that consist of active and the passive components. The main once are; temperature sensor (LM35), humidity sensor (HH10D), light sensor (LDR), moisture sensor (Probes), analog to digital converter (ADC0809), microcontroller (AT89S52), liquid crystal display (LCD 16x2), actuators (12V relays), water pump (simulated as a bulb), sprayer (simulated as a bulb), cooler (simulated as a fan), artificial lights (simulated as 2 bulbs) and buzzer.

2.2 Method

Four general steps can be followed to appropriately select the control system:

- Identify measurable variables important to production.
- Investigate the control strategies.
- Identify the software and the hardware to be used and
- Implement the design.

Now, the methods will be explained in detail to bring out the concept of design.

2.2.1 Identify measurable variables important to production

It is very important to correctly identify the parameters that are to be measured by the controller's data acquisition interface and how they are to be measured.

The set of variables typically used in green house control is shown in Table 1A low cost electronic sensor for measuring a variable must be readily available, accurate and reliable. If a sensor is not available, the variable cannot be incorporated into the control system, even it is of very important.

For example, fertility levels in nutrient solutions for greenhouse production are difficult to measure continuously.

2.2.2 Investigate the control strategies

An important element in considering a control system is the control strategy that is to be followed. The simplest strategy is to use threshold sensors that directly affect actuation of devices. For example, the temperature inside a greenhouse can be affected by controlling heaters, fans, or window openings once it exceeds the maximum allowable limit. The light intensity can be controlled using four threshold levels. As the light intensity decreases one light may be turned on. With a further decrease in its intensity a second light would be powered, and so on; thus ensuring that the plants are not deprived of adequate sunlight even during the winter season or a cloudy day.

More complex control strategies are those based not only on the current values of the controlled variables, but also on the previous history of the system, including the rates at which the system variables are changing.

2.2.3 Identify the software and the hardware to be used

It is very important that control system functions are specified before deciding what software and hardware system to use.

The model chosen must have the ability to:

- Expand the number of measured variables (input subsystem) and controlled devices (output subsystem) so that growth and changing needs of the production operation can be satisfied in the future.
- Provide a flexible and easy to use interface.
- It must ensure high precision measurement and must have the ability to resist noise.

Hardware must always follow the selection of software, with the hardware required being supported by the software selected. In addition to functional capabilities, the selection of the control hardware should include factors such as reliability, support, previous experiences with the equipment (successes and failures) and cost.

2.2.4 Design implementation

The block diagram Fig. 1 gives the complete diagram of the design. The sub blocks of Fig. 1 are explained in the next sub section.

Soil moisture sensor:

The soil moisture sensor consists of two copper leads act as the sensor probes. They are immersed into the specimen soil whose moisture content is under test. The soil is examined under three conditions:

Case #1: Dry condition:

The probes are placed in the soil under dry conditions and are inserted up to a fair depth of the soil. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the transistor emitter in this case ranges from 0 to 0.5V.

Case #2: Optimum condition:

When water is added to the soil, it percolates through the successive layers of it and spreads across the layers of soil due to capillary force. This water increases the moisture content of the soil. This leads to an increase in its conductivity which forms a conductive path between the two sensor probes leading to a close path for the current flowing from the supply to the transistor through the sensor probes. The voltage output of the circuit taken at the emitter of the transistor in the optimum case ranges from 1.9 to 3.4V approximately.

Case #3: Excess water condition:

With the increase in water content beyond the optimum level, the conductivity of the soil increases drastically and a steady conduction path is established between the two sensor leads and the voltage output from the sensor increases no further beyond a certain limit. The maximum possible value for it is not more than 4.2V.

Humidity sensor:

The humidity sensor HH10D is used for sensing humidity. Relative humidity is a measure, in percentage, of the vapor in the air compared to the total amount of vapour that could be held in the air at a given temperature. HH10D gives the output in terms of frequency at a range of 5 kHz to 10 kHz from frequency out pin.

Temperature sensor:
The LM35 IC has been used for sensing the temperature. It is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ?). The temperature can be measured more accurately with it than using a thermostat. The sensor circuitry is sealed and not subject to oxidation, etc.

Light sensor:
Light dependent resistor (LDR):
Also known as photoconductor or photocell, is a device which has a resistance which varies according to the amount of light falling on its surface. Since LDR is extremely sensitive in visible light range, it is well suited for the application.

Analog to digital converter (ADC 0808):
In physical world, parameters such as temperature, pressure, humidity, and velocity are analog signals. To converts physical quantity to electrical signals we need an analog to digital converter (ADC). ADC is an electronic circuit that converts continuous signals into discrete form so that microcontroller can read the data. Analog to digital converters are the most widely used devices for data acquisition.

Microcontroller (AT89S52):
The microcontroller is interfaced with the ADC in polling mode. **INT0** is used for the LCD mode selection switch in order to switch between two modes of display:

- Sensor output display
- Actuator status display

Port details:

§ Port 0: Interfaced with the LCD data lines.
§ Port 1: Interfaced with the ADC data lines
§ Port 2: Interfaced with the LCD Control lines and AC Interface control
§ Port 3: Interfaced with the ADC control lines.

Buzzer:
A buzzer or beeper is a signaling device, usually electronic; it is connected to the control unit through a transistor that acts as an electronic switch for it. When the switch forms a closed path to the buzzer, it sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.
The transistor acts as a normal controlled by the base connection. It switches **ON** when a positive voltage from the control unit is applied to the base of the transistor. If the positive voltage is less than 0.6V, the transistor switches **OFF**, no current flows through the buzzer in this case and it will not buzz. A protection resistor of 10k ohm is used in order to protect the transistor from being damaged in case of excessive current flow. In our system, the buzzer is designed to give a small beep whenever one of the devices such as a cooler or a bulb turns on in order to alert the user.

Liquid crystal display (LCD):
Many microcontroller devices use 'smart LCD' displays to output visual information. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8x80 pixels of the display. They have a standard ASCII set of characters and mathematical symbols.

Signals to the LCD:
The LCD also requires 3 control lines from the microcontroller:

i. **Enable (E)**

This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.

ii. Read/Write (R/W)
This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.

iii. Register selects (RS)
With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

Logic Status on Control Lines:
a. ***E*** - 0 Access to LCD disabled
1 Access to LCD enabled
b. ***R/W*** - 0 Writing data to LCD
1 Reading data from LCD
c. ***RS*** - 0 Instructions
1 Character

Writing and Reading Data from the LCD:
Writing and reading data from LCD could be done through several steps.
1. Writing data to the LCD is done in several steps:
a. Set R/W bit to low
b. Set RS bit to logic 0 or 1 (instruction or character)
c. Set data to data lines (if it is writing)
d. Set E line to high
e. Set E line to low
2. Read data from data lines (if it is reading):
a. Set R/W bit to high
b. Set RS bit to logic 0 or 1 (instruction or character)
c. Set data to data lines (if it is writing)
d. Set E line to high
e. Set E line to low

Relay:
A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts.

Despite the speed of technological developments, some products prove so popular that their key parameters and design features remain virtually unchanged for years. One such product is the relay, which has proved useful to many designers who needed to switch up to 10A, whilst using relatively little PCB area.

Since relays are switches, the terminology applied to switches is also applied to relays. A relay will switch one or more poles, each of whose contacts can be thrown by energizing the coil in one of two ways:

- **Normally - open (NO)** contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a FORM A contact or "make" contact.

- **Normally - closed (NC)** contacts disconnect the circuit when the relay is

activated; the circuit is connected when relay is inactive. It is also called FORM B contact or"break" contact.

2.3 Drip Irrigation System for Controlling Soil Moisture

Drip, or micro-irrigation, technology uses a network of plastic pipes to carry a low flow of water under low pressure to plants. Polyethylene tubing is run from the source of water to the plant, where the emitter is attached for dripping water. Emitter line (poly tubing with pre-installed emitters) is used where a continuous band of water is needed. Fittings are available to make sharp turns (elbows), branch lines (tees), and to make the transition between different sizes of tubing as in Fig. 1. When plants are removed or die, drip lines should be plugged.

Drip irrigation (sometimes called trickle irrigation) works by applying water slowly, directly to the soil. The high efficiency of drip irrigation results from two primary factors. The first is that the water soaks into the soil before it can evaporate or run off. The second is that the water is only applied where it is needed, (at the plant's roots) rather than sprayed everywhere.A drip irrigation system slowly provides water to the plant's root system. Regular watering prevents plant dehydration, but roots don't get overly soaked and in turn, plant growth can increase up to 50%. Drip systems irrigate all types of landscape: shrubs, trees, perennial beds, ground covers, annuals and lawns. Drip is the best choice to water roof gardens, containers on decks and patios, row crops and kitchen gardens, orchards, and vineyards.

In dry system, the microcontroller (embedded system) Figure 1 comes to play. The soil moisture sensor was used and programmed with respect to an input pin of the microcontroller as define in the programme. Water moisture is defined in voltages as in Table 2. Two copper rods were used as probes; they are 1cm apart for good conduction and were immersed in the farm soil to measure the moisture of the soil. An actuator (switch) is connected output pin of the microcontroller to either switches ON or switches OFF the water flow from the source to the plant, see Fig. 2. When the probes notice the dryness of the soil, it will notify the microcontrollers which will eventually energies the water source switch or de-energies the switch to enable the water to the plant.
The system will monitor all the parameters of the plants and display on an LCD (Screen) in case the farmer will like to visualize the parameters on real time.

2.3.1 Artificial growing lights for controlling illumination

Growing lights enable cultivators to extend daylight hours - useful for winter growing when levels of natural lights can be low, and one can therefore improve plant growth. Three basic types of lamps used in greenhouse lighting are:

1. Fluorescent lamps - These have the advantage of higher light efficiency with low heat. This type of lamp is the most widely used for supplemental light. It is available in a variety of colors but cool-white lamps are the most common, high intensity fluorescent tube.
2. Incandescent lamps - These vary in size from 60W to 500W. The grower can vary foot-candle levels by adjusting the spacing and mounting height above the plants.
3. High-Intensity Discharge (HID) lamps - These have a long life (5000 hours or more). With improvements made possible by the addition of sodium and metal-halides, the lamp has a high emission of light in the regions utilized by plants.

The following generally accepted cultural divisions describe light levels:

Very high: Over 5000 foot candles--nearly full sun except at midday, when full summer sun in most latitudes may reach 10,000 ft.

High: 4000-5000 foot candles--bright light, just fewer than 50% of the full midday sun.

Intermediate: 1800-4000 foot candles--dappled sunlight.

Low: 1000-1800 foot candles--reduced sunlight, so that if a hand is passed over the leaves it does not produce a shadow.

One foot candle is equal to 10.76 lux, although in the lighting industry, typically this is approximated as 1 foot candle being equal to 10 lux.

2.3.2 Temperature controllers

The temperature control could be achieved through the cooling equipment or heating equipment, this depends on what is needed for the plant metabolic.

2.3.3 Cooling equipment

There are three primary cooling devices in most greenhouses. These are the vent system, exhaust fan, and swamp cooler. Some greenhouses may make use of air conditioners and/or mixing systems as well.

Vents: are hinged or track connected panels in the roof or sides of greenhouses. They open up the greenhouse to outside natural air. Hot air that builds up in the greenhouse can escape, and fresh air can enter the house. The microcontroller can be used to automate the opening and closing of these vents depending upon requirement. But during hot summer days, venting alone will not get the job done.

Exhaust fans: can move a large volume of the hot greenhouse air out and pull fresh air in through the rear vent. They're powerful for a reason, as full sun on a hot summer day can cause temperatures inside the greenhouse to superheat. An exhaust fan must be able to pull this air out, or the temperatures will continue to rise.

Swamp coolers: come in different widths and lengths. They can be configured to the appropriate size, as this varies depending on the length and width of the greenhouse, location where you live, and type of plants you wish to grow.

2.3.4 Heating equipment

Hot-water or steam heater:

A hot-water system with circulator or a steam system linked with automatic ventilation will give adequate temperature control. In some areas, coal or natural gas is readily available at low cost. This fuel is ideal for hot- water or a central steam system. Steam has an advantage in that it can be used to sterilize growing beds and potting soils.

Electric heaters:

Overhead infrared heating equipment combined with soil cable heat provides a localized plant environment, which allows plants to thrive even though the surrounding air is at a lower than normal temperature. Electric resistance-type heaters are used as space heaters or in a forced air system.

2.3.5 Humidification systems

Many evaporative cooling and humidifying systems are available: **F**oggers, Mist systems, Roof Sprinklers, and Pan/Fan Systems. They add water vapour to the air, and may subsequently reduce the amount of water that the plants need to transpire.

a. Roof sprinklers add water vapour and cool the incoming air. On large ranges, it is possible to decrease the temperature by $3 – 5^{o}C$

b. Pad and fan systems consist of porous wet pads at the inlet end of a fan ventilated Greenhouse. As the exhaust fans draw air through the wet pads, water evaporates, cooling and humidifying the air. Temperatures tend to be coolest nearer the fans and hottest at the exhaust when using these systems.

c. Mist and fog systems produce tiny water droplets that evaporate, thereby cooling and humidifying the greenhouse air. A misting system can provide needed moisture to maintain a healthy humidity level of 50 to 70%.

2.3.6 Working flowchart of the design

The complete flowchart for the working of the system is simplified in Fig. 3. While the flow chart for LCD initialization in simplify on Fig. 4, and finally the flowchart of the ADC initialization is explain in Fig. 5.

3.0 RESULT ANALYSIS

The transducer reading of the soil moisture was presented in voltage; this gives the relationship of the soil condition with respect to the sensor output voltage as in Table 2.

All readings are taken at room temperature of 32°C with soil moisture sensor of tolerance $\pm 0.2V$.

The Light sensor (LDR) with the tolerance of $\pm 0.1V$ was compared with the Illumination Status as in Table 3.

At normal room conditions the humidity sensor used can range between 35% and 45% of Relative Humidity (RH). Our test results were observed at temperature ranging between 32°C

$$\text{Temperature (°C)} = \left(\frac{V_{out}}{5}\right) * 100(°C^{-1}V) \quad (1)$$

4.0 CONCLUSION

A step-by-step approach in designing the microcontroller based system for measurement and control of the four essential parameters for plant growth, i.e. Temperature, humidity, soil moisture, and light intensity, has been followed. The prototype of the design is on appendix A. The results obtained from the measurement have shown that the system performance is quite reliable and accurate.

The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment.

The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable sensors are developed for use in agricultural production.

Although the enhancements mentioned previously may seem far in the future, the required technology and components are available, many such systems have been independently developed, or are at least tested at a prototype level. Also, integration of all these technologies is not a daunting task and can be successful carried out.

4.1 Recommendation For Further Development

1. The performance of the system can be further improved in terms of the operating speed, memory capacity, and instruction cycle period of the microcontroller by using other controllers such as AVRs and PICs. The number of channels can be increased to interface more number of sensors which is possible by using advanced versions of Microcontrollers.
2. The system can be modified with the use of a data logger and a graphical LCD

panel showing the measured sensor data over a period of time.

3. A speaking voice alarm could be used instead of the normal buzzer.
4. This system can be connected to communication devices such as modems, cellular phones or satellite terminal to enable the remote collection of recorded data or alarming of certain parameters.
5. The device can be made to perform better by providing the power supply with the help of battery source which can be rechargeable or non-rechargeable, to reduce the requirement of main AC power.
6. Time bound administration of fertilizers, insecticides and pesticides can be introduced.
7. A multi-controller system can be developed, to enable a master controller along with its slave controllers to automate multiple greenhouses simultaneously.

REFERENCES

Driscoll E.F. (1996) "Industrial Electronics" Doghusman Press Ltd. U.S.A.

Hughes E. (2004) "Electrical and Electronic Technology", 8th Edition, Pearson Education plc. Indian Branch.

Link J. D. (1996) "Hand book of simplified solid state circuit design", McGraw Hills, New York.

Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mc Kinlay , (2008), 2nd Edition. *"The 8051Microcontroller & Embedded Systems"* Pearson Education Inc.

Ronald J. and Tossinial S. (1997) "Analog and Digital systems principle and application" 8th Edition. Jahor Baharu Press LTD Singapore.

Ryder, J. D, (1989) "Electronics Fundamentals and application", prentice – Hall of Indian books.

Savant C. J., Roden M.S and Carpenter G., (1981) "Electronic design".

Table 1: Importance of the Targeted Parameters

Monitored Variable	Importance to Plant
Temperature	Affects all plant metabolic functions.
Humidity	Affects transpiration rate and the plant's thermal control mechanisms.
Soil moisture	Affects salinity and pH of irrigation water
Solar radiation	Affects photosynthetic rate, responsible for most thermal load during warm periods

Table2: Soil Moisture Sensor Readings

Soil Condition	Soil is dry	Optimum level of soil moisture	Slurry soil
Transducer Optimum Range (V)	0.0-1.5	1.9- 3.5	>3.5

Table 3: Light Sensor Readings

Illumination Status	Optimum Illumination	Dim light	Dark	Night
Transducer Optimum Range (V)	0.0-0.69	0.7-2.5	2.5- 3.0	3.0-3.47

Table 4: Temperature Sensor Readings

Temperature Range (Ä	10	15 to 20	20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	50 to 55	55 to 60
Temperature Sensor Output V	0.5	0.75-1.0	1.0-1.25	1.25-1.5	1.5-1.75	1.75-2.0	2.0-2.25	2.25-2.5	2.25-2.5	2.75-3.0

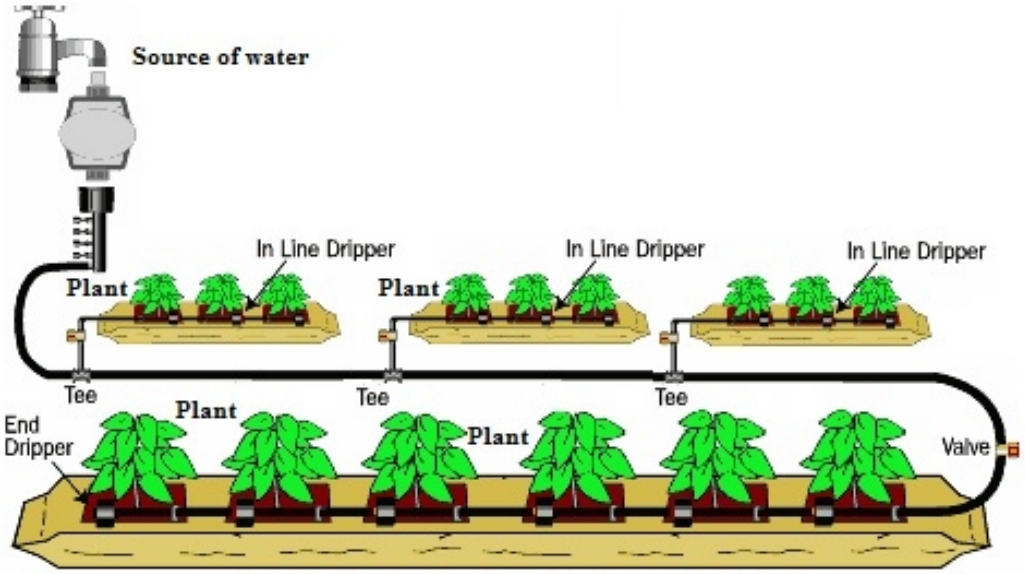


Fig. 2: Drip (Trickle) Irrigation System

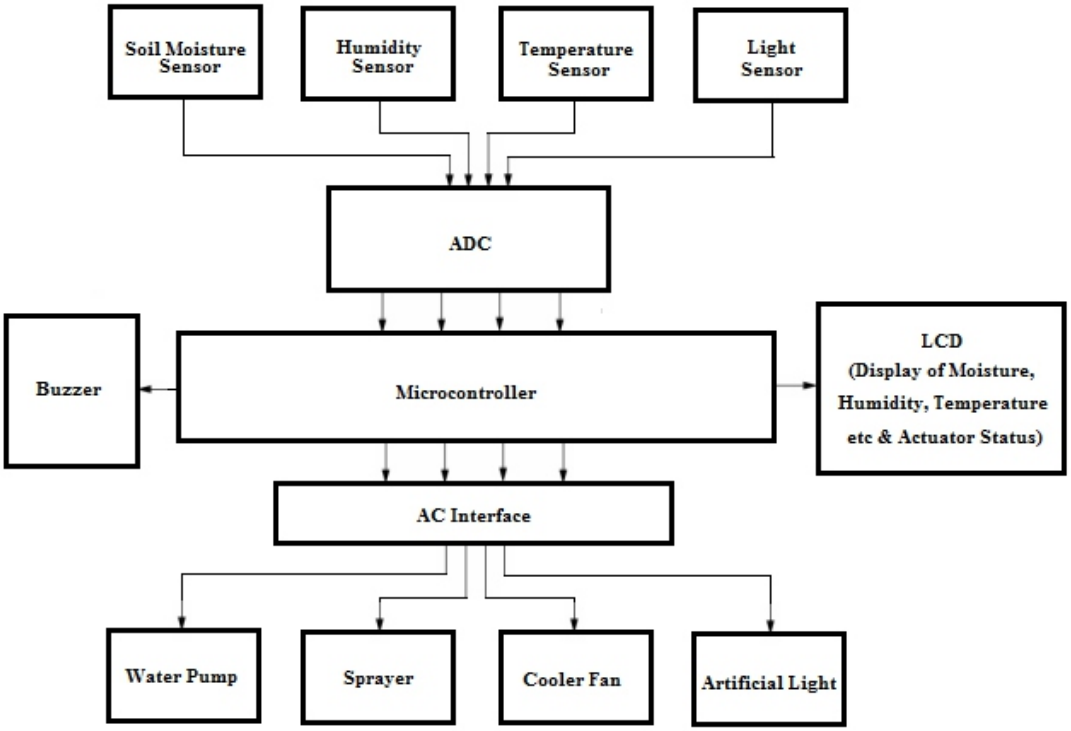
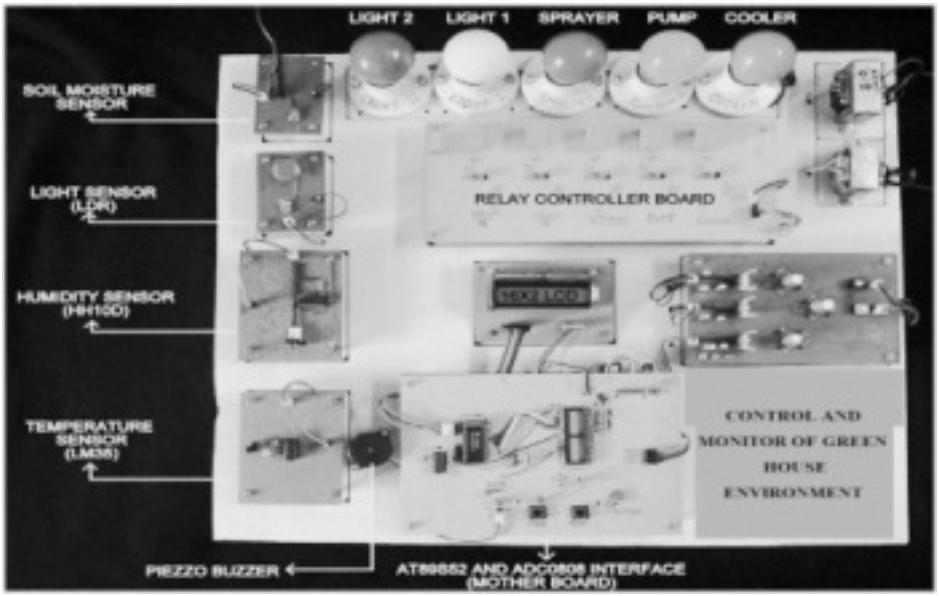


Fig. 1: Complete Block Diagram of the Design

APPENDIX A
Picture of the Complete System



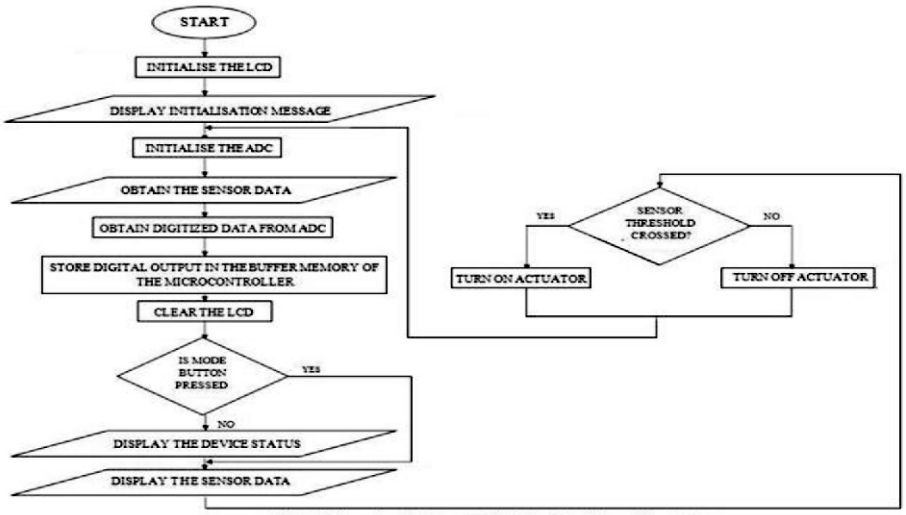


Fig. 3: Flowchart Representing the Working of the System

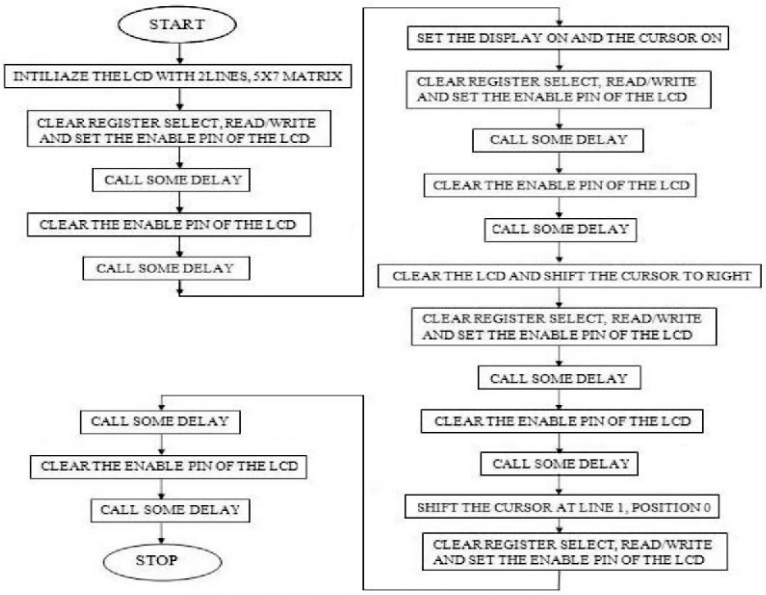


Fig. 4: Flowchart for LCD Initialization

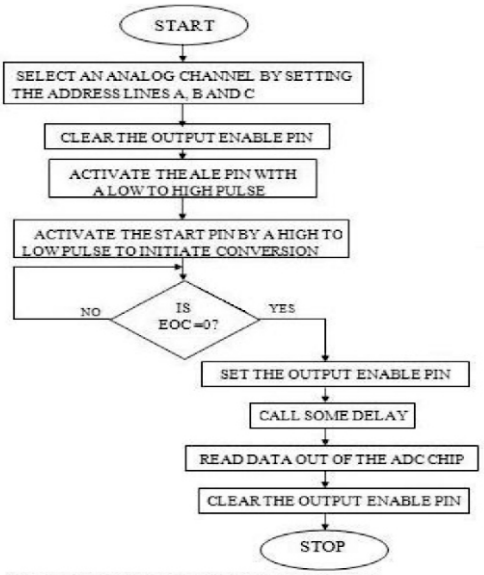


Fig. 5: Flowchart for ADC Initialisation

INFLUENCE OF EDUCATIONAL BACKGROUND ON THE ADOPTION OF MECHANISED PRACTICES IN AGRICULTURE IN AKWA IBOM STATE

Ikpe J. Udom[1]; Alexis M. Roberts[2] and Noamy I. Udom[3]
[1]Department of Agricultural Engineering, Akwa Ibom State University, Ikot Akpaden, Nigeria,
[2]Department of Mechanical Engineering Technology, Akwa Ibom State Polytechnic, Ikot Osurua, Nigeria.
[3]Department of Vocational Education University of Uyo, Uyo, Nigeria.
E-mail:ikpeudom@yahoo.com. +2348027845880

ABSTRACT
The present level of adoption agricultural mechanisation practices in Nigeria is unarguably low. This study was conducted to examine the influence of educational background on the adoption of mechanised practices in agriculture in Akwa Ibom State, Nigeria. A survey of 300 farmers randomly selected from a population of 729 drawn from three local government areas of Ukanafun, Oruk Anam and Etim Ekpo in Akwa Ibom State was carried out. Questionnaires were used to collect information on farmers' educational background namely: Farmers' educational level, Farmers' type of education (informal/formal), Farmers' area of study in school and Farmers' nature of study in school. Frequency distribution, percentages and means were used to analyse the data. The findings revealed that Farmers' level of education, type of education and area of study in school have positive influence on farmers' adoption of mechanised practices while Farmers' nature of study in school has no significant influence on adoption of mechanised practices in agriculture. It is therefore concluded that farmers' level of education, type of education and area of study in school have significant influence on farmers' adoption of mechanised practices in agriculture.

Keywords: Mechanisation, Mechanised Practices, Adoption, Dry Season Agriculture, Akwa Ibom State.

1.0 INTRODUCTION

It is unarguable fact that education is one of the important factors in the transformation of man as well as the society. The society is made more sophisticated due to emergence of new ideas and innovation.

In agriculture, science, technology and engineering which are aspect of education play remarkable roles to increase crop production. The National Policy on Education (2004) emphatically stresses the importance of vocational education in the training of skilled man-power for our industries and agricultural sector. In this regard Obi (2005) opined that the delivery of vocational agriculture at the secondary school level should not be handled as ordinary science subject but as a vocational subject for acquisition of practical agricultural skills for meaningful living. Stressing further, Ellah (2007) explained that agricultural education is concerned with the acquisition of professional training by an individual in the art of pedagogy as well as acquisition of the knowledge, skills and attitudes required in agriculture.

Major tools for farm operation are still the hoes, cutlasses, harvesting knives and other simple and locally made tools which results in prohibitive cost of production per hectare thereby making agricultural production to remain an industry of inherent toilage, indignity, a world of drudgery, peopled by aged and aging peasants and shunned, despised and hated by the youths.

Technology and engineering have made the production of sophisticated farm implements such as tractors, harrows, rotavators and cultivators possible. The emergence

and application of these sophisticated farm machines to farm production gave birth to farm mechanization.

Mechanized as explained by Hornby (2000) is to change a process so that the work is done by machines rather than people. The use of machines in agricultural production which include land preparation, planting, harvesting etc therefore constitute mechanized practices.

Mechanization as observed by Odigboh (2005) encompasses the use of hand and animal operated tools and implement as well as motorized equipment to reduce human effort, improve timeliness and quality of various farm operations in an attempt to increase productivity and overall efficiency. But to what extend has this been practiced in Nigeria. Enaboifo (2011) observed that the level of machine application in agriculture in Nigeria is relatively low even though the tractorization intensity is about 18hp/ha and over 70% of tractors and implement in the country are not functional.

Agricultural machines when used for effective application of input like fertilizer, herbicides, fungicide and also in irrigation, planting, harvesting and processing of farm produce usually result in optimum productivity hence attainment of food security and increased income to farmers.

Adoption therefore as explained by Hornby (2000) is the decision to start using something such as ideas, a plan or a name, example being the adoption of new technology. Feder (1985) observed that adoption is the degree of use of a new technology when farmers have full information about the technology and its potentials.

Adoption in agriculture may be regarded as the utilization of new ideas, concepts, and technologies in agricultural production. These assertions explain the fact that there is close relationship between adoption and educational background of a person particularly farmers. As observed by Chinsman (2008) small holder farmers and processors of agricultural products will have to be literate to be able to profit maximally from appropriate technologies such as mechanization designed to improve productivity. Similarly, Otula (2004) confirm that literacy, age, farm income, social participation have important relationship with the adoption of agricultural technologies.

1.1 Statement Of The Problem

In Nigeria there have been reported cases of acute food shortage and the consequent scourge of hunger. A country that previously had agriculture as the main stage of its economy has become a massive importer of staple food items. The fact remain that food production becomes impossible because of several factors such as conflicts, different forms of disasters, insufficient use of land, water and energy. In many states of the federation including Akwa Ibom State, insufficient use of land, water and energy have continued to hamper food production and aggravate the problem of hunger.

For decades, the country has been paying lip service to mechanization of agriculture so much that the farming population has been ageing while necessary facilities needed to attract the younger generation to agriculture and ancillary activities are not in place.

However, in 2006, the intervention of the European Union sponsored, National Planning Commission Supervised pilot project for small scale irrigation (SSI) development in Akwa Ibom State made aid available in the form of small water pumps and other irrigation accessories and input for mechanization of dry session agriculture in several locations in the state. By 2010, some of the SSI schemes were no longer functioning and some farmers had reverted to Traditional Irrigation Practices (ITP) used previously before the aid, even when Udom (2009) had showed that the mechanized pump irrigation system earned 47 kobo per invested naira against 37 kobo earned by the traditional irrigation system.

Observation therefore reveals that farmers are still practicing traditional methods

of farming. This poor attitude towards adoption of mechanized practices is likely to be caused by some factors such as educational background of farmers. This study therefore aims to establish the extent to which this factor determined the adoption of mechanized practices in agriculture.

The purpose of this study was to determine the influence of farmers' educational background on the adoption of mechanized practices in agriculture.

Specifically, this study sought to examine the influence of

i. Farmers' educational level
ii. Farmers' type of education (informal/formal)
iii. Farmers' area of study in school and,
iv. Farmers' nature of study in school (part-time and regular)

1.2 Research Questions

1. What influence does farmers' level of education have on their adoption of mechanized practices in agriculture?
2. What influence does farmers' type of education have on their adoption of mechanized practices in agriculture?
3. What influence does farmers' area of study in school have on their adoption of mechanized practices in agriculture?
4. What influence does farmers' nature of study in school have on their adoption of mechanized practices in agriculture?

2.0 METHODOLOGY

Four research questions were developed to guide the study while four hypotheses were formulated and tested at the probability of 0.05 level of significance.

Survey research design was used for this study. Survey research design in the opinion of Nworgu (2006) is a design in which a group of people or items is studied by collecting and analyzing data from the few people or items considered to be representative of the entire group.

2.1 Area of Study

The study was conducted in three local government areas of Ukanafun, Oruk Anam and Etim Ekpo all in Akwa Ibom State of Nigeria. The choice of this area is because they are among the agricultural base areas in Akwa Ibom State and are located in close proximity to each other.

2.2 Population of the Study

The population for this study consisted of all registered farmers with appropriate government agencies numbering 726 drawn from the three local government areas involved in the study.

2.3 Sample and Sampling Techniques

The sample for this study was 300 farmers using stratified random sampling techniques. A total of 100 farmers were selected from each of the participating local government areas through simple random sampling method.

2.4 Instrumentation

Instrument known as questionnaire on Farmers Adoption of Mechanized Practices in Agriculture (FAMPA) developed by the researchers was used to collect information from the subjects. The items were generated from review of related literature. A five point (Likert) scale response mode was used in the questionnaire to collect data

from the respondents with the corresponding nominal value and the options ranging from strongly agree (SA) = 5 points; Agree (A) = 4 points; Undecided (U) = 3 points; Disagree (D) = 2 points; and strongly Disagree (SD) = 1 point.

2.5 Validation of Instrument

Since the items were constructed by the researchers, the face and constent validation were carried out by two experts in the vocational education department of university of Uyo and one expert from the department of Agricultural Engineering, Akwa Ibom State University.

2.6 Reliability of the Instrument

A trial test was conducted in Mkpat Enin Local Government Area of Akwa Ibom State which did not take part in the study. There were 30 farmers that were involved in the test. The raw score obtained from the test were used for the split-half reliability test, therefore, the two set of scores were correlated using Cronbach alpha. The Cronbach alpha coefficient of 0.85 was obtained and adjusted adequately for the study.

2.7 Method of Data Collection

Copies of the questionnaire were personally administered by the researchers taking each local government area in turn. All the copies of the questionnaire administered were collected from the respondents.

2.8 Data Analysis

The data generated from the questionnaire were analyzed using the mean to answer the research questions.

The mean for the response scale was interpreted using the real limits as follows:

4.50 - 5.00 implies strongly agreed
3.50 – 4.49 implies agreed
2.50 – 3.49 implies undecided
1.50 – 2.49 implies disagree
0.00 – 1.49 implies disagree

In addition, the option with the simple majority or highest frequency translated in percentage was used alongside with the calculated mean to determine consensus opinion.

3.0 RESULTS

The results are presented in accordance with the research questions formulated in the study.

In table 1, item 1 which sought the opinion of farmers on whether it is only farmers who are academically high that use motorized irrigation revealed that 26.3% and 43% strongly agreed and agreed respectively while only17% and 10.3% disagreed and strongly disagreed respectively. In all, mean score of 3.58 indicated that only farmers who are educationally sound used motorized pumps for irrigation.

Indeed, percentages and mean score responses for item 2 and 3 respectively revealed that the use of manual labour for farm work is mostly done by uneducated farmers and the demand for tractor services by farmers depend on their level of education. This is as also revealed in their mean score response of 3.5 and 3.77 respectively. The percentage for each of the items also show 32% and 34% of strongly agreed and strongly disagreed respectively for item 2 and 33% and 40% strongly agreed and agreed respectively for item 3.

In table 2, the percentage response and the mean response of the respondents to item 4 showed that it is not quite clear (undecided) whether farmers who pass through

informal education still hold the belief that yield does not depend on mechanized practices in agriculture. This is as indicated by 29% of the respondents disagreeing while 18% strongly disagreed and the disagreement is further confirmed by the mean response of 22.9. But in item 5, it is the popular opinion of the farmers that only farmers who passed through formal school system embrace motorized irrigation. This is as indicated by the high percentage of farmers strongly agreeing and agreeing to the item with 27% and 47% respectively supported with a mean score of 3.62. Also, there is a high acceptance to the fact that only those farmers who passed through formal school system like to adopt scientific theories in agricultural practices. This is as indicated by the 32% and 47% of the respondents who strongly agreed and agreed respectively and with a mean of 3.85. The responses of the farmers to items 7 show strong agreement to the fact that farmers who passed through on-job training still hold some traditional belief against the use of seed planting machines. This is as indicated by a high percentage of farmers who strongly agreed and agreed to the items with a corresponding percentage of 32% and 55% respectively also supported with a high mean score of 4.0. The grand mean score of 3.62 shows that farmers' type of education has influence on their adoption of mechanized practices in agriculture.

In table 3, responses to item 8 reveal that the farmers agreed that it is only farmers who studied agriculture related courses in school adopt mechanized means of planting seedling in their farm, this is as shown in the 33% and 40% of responses and also confirmed by the mean score of 3.73 responses to item 9 indicate that the respondents agreed to the item as shown by mean score of 3.7 and the high percentages of 27% and 45% of respondents who strongly agreed and agreed respectively. However, it is also agreed that farmers who did not study agriculture or agriculture related courses in school do not depend on the use of fertilizer on their farm as those who studied do. This is indicated by the mean score of 3.56 to item 10. The percentage of 26 and 41 are also in support. There is agreement that farmers who did not study agriculture or agriculture related course do not depend on the use of tractor as those who studied do. This is as indicated by over 60% of the subjects agreeing to item 11 with a mean score of 3.5. The grand mean of 3.62 reveals that farmer's area of study in school influences the adoption of mechanized practices in their farm hence in agriculture.

In table 4, item 12 which sought the opinion of farmers on whether farmers who passed through full time training in school use tractors in their farm than those who passed through part time training, a total of 191 farmers out of the 300 that participated in the study representing 64% disagreed with the item. The disagreement is strengthened by the mean of 2.48. Also disagreed is item 13 which sought the opinion of farmers on whether farmers who passed through full time training in school use mechanized system of irrigation than those who passed through part time. This is as indicated by 67% of the respondents and with a mean of 2.46.

Similarly, the statement in item 14 which state that farmers who passed through full time training in school embrace crop planting machines than those who passed through part time is disagreed upon as indicated by 70% of the respondents with a mean of 2.0.

The grand mean of 2.2 reveals that farmers' nature of study in school does not influence their adoption of mechanized practices in agriculture.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Most farmers in Akwa Ibom State of Nigeria do not adopt mechanized practices in their agricultural operations but instead are involved in the hiring of manual labour and this has affected the rate of food production negatively with inherent danger of food shortages, high cost of food items, general food crisis and poverty.

This study has provided empirical evidences to show the influence of farmer's educational level on their adoption of mechanized practices in agriculture in Akwa Ibom State of Nigeria. It is therefore concluded that the provision of proper education to the citizens of the State is the only means by which farmers would be sensitized on the need to adopt mechanized farming for food security and poverty eradication.

In line with the findings, the following recommendations were made:

1. Government should establish institution that will train middle man power in agriculture as none is in existence. This will go along way in eradicating ignorance on the importance and use of mechanized practices in agriculture for food security.
2. Appropriate Government Agencies and Non-Governmental Organizations (NGOS) should enlighten farmers on the importance of in-service training in order for them to update their knowledge in modern technologies as they relate to agriculture.
3. The state Integrated Farmers Scheme (IFS) should emphasize mechanized practices and field demonstrations in her training curriculum.
4. Tractor Hiring Units (THUS) should be made functional, affordable and with capacity for wider coverage.

REFERENCES

Obi, C. I. 2005. A critique of vocational agricultural education in Nigerian Secondary Schools. Journal of Home Economics Research, 6 (2) 57 – 61.

Ellah, B. I. 2007. Effectiveness of quality assurance curriculum frame factors on implementation of agricultural education program of colleges of education in Eastern Nigeria. Unpublished Ph. D Thesis, Department of Vocational Teacher Education, University of Nigeria, Nsukka.

Hornby, A. S. 2000. Oxford Advanced Learners' Dictionary of current English, sixth edition, Oxford University Press.

Nworgu, B. G. 2006. Educational Research. Basic Issues and Methodology, Nsukka; University Trust Publishers.

Igbeka, E. C. 2002. Agricultural mechanization and the society NAE quarterly Vol. 3 No. 3.

Enaboifo, M. A. 2011. Mechanization strategies for increased agricultural production in Nigeria. Journal of Agricultural technology 7 (1): 1 – 17.

Udom, I. J. 2009. Mechanization of traditional irrigation practices for dry season vegetable production in rural areas of Akwa Ibom State, Nigeria. Environmental issues and agriculture in developing countries 1 (3) 50 – 63.

Federal Government of Nigeria 2004. National Policy on Education (4th Edition). Lagos: NERDC Press.

Feder, R. S. 1985. Pattern, Processes and Problems of agricultural technology infusion in

developing countries. International Food Policy Research Institute. Washington D. C.
Chinsman, O. A. 2008. Small holder mechanization social economic considerations. AMA 18 (2) 43 – 56.
Otula, S. K. 2004. Factors influencing the adoption of improved oil palm production technologies of small holders in Imo State, Nigeria. A paper presented at the 3rd National Farming System Research Workshop held at the University of Calabar. 5th August, 2004.

Odigboh, E. U. 2005. Symposium on appropriate approaches for accelerated food production in rain forest zone of Nigeria. University of Nigeria, Nsukka.

Table 1: Percentage and Mean Standard Deviation Response Score Of Farmers' Level Of Education On Adoption Of Mechanized Agriculture.

S/N	ITEMS	SA	A	U	D	SD	Ef	Efx	X	Remarks
1.	It is only farmers who are educationally high that use motorized pump for irrigation in this farm?	(26.3) 79	(43.0) 129	(3.3) 10	(17.0) 51	(10.3) 31	(100) 300	1074	3.58	Agree
2.	The use of mainly manual labour for farm work is mostly done by uneducated farmers	(32.2) 96	(34.0) 101	(2.0) 5	(21.0) 63	(11.0) 35	(100) 300	1060	3.53	Agree
3.	The demand for tractor services by farmers depends on their level of education.	(33.0) 99	(40.3) 121	(1.0) 3	(17.7) 53	(8.0) 24	(100) 300	1118	3.72	Agree
4.	Ef	274	351	18	167	90	900			
	Efx	1370	1404	54	334	90		3252	3.61	Agree

Values in parentheses are percentages.

Table 2: Percentage and Mean Responses Of Farmers' Types Of Education On Adoption Of Motorized In Agriculture.

S/N	ITEMS	SA	A	U	D	SD	Ef	Efx	X	REMARKS
4	Farmers who passed through informal education still hold the belief that yield does not depend on mechanized practices in agriculture.	(19.0) 57	(26.0) 77	(8.0) 25	(29.0) 87	(18.0) 54	(100) 300	896	2.99	Undecided
5	Only those farmers who passed through formal school system embrace motorized irrigation.	(27.0) 82	(43.0) 130	(3.3) 10	(16.0) 48	(10.3) 30	(100) 300	1086	3.62	Agree
6	Only those farmers who passed through formal school system like to adopt scientific theories in agricultural practices.	(32.0) 96	(47.3) 142	(1.0) 2	(14.0) 41	(6.0) 19	(100) 300	1155	3.85	Agree
7	Farmers who passed through on the job training alone still hold some traditional belief against the use of seed planting machines.	(32) 98	(55) 165	(1) 2	(6) 17	(6) 18	300	1208	4.0	Agree
	Ef	333	514	30	193	121	1200			
	Efx	1665	2056	117	386	121		4345	3.62	

Values in the parentheses are percentages.

Table 3: Percentage Analysis For Farmers' Area Of Study In School On The Adoption Of Mechanized Practices.

S/N	ITEMS	SA	A	U	D	SD	Ef	Efx	X	REMARKS
8	It is only those farmers who studied agriculture related course that adopt mechanized means in planning seedling in their farm.	(33) 98	(40) 120	(3) 10	(16) 48	(8) 24	(100) 300	1120	3.73	Agree
9	It is mostly farmers who studied agriculture or agriculture related course that use motorized irrigation in their farm	(27) 81	(45.7) 134	(3) 9	(18) 55	(17) 21	(100) 300	1099	3.70	Agree
10	Farmers who did not study agriculture or agriculture related course do not depend on the use of fertilizer on their farm as those who studied do.	(26) 78	(41) 124	(4) 12	(20) 60	(9) 26	(100) 300	1068	3.56	Agree
11	Farmers who did not study agriculture do not depend on the use fo tractor as those sho studied do	(20) 59	(48) 145	(2) 5	(20) 61	(10) 30	(100) 300	1042	3.50	Agree
	Ef	260	492	37	279	132	1200			
	Efx	1300	1968	111	558	132		4069	3.62	

Values in parentheses are percentages.

Table 4: Percentage Analysis of Farmer's Nature of Study in School on Adoption of Mechanized Practices in Agriculture.

S/N	ITEMS	SA	A	U	D	SD	Ef	Efx	X	REMARKS
12	Farmers who passed through full time	(9.0)	(14.0)	(3.0)	(64.0)	(10)	(100)			Disagree
	training in school use tractor than those who passed through part time.	28	41	10	191	30	300	746	2.48	
13	Farmers who passed through full time	(8.0)	(13.0)	(4.0)	(67.0)	(8.0)	(100)			Disagree
	training in school use mechanized irrigation techniques than those who passed through part time.	25	39	11	201	24	300	740	2.46	
14	Farmers who passed through full time	(4.0)	(13.0)	(5.0)	(61.0)	(17.0)	(100)			Disagree
	training in school use crop planning machine than farmers who passed through part time.	13	40	15	182	50	300	684	1.95	
15	Farmers who passed through full time	(2.0)	(5.0)	(3.0)	(70.0)	(20.0)	(100)			Disagree
	Training in school apply fertilizer in their farm thank those who passed through part time	6	15	9	211	59	300	598	1.99	
	Ef	72	135	45	785	163	1200			Disagree
	Efx	360	540	135	1570	163		2668	2.2	

Values in parentheses are percentages.

COMMUNIQUÉ OF THE INTERNATIONAL CONFERENCE AND 34TH ANNUAL GENERAL MEETING OF THE NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE) HELD AT THE IBOM E-LIBRARY, UYO, AKWA IBOM STATE FROM 21ST-24TH OCTOBER, 2013.

PREAMBLE

The International Conference and 34th Annual General Meeting (AGM) of the Nigerian Institution of Agricultural Engineers (NIAE) tagged Uyo 2013 was hosted by the University of Uyo and held at the Ibom e-library from 21st-24th October, 2013. The theme of the conference was "Agricultural Mechanization: A Veritable Component of Agricultural Transformation Agenda". It was attended by Agricultural Engineers and other related professionals from various higher institutions of learning within and outside Nigeria; Federal and State Ministries of Agriculture, Departments and Agencies. A total of 230 participants registered for the conference. A total number of 97 technical papers on the various sub-themes were edited and published in the conference proceedings.

INTRODUCTION

The opening ceremony was chaired by Professor Fola Lasisi; FAEng, FNSE, FNIAE, FNIM, FASCE, PE, COREN Reg. Engr., a renowned Agricultural Engineer and pioneer Vice-Chancellor of the University of Uyo and Crescent University Abeokuta, respectively. The keynote address was delivered by Rev.Fr. Professor Godfrey Nzamujo, the Proprietor, Shonghai Integrated Farm Concepts, Cotonou, Benin Republic. The Honourable Minister of the Federal Ministry of Agriculture and Rural Development, Dr. Akinwumi Adesina was ably represented by the Executive Director, National Centre for Agricultural Mechanization (NCAM) Ilorin, Engr. Ike Azogu. Remarks were made by the current Vice Chancellor, University of Uyo, Prof. Mrs. Comfort M. Ekpo and the National Chairman, NIAE, Prof. B.A. Adewumi during the opening session. Goodwill messages were also presented from allied organizations, Deans of Engineering, Professional bodies and Hon. Commissioner, Ministry for Agriculture and Natural Resources, Akwa Ibom State.

Six lead papers were presented at the plenary session. At the technical sessions, papers were presented and discussed under the following fields of Agricultural Engineering: Power and Machinery; Farm Structures and Environment; Emerging Technologies; Soil and Water Engineering; and Post Harvest and Food Engineering.

At the end of the conference, the following critical issues were observed and recommendations made to enhance successful implementation and sustainability of our country's Agricultural Transformation Agenda through mechanization programmes, projects and policies:

OBSERVATIONS

The following observations were made during the conference:

- The efforts of the Federal Government through the Honourable Minister for Agriculture and Rural development with respect to the Agricultural Transformation Agenda (ATA) so far are commendable.

- Agricultural mechanization is an important key to unlocking the green economy for the wellbeing of Nigerians.
- There exist agricultural policy that has an aspect of mechanization, but there is no policy on that address the entirety of agricultural mechanization in Nigeria.
- Nigeria, as a nation cannot boast of food security. The increasing food importation into the country is not acceptable, not sustainable fiscally, economically or politically.
- Innovation and entrepreneurship at every stage of agricultural production process is the bridge to agricultural food value addition and reduction in unemployment.
- Nigerian agriculture is supply driven, which make the country a net importer of foods.
- The use of agricultural waste management to create wealth in the country is at its infinitesimal level. Agricultural waste can contribute to the National Integrated Power Program (NIPP).
- The Agricultural Transformation Agenda (ATA) as it is today cannot be fully accomplished without effective impact of the Agricultural mechanization component and deliberate intervention and collaboration with Agricultural Engineers.

RECOMMENDATIONS

The following recommendations emanated from the conference:

- The Nigerian Centre for Agricultural Mechanization (NCAM) should be encouraged to perform its role more effectively, through increased funding, to enable it to fulfill her mandates especially in the area of standardization of Agricultural machinery and equipment and tractor imported into Nigeria.
- Definite and all encompassing policies on agricultural mechanization should be passed to law and implemented. The policy should include mechanical, draught animal, wind energy, solar power and hydro power source of farm power; rural infrastructures; rural water supply; rural electrification; and tractorization issues to guide in the acquisition of tractors and implements over a defined period in the nation.
- Appropriate processing, preservation and storage facilities should be developed at commercial level and adopted for value addition to reduce postharvest losses and achieve food and economic security entrenched in ATA.
- Adoption and commercialization of Research and Development outputs of agricultural engineering research technology should be encouraged by government and industries to drive the ATA.
- There should be a synergy between the universities, research institutes and industries in solving the agricultural mechanization challenges of the country to enhance the success of ATA.
- Agricultural Engineers should be innovative and build entrepreneurial skills to be able to create jobs and be employers of labour to scare off poverty in the land and make agriculture to solve the problem of mass unemployment.
- A paradigm shift through an integrated development system that organically creates dynamic linkages and synergy between agriculture, industries and services is needed to enhance ATA.
- A demand driven agriculture, not supply driven agriculture is the way out of the food insecurity unemployment and rural- urban drift in the country.
- Agricultural waste management should advance to the next level of using waste and energy to create wealth to generate small and medium scale employment.

Nigeria's Agricultural Transformation Agenda (ATA) requires a holistic and broad based approach to develop trajectories that will produce more with less through zero emission research initiative (ZERI).



Engr. Prof. Babatunde Adewale ADEWUMI, fnse, fniae
National Chairman
Nigerian Institution of Agricultural Engineers