TABLE OF CONTENTS

ASSESSMENT OF CROP FARMERS VULNERABILITY, MITIGATION AND ADAPTATION MEASURES TO CLIMATE CHANGE IN NIGER STATE, NIGERIA

Ibrahim F.D[1], Usman M.N[2], Tanko L.[1] and Coker A. A.[1]
[1] Department of Agricultural Economics And Extension Technology, School of Agriculture And Agricultural Technology, Federal University of Technology, Minna, Niger State, Nigeria.
[2] Niger State Agricultural Development Project.
Corresponding Author's E-mail: idfaith006@yahoo.com
Phone number: 234-706-8156241

ABSTRACT
This study examined the mitigation and adaptation of climate change by crop farmers in Niger State, Nigeria. Primary data was used to obtain a cross sectional data. Questionnaire was used to elicit relevant information from the respondents. Data collection lasted for two months that is from September 2014 to November 2014. Multi-stage sampling technique was used to elicit data from 280 respondents and data analysis was done using descriptive statistics. Results showed that most practised adaptation measures used included early planting, increased use of agrochemicals and weeding. Access to credit, household size, membership of association, farm size, number of hazards and topography were significant factors affecting vulnerability to climate change. The study concluded that farmers in the study area were employing one or more adaptation techniques to mitigate the adverse effects of climate change. The study recommends making available credit facilities to farmers through Government interventions to enhance farmers incomes to enable them employ adaptive measures that could be effective in alleviating negative impacts of climate change. It was also recommended that farmers should be encouraged to join farmer groups/cooperatives to increase their chances of access to agricultural credit.

Keywords: Climate change, Vulnerability, Mitigation and Adaptation.

INTRODUCTION

Agriculture remains the main source of livelihood for rural communities in sub-Sahara Africa providing employment for more than 60 percent of the population; contributing about 30 percent of Gross Domestic Product (GDP) and accounted for up to 55 percent of the total value of Africas export (Sokona and Denton (2001). The World Bank (2000) observed that 70 percent of all Africans and nearly 90 percent of Africa's poor work primarily in agriculture. Climate change affects agriculture and agriculture also affects climate change through the emission of Green House Gases (GHG) from different farming practices (Maraseni, Mustaq, and Maroulis 2009, Edwards and Harris, 2009).

The term "climate change" often refers to changes in climate which according to the Intergovernmental Panel on Climate Change IPCC (2007), are 90-95 percent likely to have been in part caused by human action. It describes changes in the variability of average state of the atmosphere over time scales, ranging from a decade to millions of years (Adejuwon, 2004). Swings in the global climate pattern have aroused attention at local, national and international levels (Onyeneke, 2010). Moreover, climate change is expected to increase with increased frequency and intensity of extreme weather conditions in Nigeria's coastal and rainforest regions (Babatunde, Ayobami and Mark, 2011). The implications for the region are that it would generally experience wetter than average climate, more extreme weather conditions, particularly erosion, sea level rise and floods (Onyeneke, Iruo and Ogboko, 2012).

Given that agriculture and fishing remains the main sources of livelihood for most rural communities in Nigeria's coastal and rainforest regions, climate change is expected to have greater negative impacts on poorer farm households as they have the lowest capacity to adapt to change in climate conditions and more vulnerable to vagaries that are climate induced. (Onyeneke, Iruo, and Ogboko, 2012; Onyeneke and Madukwe, 2010). Adaptation measures are therefore important to help these communities to better face extreme weather conditions and associated climate variations (Adger, Brown, Conway and Hulme, 2003). Estimates by Building Nigeria's Response to Climate Change (BNRCC), (2011) suggest that, in the absence of adaptation, climate change could result to loss of 6 and 30 percent by the year 2050 (BNRCC, 2011). This loss is equivalent to ₦15 trillion (US$100 billion) and has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions (Kandlinkar and Risbey, 2000).

According to the Inter Academy Council Report (IACR) (2004), adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood. The challenge this poses affects sustainable development on the

continent. This challenge is composed of the likely impacts on the ecosystem, agricultural production, and livelihoods. Generally, losses in the agricultural sector due to climate change have economy wide consequences, like loss in gross domestic output, a decline in the income and the general deterioration on households' welfare. Climate change is also expected to exacerbate Africa's struggles with strained water resources and food security. Mendelsohn, Dinar and Dalfelt (2000) affirmed that rising global temperatures are expected to increase flooding in coastal areas, cause declines in agricultural production, threaten biodiversity and the productivity of natural resources, increase and exacerbate desertification. Thereby exerting a disproportionately adverse impact on Africa's agriculture-based economy. To make matters worse, Africa has a low adaptive capacity due to its dependence on rain fed agriculture, low levels of human and physical studies on the effects of climate change on economic variables, estimated and a very high predicted loss of income due to climate change through crop simulation experiments (Rosenzweig and Parry, 1994). Against this backdrop the present study was undertaken with the following objectives: i. to describe the socioeconomic characteristics of crop farmers in the study area; ii. identify the hazards faced by respondents, iii.identify and describe the adaptation measures used by the crop farmers to mitigate the adverse consequences of climate change.

METHODOLOGY

The study area: The study was conducted in Niger State, Nigeria. The State has its capital at Minna, and it is located in the North central zone of Nigeria. It was created out of the defunct North western State. The State lies in the Guinea savanna vegetation belt of the country with favourable climatic condition for crop and livestock production. (Nigerstategov.ng, 2006).

The location of the State is between Latitudes 8^0 20′ and 11^0 30′ North of the Equator and between Longitudes $3^0$30′ and 7^0 20′ East of the Greenwhich Meridian. The provisional result of the 2006 National Population Census showed that the State had a population of 3,950,00 (NPC, 2006). Going by the population growth rate in of 3.2% in Niger State (NPC, 2011) the population was projected to 5, 056, 321 as at 2014.

Sampling procedure: Multi-stage sampling method was used in the selection of respondents for this study. The first stage involved the random selection of one Niger State Agricultural Mechanization and Development Authority (NAMDA) Zone out of the three zones.

In the second stage, three (3) Local Government Areas (LGAS) were purposively selected out of the total number of eight (8) LGAs in the Zone. They are Agaie, Bida, and Mokwa LGAs in Zone I. The purposive selection was based on the dominant cropping enterprises in each LGA. The samples were drawn from the frame. The third stage involved a random selection of three (3) villages from each of the LGAs giving a total of nine (9) villages. The fourth and final stage involved a selection of crop farming households from each village. Data were obtained through a cross-sectional survey. Primary data was collected through structural questionnaire complemented with interview on the socioeconomic characteristics of respondents such as farmers vulnerability, years of experience in crop production, and their perceptions of adaptation measures to mitigate climate change.

Analytical Technique

The study employed descriptive analysis of frequency, percentage and means.

RESULTS AND DISCUSSION

The results of the socio-economic characteristics of the respondents are presented in Table 1. The results revealed that the average age of the respondents was 41 years. Most of the respondents were within the age range of 31-50 years and accounted for 87%. A total of 8 percent constituted those less than 40 years while 5.4 percent were over 50 years of age. This implies that a greater percentage of the respondents were still in their active working age. Age is an important variable which defines the probability of a given respondent to be vulnerable to the vagaries of climate change. Older respondents are likely to have more years of farming experience which would enable a farmer cope and adapt to climate change phenomenon.

Adaptation Measures to Mitigate Consequences of Climate Change

This study found that farmers adopted various measures to be able to adapt to the adverse consequences of climate change. The results are presented in Table 2The results revealed that all the respondents resorted to early planting and use of agrochemicals which ranked first. Increased frequency of weeding ranked 3rd whereby 89.6% of the respondents utilized the strategy as a way out of the adverse consequences. Other adaptation measures adopted in decreasing magnitude of importance use, change in the timing of land preparation (23.6%) and changing harvesting dates, mixed cropping (1.1%) and the use of wind breaks (1.1%). Migration from climate risk areas and use of wind breaks/shelter belts was also adapted by the farmers. This finding is in line with the findings of Adenike and Salman (2014) who found that

Table 1: Distribution of respondents according to socioeconomic characteristics

Variables	Frequency	Percentage	Mean
Age			
< 31	21	7.5	41
31 – 40	154	55.0	
41 – 50	90	32.1	
> 50	15	5.4	
Total	280	100.0	
Sex			
Male	268	95.7	
Female	12	4.3	
Total	280	100.0	
Marital Status			
Married	262	93.6	
Single	18	6.4	
Total	280	100.0	
Household Size			
<11	181	64.4	10
11 – 20	79	28.2	
21 – 30	17	6.1	
>30	3	1.1	
Total	280	100.0	
Educational Status			
Primary	72	25.7	
Secondary	79	28.2	
Tertiary Edu.	55	19.6	
Adult Edu.	10	3.6	
Quranic School	64	22.9	
Total	280	100.0	
Occupational Status			
Part-time Farming	92	32.9	
Full-time Farming	188	67.1	
Total	280	100.0	
Sec. Occupation			
Agro-trading	34	19.3	
Livestock	60	33.6	
Transport	48	27.1	
Agro-processing	69	38.6	
Construction	11	6.4	
Civil Servant	58	32.9	
Total	280	100.0	

Source: Field Survey, 2014

majority of the households in Ondo State, Nigeria adopted adaptation measures which include diversion to other crops, diversion to non-farm activities, irrigation, increased used of agrochemicals and change in planting and harvesting dates, to circumvent climate change so as to enhance farm productivity.

Table 2: Adaptation Measures Employed to Mitigate Adverse Consequence of Climate Change.

Measures	*Frequency	Percentage	Rank
Early Planting	280	100.0	1st
Conservation	3	1.1	7th
Tillage	248	88.6	4th
Use of Agrochemicals	280	100.0	1st
Weeding	251	89.6	3rd
Mixed Cropping	3	1.1	7th
Change in the Timing Land Prep.	66	23.6	5th
Changing Harvesting Dates	66	23.6	5th
Migration	3	1.1	7th
Wind breaks	3	1.1	7th

Source: Field Data, 2014
*** Multiple Responses recorded**

Vulnerability of Farmers to Climate Change Phenomenon

Results in Table 3 presents Climate Change phenomenon respondents were vulnerable to. A total of 80.0% of respondents reported that they had never experienced drought while 20.0% of the respondents in the study area experienced drought once, 50.7% of the respondents had never experienced fire incidence while 49.3% experienced fire incidence once, In the case of pastoral agricultural conflicts, 90.0% of the respondents did not face the constraint while 10.0% of the respondents had the problem once which indicated that majority of the farmers in the study area had once faced disasters that had occurred naturally, since they faced natural disasters which may affect their yield and livelihood. This implies that climate change, which is attributed to natural climate cycle and human activities such as deforestation has adversely affected farmers in the study area, This result corroborates the findings of Zoellick (2009). As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent. Farmers (who constitute the bulk of the poor in Africa) face challenges of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases.

CONCLUSION AND RECOMMENDATIONS

The study concluded that farmers in the study area were vulnerable to effect of climate change as most of them were lacking in resource endowment that could make them withstand the challenges so as to become less vulnerable to climate change. Farmers

also preferred early planting and use of agrochemicals, increased frequency of weeding in the farm, and they also employ different adaptation techniques to mitigate the adverse effect of climate change.

Table 3: Vulnerability and Experience of Farmers to Climate Change Phenomenon in the last two years

Variables	Frequency	Percentage
Drought		
Nil	224	80.0
Once	56	20
Total	280	100.0
Fire		
Nil	142	50.7
Once	138	49.3
Total	280	100.0
Pastoral Conflict		
Nil	29	90.0
Once	251	10.0
Total	280	100.0
Types of Climate Change Observed		
Delayed Rainfall		
Yes	29	10.4
No	251	89.6
Total	280	100.0
Early Rainfall		
Yes	215	76.8
No	65	23.2
Total	280	100.0
Haillstorm		
Yes	4	1.4
No	276	98.6
Total	280	100.0
Too Much Rain		
Yes	160	57.1
No	120	42.9
Total	280	100.0
Less Rainfall		
Yes	43	15.4
No	237	84.6
Total	280	100.0

Source: Field Survey, 2014

The study revealed that farmers were vulnerable to climate change, it is therefore recommended that farmers be assisted through Government interventions of credit facilities to enable them assess inputs early. Prompt assessment of inputs such as planting materials and agrochemicals would enable farmers to put in place mitigation options against climate change as revealed from the research results.

REFERENCES

Adejuwon, S.A. (2004). Impacts of climate variability and climate Change on crop Yield in Nigeria. Lead paper presented at the stakeholders' workshop on assessment of impacts and adaptation to climate change, held at the Conference Center, ObafemiAwolowo University, Ile -Ife 20-21st September, 2004.

Adger, W.N., Huq, K., Brown, D. Conway, & M. Hulme (2003). Adaptation to climate change in the Development World. *Progress in Development studies* No. 3.

Babatunde J.A., Ayobami, T.S & T; Mark (2011). Developing climate change scenarios, Biophysical impacts and Adaptation strategies in Nigeria. A final report submitted to Nigerian Environmental Study Action Team (NEST) as part of Building Nigeria's Response to climate change (BNRCC) project.

Building Nigeria's Response to Climate Change, (BNRCC) (2011). National Adaptation Strategy and plan of action for Climate Change in Nigeria (NASPA-CCN) Prepared for the Federal Ministry of Environment.

Intergovernmental Panel on Climate Change (IPCC), (2007). Climate Change; Impacts, Adaptation, and Vulnerability.Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change edited by (Parry, Martin L, Caziani, Osvaldo F., Palutikof, Jean P., Vander Linden, Paul J., and E. Hanson, Cambridge University Press, Cambridge, United Kingdom, 1000 pp.

Inter Academic Council Report (IACR). (2004). Realizing the promise and potential of African agriculture. Royal Netherlands Academy of Arts and Sciences, NL-1000 GC Amsterdam. The Netherlands.

Kandlinkar, M. & J. Risbey (2000): Agricultural impacts of climate change: If adaptation is the answer. What is the question? Climate change. 45:259-539.

Maraseni, T.N., Mustaq, S. & J. Maroulis. (2009) Greenhouse gas emissions from rice farming cross-country assessment. *Journal of Agricultural science*, 147, 117-126.

Mendelsohn, R., A,Dinar& A. Dalfelt. (2000). Climate change impacts On African agricultural. Preliminary analysis prepared for the World Bank, Washington, District of Columbia PP25.

National Population Commission (NPC) (2006). Report of Nigeria's National Population Commission on 2006 census. *Population and Development Review 33(1): 206 – 210*

National Population Commission (NPC) (2011). Retrieved from pop.gov.ng in November,7th 2014.

Onyeneke R.U & D.K. Madukwe, (2010). Adaptation measures by Crop farmers in the South East of Nigeria to Climate Change. *Science World Journal,* 5 (1), 32-34.

Onyeneke, R.U; F.A, Iruo, & I.M. Ogoko (2012). Micro level Analysis of Determinants of Farmers' Adaptation Measures to Climate Change in the Niger Delta Region of Nigeria: lessons from Bayelsa State. *Nigerian journal of Agricultural Economics.* 3 (1):9-18

Rosezwerig, C. & M.L. Parry (1994). Potential impact of climate change on world food supply *Nature* 307, 133-138.

Sokona, Y. & F. Denton. (2001). Climate change impacts; Can Africa cope with the challenges? Climate Policy 1 (1), 117-123.

World Bank (2000). Can Africa Claim the 21st Century.

World Bank (2013). Nigeria Population Growth. World Development Report 2013.Washington D.C. The World Bank. *An introductory analysis,* 2nd Ed., New York, Harper and Row

Zoellick, B. (2009). A Climate Smart Future. TheNation Newspapers. Vintage Press Limited. Lagos, Nigeria. Page 18.

EFFECT OF *AMARANTHUS MOSAIC VIRUS* (AMV) AND BITTER LEAF MOSAIC VIRUS (BMV) ON GROWTH, PROXIMATE, NUTRIENT CONTENT AND SENSORY ACCEPTABILITY OF GREEN AMARANTH (*Amaranthus hybridus* L.)

Aliyu T. H [1], Abdulkareem H. A[1], Balogun, O. S [1], Eifediyi, K. E [2] and Kayode, R. M. O[3]
[1] Department of Crop Protection, Faculty of Agriculture, University of Ilorin – Nigeria.
[2] Department of Agronomy, Faculty of Agriculture, University of Ilorin – Nigeria.
[3] Department of Home Economics & Food Science, Faculty of Agriculture, University of Ilorin, Nigeria.
Corresponding Author's E-mail: aliyutaiyehussein@yahoo.com
Phone number: +2348030472667

ABSTRACT
A greenhouse experiment was conducted to evaluate the effect of Bitter leaf mosaic virus (BMV) and Amaranthus mosaic virus (AMV) on growth response, proximate, nutrient composition and sensory acceptability of green amaranth (Amaranthus hybridus L.). The treatments comprised single and double inoculations of A. hybridus with AMV and BMV while buffer inoculated plants served as control. Data were collected from 1st to 8th week after inoculation (WAI) for plant height, number of leaves, and number of leaves with viral disease symptoms. Standard methods of the Association of Official Analytical Chemist were used for determining the proximate composition and sensory acceptability were carried out on the leaves at harvest. The results showed that the significantly highest percentage disease severity at 8 WAI was recorded in plants inoculated with AMV (19.3%) followed by BMV (16.2%) and BMV + AMV (15.1%). The growth parameters from the 5th to the 8th WAI indicated that AMV inoculated plants were the shortest plants (22.6 to 33.7cm) with the significantly lowest number of leaves (6.9 to 23.6cm) compared to the control plants which were the tallest. The analysis showed a depletion of the proximate and mineral contents of the leaves by the viruses. However, the sensory evaluation revealed overall general acceptability of the virus infected plants despite an aversion to the colour.

Key words: *Amaranthus* species, inoculation, mineral content, proximate analysis, vegetables, virus.

INTRODUCTION
Vegetable is an important contributor to human well being (Mepha *et al.*, 2007). They are usually responsible for more subtle feeling of daily well being and for protection from long term degenerated diseases (Raheena, 2007). African leafy vegetables are increasingly recognized as possible contributors of both micronutrients and bioactive compounds to the diets of populations in Africa (Smith and Eyzaguirre, 2007). The continent is rich of vegetable species including amaranths which are among the most popular leafy vegetables on the continent (Maundu *et al.*, 2009).

Amaranths consist of 60–70 species and include at least 17 species with edible leaves and three grain amaranths grown for their seeds (Grubben and Denton, 2004). Several amaranth species are often considered to be weeds, even though many people around the world consume it as leafy vegetables and cereal crop (Xu and Sun, 2001; Grubben and Denton, 2004; Trucco and Tranel 2011). *Amaranthus hybridus* is cultivated in several areas of the world including South America, Africa, India, China and the United States (He *et al*., 2002). It grows well in semi arid region such as southern Africa and its commercial production is increasing throughout the world as an important alternative food source (Rawate, 1983; Kauffma, and Weber, 1990).

In Africa amaranths are among the most important leafy vegetables, a fact attributed to their easy of cultivation, wide occurrence, low pests and diseases incidence, low labour input, ease in cooking and high nutritional value (Maundu *et al.*, 2009). Cultivation occurs in all agro-ecological zones of West Africa, from the coastal sector in the Guinean zone to the dry forests and herbaceous savannahs in the Sudanian zone. In Benin Republic, *Amaranthus* species are the most commonly cultivated and consumed African leafy vegetables throughout the country. (N'Danikou *et al*., 2010).

Amaranthus hybridus is grown on a commercial scale in Southern Nigeria and constitutes a major part of the diet of the people of Nigeria, where they are mostly used in soups, because of their rich source of protein, minerals and vitamin C (Oke, 1980). It was reported that *A. hybridus* seed oil contained squalene which has important beneficial effects on cancers (Rao and Newmarj, 1998) and reduces cholesterol level in the blood (Miettinen and Vanhanen, 1994; Smith, 2000). *Amaranthus hybridus* production has been reduced by pest and disease attack. It is mostly affected by fungal diseases like, damping off caused by *Pythium* spp., stem canker by *Rhizoctonia* spp., *Alternaria* leaf spot, wet rot caused by *Choanephora cucurbitarum* (PROTA, 2004). The wet rot of *Amaranthus* causes a lot of damage if ignored, especially in the

endemic areas (Robert *et al.*, 2003). *C. cucurbitarum* affects portions of the stem which are cut during harvesting (Messiaen, 1994). In Africa, the high incidence of the disease adversely affects the cultivation of *Amaranthus* (Odebunmi-Oshilanu, 1977). In the humid tropics of Nigeria especially, the wet rot of *Amaranthus* reduces productivity of the crop (Awurum and Ogbonna, 2013).

Worldwide, diseases caused by virus have been recognized to constitute one of the major factors limiting vegetable production (Grogan, 1980). In most African countries, viruses are a major limiting factor to vegetable production and also serve as hosts to a number of other viruses (Nono-Womdim, 2003; Nyamupingidza and Machakaire, 2003). In 1988, a virus disease of *A. hybridus* named *Amaranthus mosaic virus* (AMV) was reported for the first time in Nigeria (Taiwo *et al.*, 1988). Since then, AMV has been found to be highly prevalent with an incidence rate of 19.7% (Taiwo and Owolabi, 2004). A recent study by Aliyu *et al.* (2014) showed the vulnerability of *Celosia argentea* to BMV virus infection with consequential reduction in the development of the vegetable.

The persistence of natural and recombinant virus genotypes depends on their competitive interactions at the individual and the ecosystem level (Hoover *et al.*, 1995). The distribution of any single virus within host plants is influenced by interaction of the virus and host, the environment, fitness of the virus strain, and grower management practices (William *et al.*, 2010). Virus distribution within plants is also influenced by interaction of the virus with other viruses or pathogens. The frequency with which two viruses are found occupying the same niche is a measure of the affinity for coexistence (Ludwig and Reynolds, 1988).

*Amaranthus mosaic virus*s has a restricted host range confined to a few species of the *Amaranthaceae, Chenopodiaceae* and *Solanaceae* families and there is no evidence of AMV transmission by seeds. The viral coat protein had a relative molecular mass (M(r)) of about 30.2 K. Electron microscopy of purified virus preparations revealed flexuous rod shaped particles of about 750 nm in length (Owolabi *et al.*, 1998). The virus isolated from *Vernonia amygdalina* Del. (bitterleaf) is mechanically transmissible but had a narrow host range restricted to *Nicotiana benthamiana, Chenopodium quinoa* and *C. amaranticolor*. The virus was purified from N. benthamiana and about 750 nm long flexuous rod-shaped particles were observed in purified preparations as well as in leaf-dips of *Vernonia* sp. Inclusion bodies in the form of pinwheels and scrolls were observed in ultrathin sections of Vernonia leaves by electron microscopy. M(r), of the viral coat protein was estimated to be about 34 K (Taiwo and Dijkstra, 2004). The objective of this study therefore was to document the effect of *Amaranthus mosaic virus* (AMV) and Bitter Leaf mosaic virus (BMV) on the growth, proximate/nutrient content and sensory acceptability of *Amaranthus hybridus.*

MATERIALS AND METHODS

Experimental design and plant propagation: The experiment was conducted at the Faculty of Agriculture, University of Ilorin and Biosciences Limited, Ibadan-Nigeria. *Amaranthus hybridus* seeds (NHAM/114) were obtained from the National Horticultural Research Institute (NIHORT), Ibadan. The viral inoculums (*Bitter leaf mosaic* virus and *Amaranthus mosaic virus*) were sourced from the Department of Crop Protection, University of Ilorin.

Ninety six (50 cm diameter) plastic pots were filled with sandy loam soil that was previously steam sterilized at 120°C for 240 minutes. The *A. hybridus* seeds were sown at the rate of ten seeds per bucket and later thinned to four stands per pot seven days thereafter The buckets were arranged in the greenhouse in a completely randomized design with 3 replications per treatment.. The treatments were as follows:

(i) Plants inoculated with *Bitter leaf mosaic virus* comprised of 24 pots and 96 plants.
(ii) Plants inoculated with *Amaranthus mosaic virus* comprised of 24 pots and 96 plants.
(iii) Plants inoculated with *Amaranthus mosaic virus and Bitter leaf Mosaic virus* comprised of 24 pots and 96 plants.
(iv) Buffer inoculated plants which served as control for the experiment comprised of 24 pots and 96 plants.

Inoculation procedure: The viral isolates were extracted from the infected leaves by homogenization, using mortar and pestle in 0.05M Phosphate buffer (2.72g KH_2PO_4 14.20g Na_2HPO_4 x $2H_2O$ 800 ml demineralised water set pH to 7.4 with NaOH and demineralised water to 1000 ml total volume) at the rate of 1g leaf sample to 5 ml of buffer. In all cases, the four plants in each pot were mechanically inoculated. Inoculation was done by mechanical transmission of virus through sap when the plants were at the four leaf stage. The sap was applied on the surface of the leaves previously sprinkled with carborundum (800 mesh), by gently rubbing the leaves with a cotton wool dipped in the sap. The control plants were buffer inoculated alone, after which all the plants were rinsed with water to reduce inoculation stress on them. Thereafter, all the necessary agronomic

practices were equally observed on all the treatment pots. This included hand weeding with hoes when needed and daily watering of plants twice daily at 7am and 5pm.

Data Collection: Data were collected from the 1st to the 8th week after inoculation (WAI) on plant height, number of leaves per plant, and number of leaves with virus disease symptoms. The percentage disease severity was measured by the number of diseased leaves relative to the total number of leaves on any given plant and this value was expressed as a percentage.

Preparation of samples for proximate and mineral analysis: The leafy vegetables were harvested at 9th WAI, and thoroughly washed differently with distilled water and air dried. The dried leaves were ground into powder using pestle and mortar. The ground portion was kept in a plastic bottle in a freezer prior analysis.

Proximate Analyses: Standard Methods of the Association of Official Analytical Chemists (AOAC, 1997) were used for determining the proximate composition of the leaves. Moisture content was determined by oven drying 10g each of virus inoculated and buffer inoculated leaf samples at 50^0 C to constant weights. Ash content was obtained by incinerating leaf samples in a muffle furnace at 550^0C for 30 minutes. Nitrogen was determined by the micro-kjeldahl method (Pearson, 1976) and the percentage of nitrogen was converted to crude protein by multiplying by 6.25. Fat content was determined gravimetrically after extraction with diethyl ether from an ammonical solution of the samples. The Crude fibre content was determined by acid – base digestion using 1.25% H_2SO_4 and 1.25% NaOH (w/v) solution, while carbohydrate value was calculated by difference.

Mineral Analysis: The minerals in the leafy vegetables were analysed from solution obtained when 2.0g of the samples were digested with concentrated nitric acid and concentrated per chloric acid in ratios 5:3, the mixtures were placed on a water bath for three hours at 80^oC as outlined by Asaolu *et al.* (2012). The resultant solution was cooled and filtered into 100ml standard flask and made to mark with distilled water (Asaolu, 1995). Atomic absorption spectro-photometer (Buck scientific model 200A by Beijing Beifen-Ruili Analytical Instrument Company limited) was then used for the analysis.

Sensory evaluation: Twenty panel members consisting of staff and students of the University of Ilorin were randomly selected for the sensory evaluation of the boiled fresh *Amaranth* leaves harvested at 9th WAI. Samples from each of the treatment pots were cooked in the same sauce preparation and determined for colour, taste, and overall acceptability as described by Ihekoronye and Ngoddy (1985). The samples were evaluated on a 7–point hedonic scale (1=disliked very much, 2=disliked much, 3=disliked moderately, 4=neither liked nor disliked, 5=like moderately, 6=like and 7=like very much) in the mid morning (11.00 a.m.) in a sensory evaluation laboratory under white light. Samples were presented in 3 digits code in plates. The order of presentation of the sample to the judges was randomized and the buffer inoculated *Amaranth* leaves cooked with the same sauce were used as control.

Data Analysis

All the data generated were subjected to analysis of variance (ANOVA) and where necessary, treatment means were separated using Duncan's Multiple Range Test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Viral Inoculation on plant height: Table 1 shows the effect of viral inoculation on plant height at different times after inoculation. It indicates there were no significant differences among the treatments at 1st week after inoculation. By the 2nd WAI however, the most significantly affected plants were those inoculated with AMV (11.2 cm) and combination of AMV + BMV (11.9 cm). At 3rd WAI the significantly affected plants were with the AMV inoculation (14.1 cm) followed by BMV (16.3 cm) and combination of AMV + BMV (18.6 cm). The result from the 5th - 8th WAI indicated that AMV inoculated plants were the shortest with the range of 22.6 - 33.7 cm, followed by BMV (25.4 - 38.5 cm) and AMV + BMV (31.3 - 46.6 cm). This result shows that virus inoculation caused a reduction in *Amaranth* plant heights overtime. This reduction was however most significant in AMV inoculated plants and the least in AMV + BMV inoculations. The finding is indicative of the pathogenic effect of the viruses on *A. hybridus* and is suggestive of the antagonistic effect of AMV and BMV considering its influence in this regard. Pazarlar *et al.* (2013) and Aliyu *et al.* (2014) reported stunting of some vegetables as a result of virus infection but the perceived antagonistic effect of AMV + BMV on plant height of *A. hybridus* as observed in this study is novel.

Effect of Virus Inoculation on percentage disease severity: The effect of virus inoculation on percentage disease severity is presented in Table 2. The effect of the treatment on the plants became apparent from the 3rd WAI. The significantly highest percentage disease severity was observed in plants inoculated with AMV (6.6%) followed by BMV (5.8%) and AMV + BMV (5.6%). At 4th WAI the significantly highest percentage disease

severity (11.2%) was reported in the AMV inoculated plants while AMV + BMV had the significantly lowest value (8.1%) among the virus inoculated. A consistent trend was observed such that at 8th WAI, the disease severity indicated AMV (19.3%), BMV (16.2%) and AMV + BMV (15.1%). The buffer inoculated plants which served as control also showed some level of infection although very minimal, probably be due to seed-borne infection. This is a confirmation of the work of Leisner and Howell (1993) who reported that many plant viruses move from cell to cell along with the flow of photoassimilates with increasing severity. The fact that AMV and BMV were more severe singly inoculated compared to AMV + BMV on *A. hybridus* suggest an antagonistic effect of the two viruses and is in tandem with the views of Oku (1994) that the interaction between two or more viruses could be synergistic, additive or antagonistic.

Effect of virus infection on average number of leaves per plant: The effect of virus inoculation treatments on the mean number of leaves per plant is shown in Table 3. The effect of the virus inoculated at 2nd WAI was significantly highest in the AMV inoculated plants which produced the lowest mean number of leaves per plant (6.9). The BMV and AMV + BMV inoculated plants were not significantly different from each other with values of 7.4 and 7.8, respectively. At the 3rd WAI the effect was also more pronounced in AMV (8.3) which was significantly different from BMV (10.1) and AMV + BMV (12.4) inoculated plants. This same trend of was observed at the 8th WAI with significantly lowest number of leaves per plant in AMV (23.6), followed BMV (27.4) and AMV + BMV (29.2). The significant reduction in the number of leaves observed in AMV inoculation could diminish the photosynthetic ability of the plants and reduced yield as noted by Stampar *et al.* (1999). The reduction in the number of leaves observed in the present study is attributed to higher infection severity of AMV as compared to BMV and AMV + BMV. Aliyu *et al.* (2014) also assessed the pathogenicity of *Cucumber mosaic virus* and *Bitter leaf mosaic virus* on *Celosia argentea* and reported similar findings.

Table 1: Effect of Viral Inoculation on plant height (cm) of *Amaranthus hybridus* at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	5.3	12.6^{b}	16.3^{c}	19.6^{c}	25.4^{c}	31.0^{c}	34.7^{c}	38.5^{c}
AMV	5.4	11.2^{c}	14.1^{d}	18.9^{c}	22.6^{d}	27.4^{d}	30.3^{d}	33.7^{d}
BMV + AMV	5.5	11.9^{c}	18.6^{b}	25.5^{b}	31.3^{b}	37.4^{b}	42.2^{b}	46.6^{b}
BUFFER	5.2	14.8^{a}	21.2^{a}	28.9^{a}	36.1^{a}	44.2^{a}	49.9^{a}	54.1^{a}
S E M	0.012	2.126	1.006	3.826	1.652	2.805	2.227	1.876

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test. Key: BMV = *A. hybridus* inoculated with *Bitter leaf putative virus;* AMV = *A. hybridus* inoculated with *Amaranthus mosaic virus;* BMV + AMV = *A. hybridus* inoculated with *Bitter leaf mosaic virus* and *Amaranthus mosaic virus;* BUFFER = *Amaranthus* inoculated with buffer (control); WAI = week after inoculation.

Table 2: Effect of Viral infection on percentage disease severity at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	0.1	2.2	5.8^{b}	8.9^{b}	10.1^{b}	12.9^{b}	15.4^{a}	16.2^{b}
AMV	0	2.8	6.6^{a}	9.4^{a}	11.2^{a}	13.6^{a}	16.7^{a}	19.3^{a}
BMV + AMV	0.1	2.6	5.6^{b}	8.1^{b}	9.9^{b}	11.6^{b}	13.1^{b}	15.1^{b}
BUFFER	0	2.6	2.7^{c}	3.0^{c}	3.1^{c}	3.3^{c}	3.4^{c}	3.6^{c}
S E M	0.001	0.121	0.397	0.665	0.712	0.662	1.12	1.321

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 3: Effect of virus infection on average number of leaves per plant at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	4.4	7.4^{b}	10.1^{c}	12.6^{bc}	14.2^{c}	16.9^{c}	21.0^{c}	27.4^{c}
AMV	4.6	6.9^{c}	8.3^{d}	10.2^{d}	12.6^{c}	14.5^{cd}	17.9^{d}	23.6^{d}
BMV+ AMV	4.3	7.8^{b}	12.4^{b}	14.4^{b}	18.1^{b}	20.1^{b}	24.6^{b}	29.2^{bc}
BUFFER	4.4	8.9^{a}	15.3^{a}	18.6^{a}	24.7^{a}	26.8^{a}	34.4^{a}	37.7^{a}
S E M	0.011	1.221	2.021	1.332	2.983	3.732	2.322	3.614

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 4: Proximate analysis of virus and buffer infected *Amaranthus hybridus*

Proximate Composition (g/100g)	BMV	AMV	BMV + AMV	BUFFER
Protein	8.4^{c}	7.6^{cd}	10.2^{b}	16.8^{a}
Crude Fibre	3.6^{bc}	3.3^{c}	4.3^{b}	11.5^{a}
Fat	1.3^{c}	1.4^{c}	1.6^{b}	3.2^{a}
Carbohydrate	10.2^{ab}	11.1^{a}	8.4^{c}	6.1^{d}
Ash	14.0^{b}	13.9^{c}	14.6^{b}	16.6^{a}
Moisture	86.3^{b}	90.4^{a}	85.7^{b}	83.5^{c}

In each row, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Proximate analysis of virus and buffer infected *Amaranthus hybridus*: Table 4 is result of analysis of the virus infected and buffer infected *Amaranthus* leaves. The result indicated that the percentage protein content was significantly lowest in the AMV inoculated plants (7.6%), followed by BMV (8.4%) and 10.2% in the AMV + BMV inoculated plants, while the buffer inoculated plants had the highest value of 16.8%. The low protein values in the virus inoculated plants may be due to changes in the metabolic activity of the plants as a result of virus infection since viruses depend on the protein synthesis machinery of host cells for survival. This is in agreement with Yardimci *et al.* (2007) while determining the effects of AMV on the nutrient content of alfalfa plants but contrasts the work of White and Blakke (1982) that reported increased protein in barley infected with *Wheat spindle mosaic virus* (WSMV) and *Barley strip mosaic virus* (BSMV).

Crude fibre content ranged from 3.3% in the AMV inoculated plants to 4.3% in the AMV + BMV inoculated plants. The BMV and buffer inoculated plants were 3.6% and 11.5% respectively. The fat content was significantly highest in the buffer inoculated plants (3.2%), followed by AMV plus BMV inoculated plants (1.6%). The percentage fat content were not significantly different for AMV (1.4%) and BMV (1.3%) inoculated plants. The carbohydrate content was significantly highest in AMV inoculation (11.1%), followed by BMV inoculation (10.2%) and AMV + BMV inoculation (8.4%). The least carbohydrate content was in the buffer inoculated plants (6.1%). This finding is in agreement with Mofunanya *et al.* (2015) who reported that *A. hybridus* reaction to virus infection revealed marked reductions in the nutritional quality of the vegetable.

The ash content was significantly lowest in AMV inoculation (13.9%), followed by 14.0% in BMV and 14.6% in AMV plus BMV inoculation. The highest value was 16.6% in the buffer inoculated plants. These findings are in line with those of Mofunanya *et al.* (2008) and were attributed to higher levels of antioxidants in virus inoculated plants. The moisture content level was significantly highest in the AMV inoculated plants (90.4%), followed by BMV (86.3%) and AMV plus BMV (85.7%). The lowest moisture content was in the buffer inoculated (control) plants (83.5%). The high water content in the virus infected plants might be as a result of reduction in permeability of cell membrane. This is also the view of Tinklin (1970) while studying the effects of aspermy virus infection on water relations of tomato leaves.

Mineral composition of virus and buffer infected leaves of *Amaranthus hybridus*

Table 5 shows the mineral composition of virus and buffer infected leaves of *A. hybridus* at harvest. The Sodium content was significantly lowest in AMV inoculated (1.3mg/100g) followed by BMV inoculated plants (2.9mg/100g) and AMV plus BMV inoculation (3.3mg/100g). The potassium value ranged from the significantly highest value of 27.3mg/100g in AMV to 33.6mg/100g in the AMV + BMV.

The potassium value was 29.4mg/100g in BMV infected and significantly highest at 40.4mg/100g in the buffer inoculated plants. Calcium content was lowest at AMV inoculated plants (18.6mg/100g), followed by BMV inoculated plants (19.4mg/100g) and AMV plus BMV inoculated plants 22.4 mg/100g. The magnesium mineral content as expected was significantly highest in the control (223.6 mg/100g), followed by AMV plus BMV (100.2 mg/100g). The magnesium values for AMV (89.4 mg/100g) and BMV (88.6 mg/100g) were not significantly different. Iron content was also significantly lowest in BMV inoculated (3.6 mg/100g), while AMV (4.0 mg/100g) and AMV plus BMV (4.8 mg/100g) had statistically similar values. The Zinc content was not significantly different for the three inoculations but ranged from 1.0 mg/100g in AMV inoculation to 1.7 and 1.8 mg/100g in BMV and AMV + BMV inoculation. These results are similar to reports by Owolabi *et al.* (2010) but slightly differ from Shattuck (1987). Zinc has been found to have a number of different effects as in some cases it decreased, in others increased, and in

others had no effect on plant susceptibility to disease (Graham and Webb, 1991; Grewal *et al.*, 1996). It was however confirmed by Dmitriev *et al*. (2009) that Zinc induced a significant (more that 2-fold) increment of virus content in tomato plants. This therefore suggests that BMV and AMV both singly and in combination did not significantly affect Zinc content and disease severity in *A. hybridus.*

Table 5: Mineral composition of virus and buffer infected leaves of *Amaranthus hybridus*

Mineral Composition (mg/100g)	BMV	AMV	BMV + AMV	BUFFER
Sodium (Na)	2.9[c]	1.3[d]	3.3[b]	5.6 [a]
Potassium (K)	29.4[c]	27.3[d]	33.6[b]	40.4[a]
Calcium (Ca)	19.4[c]	18.6[d]	22.4[b]	44.1[a]
Magnesium (Mg)	88.6[c]	89.4[c]	100.2[b]	223.6[a]
Iron (Fe)	3.6[c]	4.0[b]	4.8[b]	12.1[a]
Zinc (Zn)	1.7[b]	1.6[b]	1.8[b]	2.9[a]

In each row, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Sensory acceptability of *Amaranthus hybridus* inoculated with viruses and buffer: Table 6 represents the results of the sensory acceptability in terms of colour, taste and overall acceptability of *A. hybridus* samples cooked after inoculation with AMV, BMV, AMV + BMV and buffer solution (Control). The significantly lowest colour ratings of 6.8 to 6.9 were in the virus inoculated and this showed that the panellist preferred the colour of the control as it appeared to be the most acceptable having recorded the score of 9.6. The unlikeable colour of the virus inoculated plants was probably due to the action of the viruses resulting in an unattractive mosaic presentation.

The result of the rating as regards taste and overall acceptability showed that there was no significant difference among the samples. Taste perception has been suggested to play a key role in determining individual food preferences and dietary habits. This finding suggests that virus infection does not affect the taste and overall acceptability of *A. hybridus* by consumers.

Table 6: Mean sensory scores of acceptance of *Amaranthus hybridus* inoculated with viruses and buffer after harvest

Sample	Colour	Taste	Overall Acceptability
AMV	6.9[b]	7.2	7.5
BMV	6.6[b]	7.6	7.3
AMV + BMV	6.8[b]	7.4	7.6
BUFFER	9.6[a]	7.7	8.1

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test

CONCLUSION

The infection of *A. hybridus* with AMV and BMV either singly or in combination of both resulted in growth parameter distortions. However, AMV inoculated singly appeared to be the more pathogenic of the two viruses. There seem to be an antagonistic effect between the two viruses as the combination was less infectious compared to single inoculations. The infection of *A. hybridus* with the viruses resulted in the depletion of the nutrients and minerals present in the leaves. Sensory evaluation revealed that although there was marked effect on leaf colour, this did not influence taste or overall acceptability by consumers.

REFERENCES

Aliyu, T.H., Balogun, O.S., Osumah, R. & Adeoti, O.M. (2014). The pathogenicity of *Cucumber mosaic virus* (CMV) and Putative *Bitterleaf mosaic virus* (BLMV) on *Celosia argentea. Taraba Journal of Agricultural Research*, 2(1): 49-53.

AOAC (1997). Methods of Analysis of Association of Official Analytical chemists (16th ed). Washington, D.C.1: 600-792.

Asaolu, S. S. (1995). Lead content of vegetables and tomatoes at Erekesan market, Ado-Ekiti. *Pakistan Journal of Industrial Research,* 38: 399-400.

Asaolu, S.S., Adefemi, O.S., Oyakilome, I.G., Ajibulu, K.E. & Asaolu, M.F. (2012). Proximate and mineral composition of Nigerian leafy vegetables. *Journal of Food Research*, 1(3): 214-218.

Awurum, A.N. & Ogbonna, M.J. (2013). Field trial on the efficacy of some plant extracts on the control of wet rot of *Amaranthus cruentus* L. induced by *Choanephora cucurbitarum. Continental Journal of Agronomy*, 7(1): 10-17.

Dmitriev, A., Shevchenko, O., Polischuk, V. & Guscha, N. (2009). Effects of low dose chronic radiation and heavy metals on plants and their fungal and virus infections. *Data Science Journal* 8: 49-66.

Ehinmore, I. & Kareem, K.T. (2010). Effect of Amaranthus Mosaic Virus on the growth characters of *Amaranthus hybridus.*

Agriculture and Biology Journal of North America, 1(2): 75-79.

Graham, D.R. & Webb, M.J. (1991). Micronutrients and disease resistance and tolerance in plants, in: Mortvedt J.J., Cox F.R., Shuman L.M., Welch R.M. (Eds.), Micronutrients in Agriculture, 2nd ed., Soil Science Society of America, Inc. Madison, Wisconsin, USA, pp. 329–370.

Grewal, H.S., Graham, R.D. & Rengel, Z. (1996). Genotypic variation in zinc efficiency and resistance to crown rot disease (Fusarium graminearum Schw. Group 1) in wheat. *Plant Soil*, 186: 219–226.

Grogan, R.G. (1980). Control of *Lettue mosaic virus* with virus free seeds. *Plant Disease*, 64: 446-449.

Grubben, G.J.H. & Denton, O.A. (2004). Plant resources of tropical Africa 2. Vegetables. PROTA Foundation, Wageningen.

He, H.P., Cai, Y., Sun, M. & Corke, H. (2002). Extraction and purification of squalene from *Amaranthus* grain. *Journal of Agriculture Food and Chemistry*, 50(2): 368-372.

Hoover, K., Schultz, C.M., Lane, S.S., Bonning, B.C., Duffey, S.S. *et al.* (1995). Reduction in damage to cotton plants by a recombinant baculovirus that knocks moribund larvae of Heliothis virescens off the plant. *Biological Control* 5: 419–426.

Ihekoronye, A.I. & Ngoddy, P.O. (1985). Integrated Food Science and Technology. Macmilian Publishers, New York. Pg 296-301.

Kauffman, C.S. & Weber, L.E. (1990). Grain amaranth. In: Janick, J., Simmon, J.E. (Eds.), Proceedings of the 1st National Symposium on New Crops, Indianapolis, IN, October 1988. Timber Press, Portland, OR, pp. 127-139.

Leisner, S.M. & Howell, S.H. (1993). Long-distance movement of viruses in plants. *Trends in Microbiology*, 1(8): 314-317.

Ludwig, J.A. & Reynolds, J.F. (1988). Statistical Ecology. John Wiley & Sons, New York.

Maundu, P., Achigan-Dako, E.G. & Morimoto, Y. (2009). Biodiversity of African vegetables. In: Shackleton CM, Pasquini MW, DrescherAW(eds) African indigenous vegetables in urban agriculture. Earthscan, London, pp 65–104.

Mepha, H.D., Eboh, L. & Banigbo, D.E.B. (2007). Effects of processing treatments on the Nutritive Composition and consumer acceptance of some Nigerian edible leafy vegetables. *African Journal of Food Agriculture and Nutritional Development*, 7(1): 1-18.

Messiaen, C.M. (1994). The Tropical Vegetable Garden. Macmillan. pp. 514. London, United Kingdom.

Miettinen, T.A. & Vanhanen, H. (1994). Serum concentration and metabolism of cholesterol drug rapeseed oil and squalene feeding. *American Journal of Clinical Nutrition*, 59: 356-363.

Mofunanya, A.A., Omokaro, D.N., Owolabi A.T. & Ine-Ibehe, N.E. (2008). Effect of *Telfairia* mosaic virus (TeMV) infection on the proximate, minerial and anti-nutritive contents of *Telfairia occidentalis* Hook (Fluted pumpkin). *Nigerian Journal of Botany*, 21: 304-315.

Mofunanya, A.A., Owolabi, A.T. & Nkangi, A. (2005). Reaction of *Amaranthus hybridus* L. (Green) to *Telfairia Mosaic Virus* (TeMV) infection. *International Journal of Virology*, 11: 87-95.

N'Danikou, S., Assogba, T.M. & Avohou, E.S. (2010). Selected species of traditional vegetable of Benin by family. In: Achigan-Dako EG,PasquiniMW,Assogba Komlan F, N'DanikouS, DansiA, Ambrose-Oji B (eds) Traditional Vegetables in Benin. Institut National des Recherches Agricoles du Be´nin. Imprimeriesdu CENAP, Cotonou, Re´publique du Be´nin, pp 93–197.

Nono-Womdim, R. (2003). An overview of major virus diseases of vegetable crops in Africa and some aspects of their control. Pages 213-232. In*: Plant virology in Sub-Saharan Africa*, Proc. Conf. Organized by IITA. J.d'A. Hughes and J.Odu,(eds.). International Institute of Tropical Agriculture, Ibadan, Nigeria.

Nyamupingidza, T.N. & Machakaire, V. (2003). Virus diseases of important vegetables in Zimbabwe. Pages 397-406. In: Plant Virology In Sub-Saharan Africa. Proc. Conf. Organized by IITA, J.d'A. Hughes and J. Odu, eds. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Odebunmi-Oshilanlu, Y.O.K. (1977). The more important diseases of selected local vegetables in Nigeria. *Nigerian Journal of Plant Protection*, 3: 79-83.

Oke, O.C. (1980). "*Amaranthus* in Nigeria". Proceedings of 2nd Amaranth Conference. Rodal Press: Emans. Pennsylvania.

Oku, H. (1994). Plant pathogenesis and disease control. Boca Raton: Lewis Publisher. Boca Raton.

Owolabi, T.A., Taiwo, M.A., Thottappilly, G.A., Shoyinka, S.A., Proll, E. & Rabenstein, F. (1988). Properties of a virus causing mosaic and leaf curl disease of *Celosia*

argentea L. in Nigeria. *Acta Virology,* 42 (3): 133- 139.

Owolabi, A.T., Mofunanya, A.A.J., Dogun, C., Akpan G.S. & Wilson, E.N. (2010). Biochemical changes in Ivy Gourd leaves (*Coccinia barteri*) infected by Nigerian strain of Moroccan Watermelon Mosaic Virus (MWMV). *Nigeria Journal of Experimental and Applied Biology,* 11: 37-46.

Pazarlar, S., Gümüş, M., & Öztekin, G.B. (2013). The Effects of *Tobacco mosaic virus* infection on growth and physiological parameters in some pepper arieties (*Capsicum annuum* L.). *Not Bot Horti Agrobo,* 41(2): 427-433.

Pearson, D. (1976). Chemical Analysis of foods, 7th Edition.London, Churchill Livingstone, 1976, pp 7-11.

PROTA, (2004). Vegetables in Plant Resources in Tropical Africa. In G.J.H. Grubben and O.A. Denton (eds). PROTA Foundational CTA Wageningen, Netherlands. pp. 667.

Raheena, B. (2007). Food, Nutrition and Dietetics, 2nd Edition, Sterling Publisher Private Limited, Delhi, pp. 106- 109.

Rao, C.V. & Newmarj, H.L. (1998). Chemopreventive effect of squalene on colon cancer. *Carcinogenesis,* 19: 287-290.

Rawate, P.D. (1983). Amaranth (pigweed): A crop to help solve the world protein shortage. Pages 287-298 In: Environmentally Sound Agriculture: Selected papers from the 4th International Conference of the International Federation of Organic Agriculture Movements. A.W. Lockeretz, ed. Praeger, N.Y.

Robert, P.D., Urs, R.R., Kucharek, T.A., Semer, C.R., Benny, G.L. & Pernezny, K. (2003). Outbreak of *Choanephora cucurbitarum* on green bean and pepper in Florida. *Plant Disease,* 87: 1149.

Shattuck, V.I. (1987). Effect of Turnip mosaic virus infection on the mineral composition of rutabaga. *Communications in Soil Science and Plant Analysis,* 18: 1269-1279.

Smith, T.J. (2000). Squalene: Potential chemopreventive agent. Expert Opin. Invest. *Drugs,* 9: 1841-1848.

Smith, F.I. & Eyzaguirre, P. (2007). African leafy vegetables: their role in the World Health Organization's global fruit and vegetables initiative. In: Oniang'o R, Grum M, Obel-Lawson E (eds) Developing African leafy vegetables for improved nutrition, Regional workshop, 6–9 December2005, Rural Outreach Program, Nairobi, Kenya, pp 1–8.

Stampar, F., Hudina, M., Usenik, V., Sturm, K., Virscek, M.N. & Batic, F. Influence of leaf area on net photosynthesis, yield and flower-bud formation in apple (*Malus domestica* Borkh.). *Plant Physiology,* 39: 101-106.

Taiwo, M. A. & Owolabi, A. T. (2004). Occurrence and prevalence of viruses of leafy vegetables in Lagos, Nigeria. *Global Journal of Pure and Applied Sciences,* 10(1): 61-67.

Taiwo, M.A. & Dijkstra, J. (2004). Properties of a virus isolated from Vernonia amygdalina Del. in Lagos, Nigeria. *Acta Virology,* 48(4): 257-262.

Taiwo, M.A., Thottapppily, G. & Shoyinka, S.A. (1988). Studies on a virus disease of *Amaranthus hybridus* L. in Nigeria. *International Journal of Tropical Diseases,* 6: 195-200.

Tinklin, R. (1970). Effects of aspermy virus infection on water relations of tomato leaves. *Physiological Plant Pathology,* 69: 515-520.

Trucco, F. & Tranel, P.J. (2011). Amaranthus. In: Kole C (ed) Wild crop relatives: genomic and breeding resources vegetables, vol XXVI. Springer-Verlag, Berlin Heidelberg, pp 11–21.

William, W. T., Chandrasekar, S. K. & Scott, A. (2010). Distribution of four viruses in single and mixed Infections within infected watermelon plants in Florida. *Phytopathology,* 100(11): 1194 -1203.

Xu, F. & Sun, M. (2001). Comparative analysis of phylogenetic relationships of grain amaranths and their wild relatives (Amaranthus; Amaranthaceae) using internal transcribed spacer, amplified fragment length polymorphism, and double-primer fluorescent intersimple sequence repeat markers. *Molecular Phylogenetic Evolution,* 21(3): 372–387.

Yardımcı, N., Eryigit, H & Erdai, E. (2007). Effect of Alfalfa mosaic virus on the content of some macro and micro nutrients in Alfalfa. *Journal of Culture Collections,* 5: 90-93

MODELING PROFIT EFFICIENCY OF SMALL SCALE GROUNDNUT FARMS IN NIGER STATE, NIGERIA: A STOCHASTIC PROFIT FRONTIER APPROACH

*Sadiq, M S[1]., Singh, I.P[2]., Suleiman Aminu[3]., Grema, I.J[4]., Usman, B.I[5]. and Yusuf, A.O[1]
[1]*Department of Agricultural Economics and Extension Technology, FUT, Minna, Nigeria**
[2]*Professor, Department of Agricultural Economics, SKRAU, Bikaner, India*
[3]*Professor, Department of Agricultural Economics and Extension, BUK, Kano, Nigeria*
[4]*Department of Agricultural Technology, Yobe State College of Agriculture, Gujba, Nigeria*
[5]*Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic Bida, Nigeria*
Author correspondence address: Sadiq, M. Sanusi, Department of Agricultural Economics, Federal University of Technology, P.M.B 65, Minna, Nigeria
Email: sadiqsanusi30@gmail.com (Tel: 07037690124)

ABSTRACT
Revamping and reviving groundnut pyramids in Nigeria has been a topical issue of discuss in the current political dispensation due to global crash in oil prices which has adversely affected the revenue base of the country. The best and most effective pathway for the country to regain its lost lead position in terms of production and export of this commodity among the comity of nations is to improve productivity of this crop through efficient utilization of scarce resources. This research empirically measure profit efficiency on small-scale groundnut farms in Niger State of Nigeria using cross sectional data obtained from 120 active farmers drawn through a multi-stage sampling technique. Results showed an active working population with a sustainable household size which lack formal education (western) and have poor resource base which affect their productivity, thus, resulting in marginal profit. The empirical results revealed presence of profit inefficiency effects in groundnut production as indicated by the significant estimated gamma coefficient and the generalized likelihood ratio test results obtained from the data analysis. However, findings indicated that 27.4% of profit loss was due to conglomeration of technical, allocative and scale inefficiencies. Thus, opportunities still exist for these producers to increase their efficiencies by improving on the aforementioned combined efficiencies. The study recommends efficient allocation of farm resources; sustainable household size and literacy level enhancement which would not only reduce inefficiency, but also minimize profit loss incurred by groundnut producers in the studied area.

Keywords: Profit efficiency; SPF; Groundnut production; Small scale; Niger State; Nigeria

INTRODUCTION
In spite of Nigeria's fertile soils, large expanse of arable land as well as suitable climatic factors, all of which favours groundnut production, the nation's output has declined over the years, thereby losing its leading position to countries like China and the United States of America that have invested immensely in both institutional and market organizations that linked the farmers to markets. Also, these countries were able to meet the new strict sanitary and phytosanitary requirements, particularly for Aflatoxin, which is a serious food toxin (FMARD, 2011). In Nigeria groundnut is a rich source of protein which is an important diet in most homes today and unfortunately the domestic production of groundnut has not met the demand thereby affecting food security. The food problem in the country has been worsened by low level of resource productivity in recent time which leads to low profit efficiency. However, the gap between demand and supply of agricultural products in Nigeria has been on the increase since focus shifted away from agriculture to other sectors of the economy.

Taphee *et al*.,(2015) reported that groundnut production in Nigeria is dominated by small scale farmers cultivating between 1-3 hectares of farms often using traditional tools; and earning not appreciable incomes. Furthermore, he stated that due to limited capacities of these small scale farmers their outputs are usually low and their productivities have remained below optimum of 2 tonnes per hectare. This calls to question the efficiency of use of available technologies by groundnut farmers in the country. An underlying premise is that if farmers, most especially the small scale category, are not efficient in the use of existing technologies, then efforts designed to improve efficiency would be more effective than introducing new technologies as a way of improving output (Taphee *et al*., 2015). The increase in groundnut consumption as a good source of protein and its cultural and religious acceptability are an indication that groundnut farmers must live up to expectation of meeting the local demand. And to achieve this; efforts must be taken to investigate the productive efficiency of the groundnut farmers in the country, using profit efficiency that is based on perfect competitive market. Profit efficiency is a wider concept than cost efficiency since it takes into account the effect of the choice of a certain vector of production both on cost and on revenues, thus offering

complementary information useful for the analysis of groundnut farming efficiency.

In Niger State the crop is a principal commodity produced by majority of household, hence output increase is an important step towards achieving food self-sufficiency within the state. With the risen population in the state, there is need to match the gap given that groundnut is an important crop for realizing this dream due to its nutritional and industrial benefits. However, it appears that groundnut farmers in the state are not getting maximum return from the resources committed to the enterprise as a result of low yield which has led to low returns that accrued to them from marketed surplus. Furthermore, based on literatures there is little or no attention devoted to analyzing the profit efficiency of groundnut farmers even though prices of output and input are known, which if researched will enhance profit efficiency which will lead to greater benefits for groundnut farmers. With this trend, onus lies on researchers to investigate the factors that reduce profit from groundnut production in the state. Therefore, the aim of this paper is to contribute towards better understanding of small scale groundnut farmers' production efficiency in Niger State with a view of predicting profit efficiencies applying stochastic frontier profit function, giving that past studies adopted traditional response function [e.g Ani *et al.*(2013); Girei *et al.*(2013)] and the few which used Stochastic frontier exclusively focused on technical efficiency (Taphee *et al.* 2015). The broad objective was to investigate profit efficiency of small-scale groundnut production in Niger State of Nigeria. The specific objectives were to:

i. describe the socio-economic characteristics of groundnut farmers in the study area;
ii. evaluate income distribution among groundnut producers in the study area;
iii. estimate costs and returns for groundnut production in the study area;
iv. determine profit efficiency and attendant risks factors influencing profit efficiency in the study area; and,
v. identify the militating factors affecting the production of this crop in the study area.

RESEARCH METHODOLOGY

Niger state code named power state and famous for production of food crops in Nigeria, is the largest in terms of landmass in the country. The ecological location of the state is guinea savannah zone while the geographical location is North-central otherwise called middle belt, and stretches between latitudes 8°20'N and 11°30'N of equator and longitude 3°30'E and 7°20'E of the Greenwich Meridian. The state enjoys luxuriant vegetation with vast Northern Guinea savannah found in the North while the fringe around Mokwa in Southern Guinea savannah which favours cultivation of arable crops and livestock production. Primary occupation of the majority of the inhabitants is farming while secondary occupations are small agribusiness, petty traders, artisanal, civil servants and *ayuverda* medicine. The study adopted multi-stage sampling technique to collect cross sectional data on small-scale groundnut farms in the state. The first stage involved convenient selection of one out of the three Agricultural zones available in the state, namely, Kuta zone due to costs and time constraint of the researcher. The second stage involved purposive selection of two LGAs, namely, Shiroro and Chanchaga due to their comparative advantage in cultivation of groundnut. The third and last stage introduced random sampling techniques to select three villages from each LGA and twenty active producers from each selected village, respectively, thus, given a total sample size of 120 respondents. Instrument of data collection was structured questionnaire coupled with interview schedule keeping in view input-output data of the farmers defined within cost content. Both descriptive and inferential statistics were used to analyze the data collected. Objective i and v; ii; iii; and, iv were achieved using descriptive statistics, Gini coefficient in conjunction with Lorenz curve, cost concepts and income measures, and, stochastic frontier profit function, respectively.

Empirical model

1. **Gini Coefficient:** It is a statistical measure of dispersion developed by an Italian statistician named Corrado Gini and published in his paper "variability and Mutability" (Italian: *Variabilitae mutabilita*). The Gini index is defined as a ratio of the areas on the Lorenz curve. The formula is specified as follows:

G = A/0.5 = 2A=1-2B …….. (1)

2. **Cost concepts and Income measures**

Cost concepts and income measures are widely used because of their relevance in decision-making process. This means that these costs serve as a basis to expand the size of the farm, to buy the requisite capital assets in the long run and the requisite inputs in the short run. The researchers re-modified the cost concepts developed by Subba *et al*.,(2016) and Dr. Sen's committee report (1979), and are specified below:

a. Cost Concepts: Costs related to groundnut production are split up into various cost concepts such as A, B, C and D

Cost A_1: Total Variable costs (Explicit costs)
Cost A_2: Total Variable cost (Economic cost)
Cost A_3: Total cost (Explicit costs)
Cost A_4: Total cost (Economic cost)
Cost B_1: The following items are included in Cost B_1

Wages of hired labour

Wages of permanent labour
Market rate of fertilizer and manure
Market rate of seed
Imputed value of own seed
Imputed value of manure
Market value of pesticides and pesticides
Land revenue and other tax
Depreciation of farm implements/ equipment's
Miscellaneous expenses

Cost B_2: Cost B_1 + rent paid for leased in land
Cost C: Cost B_1 or B_2 + interest on fixed capital excluding land + rental value of owned land
Cost D: Cost C + imputed value of family labour

b. Income Measures

Farm business income = Gross income – Cost B_1/B_2
Family labour income = Gross income – Cost C
Net income = Gross income – Cost D
Farm investment income = farm business income – imputed value of family labour

3. Stochastic profit frontier model

Profit efficiency refers to profit gained from operating on the profit frontier, keeping in view farm-specific prices and factors i.e considering a farm that optimize profit subject to perfectly competitive input and output markets. Following Bidzakin *et al.*(2014); Sadiq (2015); and, Sadiq and Singh (2015) the Cobb-Douglas functional form used is specified below:

Implicit form

$\pi = f(q_i;Z)+(Vi-Ui)$……(2)
π = Normalized profit
f= Suitable Cobb-Douglass function
qi= Vector of variable input
Z= Fixed input
V_i= Error associated with uncertainty
$-U_i$= errors associated with risks

Explicit form

$Ln = \beta_0 + \beta_1 LnP_1 + \beta_2 LnP_2 + \beta_3 LnP_3 + \beta_4 LnP_4 + \beta_5 LnZ_1 + \beta_6 LnZ_2 + (Vi - Ui)$……(3)

Where;
Ln = Natural logarithm
π = Normalized profit
β_0 =Constant term or intercept
β_1-β_n= coefficients of parameters
P_1 = Cost of labour normalized by unit cost of output (₦)
P_2 = Cost of seeds normalized by unit cost of output (₦)
P_3 = Cost of fertilizer normalized by unit cost of output (₦)
P_4 = Cost of herbicides normalized by unit cost of output (₦)
Z_1 = Depreciation on capital input
Z_2 = Farm size (hectares)
V_i = represents symmetrical random error due to factors beyond the farmers' control.
$-U_i$ = Profit Inefficiency

The inefficiency model (U_i) is defined by:

$-U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \ldots + \delta_n Z_n + \vartheta$ ..... (4)

Where:
Z_1 = Age of the farmer (Years)
Z_2 = Education (Years)
Z_3 = Household size (Number)
Z_4 = Farming experience (Years)
Z_5 = Extension contact (Yes=1, Otherwise =0)
Z_6 = Co-operative membership (Yes=1, Otherwise = 0)
ϑ = truncated random variable
$\delta_0, \delta_1 \ldots. \delta_6$ are inefficiency parameters

These socio-economic variables are included in the model to indicate their possible influence on the profit efficiencies of the groundnut farmers.

Profit loss due to inefficiency was calculated as maximum profit at farm-specific prices, fixed factors multiplied by farm-specific profit inefficiency. Profit loss is defined as the amount loss due to inefficiency in production at given prices and fixed factor endowments, and calculated by multiplying maximum profit by (1-Pe). Maximum profit per hectare was computed by dividing the actual profit per hectare of individual farms by its efficiency score.

PL=maximum profit (1-PE)…….(5)

Where:
PL= profit loss
PE=profit efficiency

3.0 RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of groundnut farmers

Results in Table 1 showed a mean age of 47±9.86, indicating that majority falls within the age bracket (17-49) recommended by FAO as productive and active in agricultural production; and majority had Quranic education due to their religious affiliation which mandates them to focus and have in-depth understanding of their religious knowledge when compared with western education, thus, hindering their responsive and receptive intuition towards new technological breakthrough. The mean household size of 6±3.64 indicates that most of the farmers had a sustainable household size recommended by FAO to be fair for a typical agricultural setting in sub-Saharan Africa. A male dominated enterprise which may be associated with the drudgery *viz.* land clearing, sowing, weeding, herbicides application, harvesting, drying, thrashing etc. Findings revealed that the mean years farming experience was 15±12.6 years, which is reasonable enough to enable them garner ample knowledge and skills involved in groundnut production; and majority acquired their lands *via.* inheritance, which in the long-run will be subject to dispute due to increase in household size which inturn would put pressure on acquired land as every adult member of the family would want to have a share of the land, thereby resulting in

fragmentation, thus, discouraging cultivation of cash crops and mechanization. Furthermore, it was observed that virtually almost all were married, indicating how marital status has become an important factor in agricultural production especially when economic capital is limited; majority have extension contact, a development that would encourage technological transfer and productivity enhancement except for those who decided to remain laggards; and, social participation of farmers through their involvement in farm organisations was found to be high, thus, enhancing diffusion of innovation, access to government assistance either in kind or cash, enhancement of market bargaining power for their outputs, pecuniary economic advantages for input purchases, and likely pre-disposal to adopt innovative technologies due to confidence in peers. These findings with respect to extension contacts, education and gender were contrary to findings reported by Taphee *et al*.(2015).

Table 1: Socio-economic profiles of groundnut producers in the study area

Characteristics	Freq.	%	X ± SD
Age			
≤ 29	6	5	
30-39	18	15	
40-49	45	37.5	
50-59	38	31.7	
≥60	13	10.8	
Total	**120**	**100**	**47±9.86**
Education			
Quranic	62	51.7	
Primary	17	14.2	
Secondary	35	29.2	
Tertiary	6	5	
Total	**120**	**100**	
Household size			
≤ 3	18	15	
4-6	51	42.5	
7-9	34	28.3	
≥ 10	17	14.2	
Total	**120**	**100**	**6±3.64**
Gender			
Male	102	85	
Female	18	15	
Total	**120**	**100**	
Experience			
1-3	16	13.3	
4-6	22	18.3	
7-9	6	5	
10-12	76	63.3	
Total	**120**	**100**	**15±12.6**
Land acquisition			
Inheritance	101	84.2	
Borrowing	19	15.8	
Total	**120**	**100**	
Marital status			
Married	1	0.8	
Single	119	99.2	
Total	**120**	**100**	
Extension contact			
Yes	77	35.8	
No	43	64.2	
Total	**120**	**100**	
Co-operative membership			
Yes	70	41.7	
No	50	58.3	
Total	**120**	**100**	

Source: Field survey, 2016

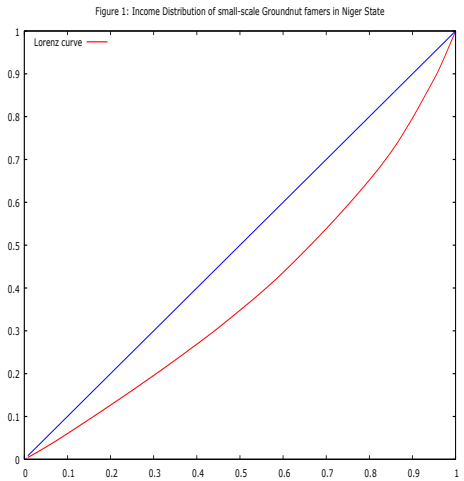
3.2 Evaluation of income distribution among groundnut producers

The perusal of Table 2 showed the estimated Gini coefficient index of 0.22, indicating equality in income distribution among groundnut producers in the study area. This was justified diagrammatically by Lorenz curve which was not farther from the line of equality (Figure 1). Therefore, it can be inferred that groundnut production in the study area was mainly dominated by farmers who belong to low income category. Also, the current producers of groundnut in the study area are fulltime farmers with poor resource base. Therefore, based on this finding study recommend that any intervention package by government or private sectors to boast commercial groundnut production should explicitly focused on this target group rather than the political or temporarily farmers.

Table 2: Income distribution of groundnut producers in the study area

Index	Estimate
Gini coefficient	0.219
Population value index	0.220

Source: Field survey, 2016



3.3 Costs and returns for groundnut production

Results in Table 3 showed that the estimated cost of cultivation incurred was ₦27518.43, with total variable cost being ₦15465.93and total fixed cost ₦12052.43. However, the total variable cost contributed 56.20% while fixed cost contributed 43.80% to the total cost incurred in groundnut production per hectare. On the basis of cost component analysis, labour costs which includes family labour calculated at opportunity cost principle and hired labour recorded the highest cost incurred (26.88%) followed by manure (17.3%), while fertilizer (0.18%) recorded least costs incurred per hectare. This means that labour is an important variable cost item that determines groundnut productivity and profitability in the studied area. Furthermore, the estimated accrue total revenue to groundnut production per hectare was ₦57989.10, while the gross margin (cash), gross margin, net cash income and net income were ₦49071.57, ₦42523.17, ₦30479.07 and ₦30471.67, respectively. Also, the ROI (accounting) was 5.50, implying that for every ₦1 invested, ₦5.50 was return, while ROI (economic) was 2.75, indicating that for every ₦1 invested, ₦2.75kobo was return. The RORCI which is the ratio of profit to total cost of production indicates what a business earns through capital outlay. The results revealed that the RORCI (accounting profit) (111%) and RORCI (economic profit)(241%) were greater than the prevailing banking rate of 8%, thus, implying that groundnut farming in the study area is a profitable venture. Therefore based on this cost concepts and income measures, it is worthwhile to invest in groundnut production in the study considering the profit margin and cost of cultivation which ascertained that the venture is reasonably profitable.

Table 3: Costs and returns estimates of groundnut production per hectare

Items	Quantity	Unit price (₦)	Cost (₦)	%
Input cost				
Variable cost				
Family labour	7.78 manday	750	5835	21.2
Hired labour	2.15 manday	750	1612.50	5.86
Seed	4.55 kg	318.75	1450.31	5.27
Fertilizer	0.87 kg	56	48.72	0.18
Manure	953.40 kg	5	4767	17.32
Herbicides	1 litre	1039	1039.00	3.78
Imputed interest on working capital	(8% of ₦8917.53)		713.40	2.59
TVC			15465.93	56.20
Fixed cost				
Rent			5000	18.2
Imputed rental value			5000	18.2
Depreciation			2052.50	7.5
TFC			12052.50	43.80
Total cost			27518.43	100
Cost concepts				
Cost A1			8917.53	
Cost A2			15465.93	
Cost A3			15970.03	
Cost A4			27518.43	
Cost B1			4964.65	
Cost B2			16683.43	
Cost C			21683.43	
Cost D			27518.43	
Return				
G/N pod				
Qty gifted	20.86 kg	78	1627.08	
Qty consumed	19.14 kg	78	1492.92	
Qty sold	638.45 kg	78	49799.10	
Total	678.45 kg	78	52919.10	
Bale				
Qty gifted	0.18 bag	1000	180	
Qty consumed	0.24 bag	1000	240	
Qty sold	4.65 bags	1000	4650	
Total	5.07 bags	1000	5070	
Total revenue			57989.10	
Farm business income			41305.67	
Family labour income			36305.67	
Gross margin (cash)			49071.57	
Gross margin			42523.17	
Net cash income			38479.07	
Net income			30471.67	
ROI (accounting)			5.50	
ROI (economic)			2.75	
RORCI (accounting)			2.41	
RORCI(economic)			1.11	

Source: Field survey, 2016

3.4.1 Maximum Likelihood Estimation of profit frontier

The results of the maximum likelihood estimates of the parameters of stochastic frontier profit function are given in Table 4a. The predict variable was restricted profit from an output of one season. All the estimated coefficients carried the expected signs and were significant at 1 percent probability level with the exception of labour cost which was non-significant, indicating that these variables were significantly different from zero, thus, important in profit gained in groundnut production. The non-significance of labour cost may be due to the free and excess family labour which renders labour cost low. The elasticities of all the significant cost variables were negative, meaning that an increase in the cost of seeds, cost of fertilizer, cost of herbicides and depreciation would decreases the profit gained. Also, for farm size which is the only non-monetary term included in the model positively influenced profit gained. In otherwords, a ₦1 increase in cost of seeds will decrease profit by 66kobo; a ₦1 increase in the cost of fertilizer will decrease profit by 36kobo; a ₦1increase in the cost of herbicide will decrease profit by 51kobo; ₦1 increase in depreciation per annum will decrease profit by 17kobo; a ₦1 increase in the cost of labour will decrease profit by 13kobo though non-significant, while 1 hectare increase will increase the profit by 33.1 percent. For diagnostic statistics, the estimated sigma squared (σ^2) was 3.157 and was significant at 1 percent probability level, implying correctness and fitness of the distribution assumption of the composite error term, while the gamma (γ) was 0.99 and was significant at 1 percent probability level, indicating that 99.2% of deviation of the actual profit from the maximum profit (frontier) is attributed to differences in farmers' practices rather than error.

Furthermore, the results of the estimated coefficient of predictor variables included in the inefficiency model showed four out of the six variables included in the model to be significant at different probability levels. The significant variables are age, education, household size and extension services, while the non-significant variables are farming experience and co-operative membership. The coefficient of age and extension services carried negative sign and are significant at 10% and 1%, respectively, implying direct relationships with profit efficiency. This means that the more the age of the farmer the more profit efficient he become; and farmers with access to extension services are more profit efficient when compared to their counterparts who have no access to extension contact because they will significantly perform better in operating at optimum efficient level. This is expected because as the farmer's age increase coupled with increase level of experience; his or her productivity will increase given that they tend to be more efficient in production. Also, this conforms to the assumption that extension services enhance good living condition of farmers; strength farmers' capacity to develop *viz.* access to agricultural information and contribute improvement in agricultural development. Furthermore, the coefficients of education and household size carried positive signs and are significant at 1% and 5% respectively, indicating an inverse relation with profit efficiency i.e reduction in profit efficiency. The higher the educational level of the farmer the more likelihood he or her will venture into white collar jobs or off farm activities thereby affecting his profit efficiency, and farmers with large house hold size are likely to incur more expenditures on house hold consumption thereby affecting profit gained from groundnut production. This agreed with the findings of Simonyan *et al*., (2011) who opined that large household size will leads to 0.36 and 0.55 decrease in efficiency of both credit and non-credit users respectively. However the coefficient of farming experience and cooperative membership carried negative and positive signs, respectively, but were non-significant; as such need no further discussion. The diagnostic test for the inefficiency model using the generalized likelihood ratio showed that the chi-square (χ^2) calculated is greater than chi-square (χ^2) tabulated, indicating the fitness of the specified inefficiency model, and that the estimated coefficients which explained profit efficiency are different from zero, hence, the traditional response function (OLS) is not an appropriate representation of the data (Table 4b).

Results in Table 4c explained the profit loss in key variables due to profit inefficiency. Interestingly, findings reported in Table 4a are uniform to the results presented in Table 4c which showed that aged farmers recorded less profit loss compared to their counterpart; farmers with extension contact recorded less profit loss when compared to their counterparts with no access; while educated farmers and farmers with large household size recorded high profit loss.

Table 4a: Maximum likelihood estimates of stochastic profit frontier function

Variable	Parameter	Coefficient	t-ratio
General model			
Intercept	β_0	4.035	5.214***
Cost of labour (₦)	β_1	-0.133	1.166^{NS}
Cost of seed (₦)	β_2	-0.663	5.227***
Cost of fertilizer	β_3	-0.363	2.626***

Variable	Parameter	Coefficient	t-ratio
(₦)			
Cost of herbicides (₦)	β_4	-0.514	2.838***
Depreciation (₦)	β_5	-0.166	2.917***
Farm size	β_6	0.3908	5.267***
Inefficiency model			
Intercept	δ_0	-7.643	2.285**
Age	δ_1	-0.068	1.662*
Education	δ_2	0.5030	2.661***
Household size	δ_3	0.2922	2.517**
Farming experience	δ_4	-0.0338	1.493^{NS}
Extension contact	δ_5	-6.301	2.632***
Co-operative membership	δ_6	0.4405	1.108^{NS}
Diagnostic statistics			
Sigma squared	σ^2	3.157	2.530***
Gamma	γ	0.992	276.558***
Log likelihood function		-41.57	

Source: Frontier 4.1 computer print-out

Table 4b: Generalized likelihood test of hypothesis of parameters in inefficiency model

H_0	χ^2-cal	χ^2-tab	Decision
H_0: γ =0	81.89		Reject H_0

Source: Frontier 4.1 computer print-out

Table 4c: Key factors explaining profit inefficiency and profit loss per hectare

Characteristics	Freq.	Profit efficiency score	Actual profit	Profit loss
Age				
≤ 29	6	0.47	6694.00	3547.82
30-39	18	0.72	10314.00	1547.10
40-49	45	0.89	13057.33	1436.31
50-59	38	0.91	13384.00	1204.61
≥60	13	0.42	7492.00	4345.36
Education				
Quranic	62	0.86	12150.67	1701.09
Primary	17	0.79	10106.67	2122.40
Secondary	35	0.71	9201.00	2668.29
Tertiary	6	0.65	8664.00	3032.40
Household size				
≤ 3	18	0.84	13888.00	2222.08
4-6	51	0.79	12660.00	2658.60
7-9	34	0.57	12564.00	5402.52
≥ 10	17	0.49	10990.00	5604.90
Extension contact				
Yes	77	0.92	14056.00	1124.48
No	43	0.57	8879.33	3818.11

Source: Frontier 4.1 computer print-out

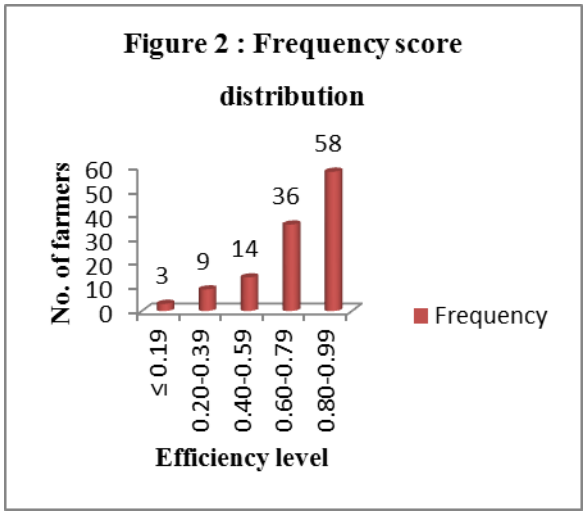
3.5 Profit efficiency score estimates

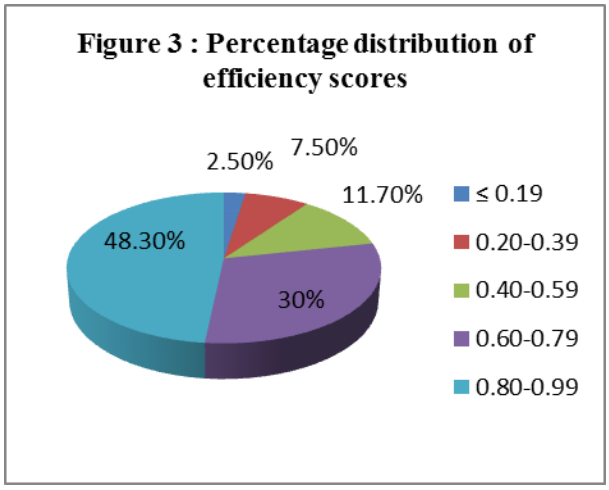
Results in the Table 5 show frequency distribution of efficiency scores of groundnut farmers in Niger State of Nigeria. The efficiency scores distribution of all the respondents are less than one (less than 100%), indicating that all the sampled groundnut farmers in the study area are below the profit frontier surface. Estimated mean profit efficiency of the farmers was 0.726, meaning that farmer who achieved an average profit efficiency score could increase profit gain by 27.4%. But this is achievable if the farmer's improved their technical, allocative and scale efficiencies. In otherwords, with given level of available resources the average farmer with efficiency score of 0.726 has the potential to increase his profit gain by 27.4%; the worst profit inefficient famer has the potential to increase his profit gain by 85.1%; and, the best profit inefficient farmer has the potential to increase his profit gain by 5.4%. Observed profit efficiency scores range was wide as evidenced from 0.149 to 0.946, however, this wide range is not only peculiar to Nigeria as similar research by Chikobola (2016) reported a wide range profit efficiency scores of 0.0950-0.9238 for groundnut production in Zambia. Also, based on the average efficiency score, approximately 64.17% were more than 72.6% profit efficient. In summary based on the mean profit efficiency score, it can be inferred that groundnut farmers in Niger state of Nigeria are relatively profit efficient, but it is clear that opportunities still exist to increase their efficiency viz. improvement in their technical, allocative and scale efficiencies. Also, there is room for improvement for the least profit efficient farmers to attain maximum efficiency if inefficiency determinants are minimized. The results are depicted in Figure 2 and 3.

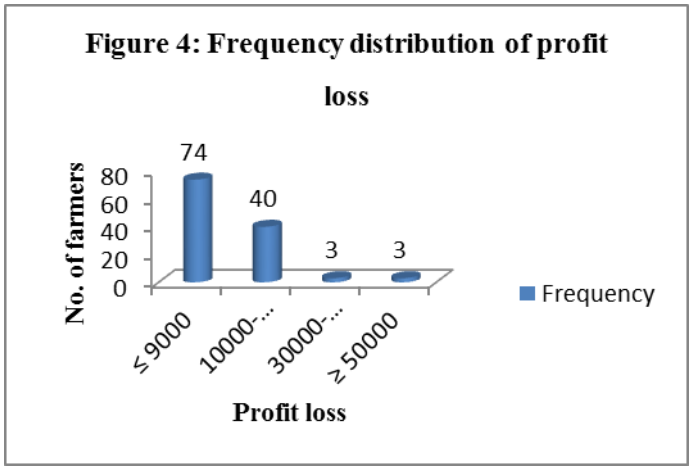
Table 5: Deciles frequency distribution of profit efficiencies of groundnut farmers

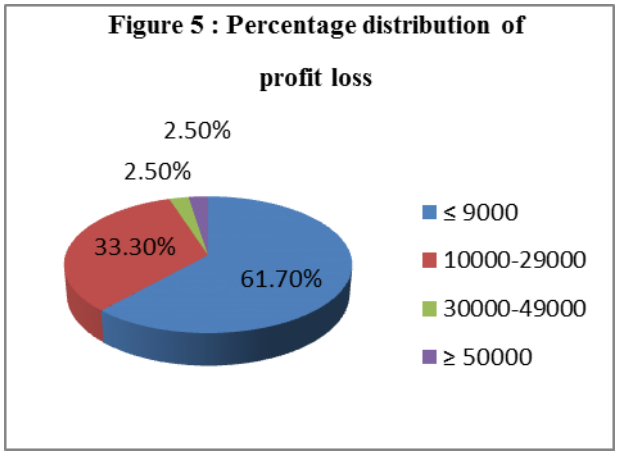
Efficiency level	Frequency	Percentage
≤ 0.19	3	2.5
0.20-0.39	9	7.5
0.40-0.59	14	11.7
0.60-0.79	36	30
0.80-0.99	58	48.3
Total	**120**	**100**
Mean	**0.726**	
Mode	**0.895**	
Maximum	**0.946**	
Minimum	**0.149**	
Standard deviation	**0.197**	

Source: Frontier 4.1 computer print-out









3.6 Profit loss in groundnut production

Table 6 showed the frequency distribution of translated profit loss as a result of inefficiency. Rahman (2003) as cited by Galawat and Yabe (2010) defined profit loss as the amount of loss due to inefficiency in production at given prices and fixed factor endowment. Findings showed the average profit loss among the farmers to be ₦12019.84k and could be minimized by improving technical, allocative and scale efficiencies. The large standard deviation (₦16278.11k) implies that there exist wide variations in profit loss among the producers. However, findings revealed wide range of profit loss, with largest farm-specific profit loss been ₦100944.48k and the least profit loss been ₦676.02k, thus, indicating the existence of opportunities to increase profit levels of the producers in the study area, at their given available technology, prices and level of fixed factors. Furthermore, findings revealed that 61% of the producers recorded profit loss of less or equal to ₦9999, an indication that the farmers tried to minimize their profit loss; approximately 33.3% recorded profit loss of between ₦10000 to ₦29999 while 5% recorded profit loss of equal or greater than ₦30000. Figure 4 and 5 shows the results diagrammatically.

Table 6: Frequency distribution of profit loss

Loss	Frequency	Percentage
≤ 9000	74	61.7
10000-29000	40	33.3
30000-49000	3	2.5
≥ 50000	3	2.5
Total	**120**	**100**
Mean	**12019.84**	
Maximum	**100944.48**	
Minimum	**676.02**	
Standard deviation	**16278.11**	

Source: Frontier 4.1 computer print-out

3.7 Perceived constraints in groundnut production

The major constraints faced by the sampled farmers on various fronts such as high-input costs, price fluctuation, inadequate extension contact, credit paucity, incidence of pests and diseases etc are presented in Table 7. These problems were ranked in ascending order from the most severe problem to the less severe problem. Among the identified constraints, high-input costs, price fluctuation and inadequate extension contact were the major

prioritized problems, while flood-drought problems and land tenureship problems were the less severe problems affecting groundnut producers in the study area. Based on these findings, study suggests measures to lessen these perceived constraints viz. necessary policy instruments so as to increase the production and productivity of groundnut in the state.

Table 7: Perceived constraints faced by groundnut producers

Constraint	Frequency	Percentage	Rank
High input cost	107	21.32	1
Price fluctuation	106	21.12	2
Inadequate extension services	104	20.72	3
Paucity of credit	74	14.74	4
Pest and diseases	66	13.15	5
Weather vagaries	26	5.18	6
Land tenure ship problem	19	3.79	7
Total	**502**	**100**	

Source: Field survey, 2016
Note: *Multiple choices

CONCLUSION

Stochastic profit frontier approach was used to investigate profit efficiency on small scale groundnut farms in Niger State of Nigeria using cross sectional data elicited from 120 active farmers' selected *viz.* multi-stage sampling technique. The study showed that despite an active working population made up young able bodied people most of them have no formal knowledge which would invariable affect their productivity thus narrowing their profit margin. Also, it was found that this product is mainly produced by low income earners with poor resource base, which invariably would jeopardize government effort towards revamping this export sector if mechanisms to look inward are not developed and put into action by policy makers. Furthermore, despite that the groundnut farmers in the study area are relatively profit efficient judging from the mean efficiency score, clear opportunities still exit for them to increase their profit efficiencies by approximately 27.4% viz. improving their technical, allocative and scale efficiencies. Also, the average profit loss among groundnut farmers in study area was ₦12019.84k per hectare which could be minimized by improving technical, allocative and scale efficiencies. The policy implication is that encouraging efficient resource allocation, enhancing farmer's literacy, sustainable house hold size and making farm business attractive for educated ones who mostly ought for white collar jobs would not only reduce inefficiency, but also minimize profit loss incurred by groundnut producers in the study area. Based on these findings the following recommendations are made:

- Government should invest more in the agricultural sector to ensure off season production through irrigation practices to tackle the seasonal price fluctuation of produce that serve as precursor/raw materials to milling industries.
- Policies made by government to enhance groundnut production should be implemented by all the agencies concerned in groundnut production in order to improve productivity.
- The groundnut farmers should be willing and ready to take risk by adopting new innovative technologies that can increase their production efficiency.
- The farmers should be advised to form or join an existing cooperative societies in order to harness their resources to improve their finances for a better production

REFERENCE

Ani, D.P., Umeh, J.C. and Weye, E.A.(2013).Profitability and economic efficiency of groundnut production in Benue State, Nigeria. *Greener Journal of Agricultural Science*, Vol.3 (2):128-136.

Bidzakin, J.K., Fialor, S.C. and Asuming-Brempong, D.(2014).Small scale maize production in Northern Ghana: Stochastic Profit Frontier Analysis. Journal of Agricultural and Biological Science, Vol. 9(2): 76-81

Chokobola, M.M.(2016). Profit efficiency of groundnut production: Evidence from Eastern Province of Zambia. *Journal of Economics and Sustainable Development*, Vol.7(8): 147-153.

Federal Ministry of Agriculture and Rural Development(FMARD)(2011).Agricultura lTransformation Agenda: We will grow Nigeria's Agricultural Sector *(Draft Discussion)*, Pp. 7-9

Girei, A. A., Dauna, Y. and Dire, B.(201).Economic analysis of groundnut (*Arachis hypogea*) production in Hong Local Government Area of Adamawa State, Nigeria. *Journal of Agricultural and Crop Research*, Vol. 1(6): 84-89.

Sadiq, M.S. and Singh, I.P.(2015).Application of stochastic frontier function in measuring profit efficiency of small-scale maize farmers in Niger State, Nigeria. *Journal of Agricultural Economics, Extension and Rural Development*, Vol. 3(1):229-239.

Sadiq, M.S.(2015).Profit efficiency of *Egusi* melon (*Colocynthis citrullus* Var. *Lanatus*) production in Bida Local Government Area of Niger State, Nigeria. *Indian*

Journal of Economics and Development, Vol. 11(2): 543-552

Simonyan, J.B., Umoren, B.D. and Okoye, B.C.(2011).Gender differentials in technical efficiency among maize farmers in Essien Udim Local Government Area, Nigeria. *International Journal of Economics and Management Science*, Vol. 1(2):17-23

Subba, R.S., Raghu, R.P., Neelakanta, S. T. A. and Bhavani, D.I.(2016).*Agricultural Economics .Second Edition*. Oxford and IBH publishing company PVT. Limited, New Delhi, India.

Taphee, B.G., Agbo, F.U. and Okorji, E.C.(2015).Resource productivity and technical efficiency of small scale groundnut farmers in Taraba State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, Vol. 5(17):25-35

INFLUENCE OF STORAGE LENGTH AND DILUENT COMPOSITION ON THE POTENTIAL VIABILITY OF CHILLED TURKEY SEMEN

*Alemede, I.C., Mohammed, B.A., Ijaiya, A.T., Banjo, A.A. and Ibrahim, M.J
*Department of Animal Production, Federal University of Technology, P.M.B. 65, Minna
e-mail:tee_baby2k6@yahoo.com

ABSTRACT

The complete dependence in commercial turkey production, on the use of artificial insemination led to the quest for an ideal diluent that can preserve turkey semen for a long period of time. This study compares the performance of four different diluents in preserving turkey semen for a period of 72 hours at 5°C. Ten (10) turkey stags averaging 15 kg body weight, 48 weeks of age, provided water ad libitum and breeders ration of 10 % CP with 2800 kcal/kg metabolizable energy and housed in individual pens were used for the study. Semen which was collected weekly, pooled, dispensed into four different diluents, labelled A, B, C and D, with spermatozoa concentration of 2 x 10^9 m/ml was subjected to semen viability analysis at 0 hour, 24 hours, 48 hours and 72 hours, respectively. In each instance viability was determined through the determination of spermatozoa Forward progressive movement (FPM), occurrence of morphological defects and dead cells. Data was generated over a period of 12 weeks. Forward progressive movement in all the diluents decreased significantly (P≥ 0.05) from 0 hours to 72 hours while the occurrence of morphological defects and dead cells increased significantly (P ≥ 0.05) throughout the storage period. The best performance was observed in diluent D with a percentage Forward progressive movement of 65 %, percentage Abnormal Spermatozoa (AS) of 4 % and percentage Dead Spermatozoa (DS) of 12 % at the end of the storage period. The least performance was that of the diluent C with percentage forward progressive movement of 55 %. Percentage abnormal spermatozoa of 5 % and percentage dead spermatozoa of 20 %. For optimum viability, it is recommended that semen diluted in all the diluents be utilized within 24 hours.

Key words: Storage, Diluent, Semen, Turkey

INTRODUCTION

The need to improve the current production of animal based protein is becoming imperative as communal clashes between the traditional suppliers of beef (the Fulani herdsmen) and arable farmers intensifies in Nigeria (Weekly Trust, 2014a). The implications are not farfetched, cattle production is becoming impossible in areas where it existed before, while areas that are favourable are either not accessible to the outside markets or products cannot be moved since cattle routes are being blocked. This situation restricts supplies to the southern markets. Another critical factor militating against cattle production and distribution within Northern Nigeria is terrorism (a deliberate act of violence against civilians aimed at gaining political, social, military or religious objectives and creating a climate of fear among the targeted geographical region). As lives and cattle are being wasted, production is on the decrease and alongside these current realities, human population is on the increase consequently, an era where livestock production will be restricted almost entirely to poultry, pigs, rabbits, small ruminants and any other livestock but not cattle is being approached. Worthy of note is the additional problem of cattle rustling involving the brutal extermination of lives which also limits production in cattle producing areas of the north and north central (Weekly Trust, 2014b). As we face these realities and the search for a solution continues, animal producers must look inwards to existing livestock. This study considers turkey production as being among these viable options.

The demand for turkey meat is enormous, it is used for festive occasions; especially the ‘‘Christian thanksgiving’’ and government policy on importation further ensures a market without international competition (NCS, 2013). In order to fully utilize these opportunities, local producers will have to increase production, which may come in two forms; Increase the current production of the local turkey, which has a slow growth rate and an eventual low matured weight or introduce the foreign heavy breasted breed that is fast growing and has a high mature weight.

The second option proffers a faster solution that is achievable within a short period. This option comes with its own problems, the challenge of the necessary use of Artificial Insemination (AI) to aid reproduction. The heavy breasted turkey stag is incapable of mating (mounting) because of its heavy weight (Donoghue and Wishart, 2000). The major problem of artificial insemination in turkey production is the fact that turkey semen do not store for long period of time (Donoghue and Wishart, 2000; Long and Bakst, 2008) and cryopreservation techniques have not provided acceptable levels of semen performance, neither do short time liquid storage lasting for more than 24 hours (Slaning *et al*, 2012).

According to Donoghue and Wishart (2000), this may be as a result of the morphology of the avian spermatozoa where the head is cylindrical and not much wider than the tail in diameter (approximately 0.5µm) hence less cytoplasmic volume resulting in lesser ability to move cryoprotectants into the sperm head, compared to bull, ram or boar spermatozoa. Furthermore, the avian sperm tail is quite long, about eight times the length of the head (90 -100µm). Semen diluents generally use for semen preservation and increasing of semen volume are of different types, and do exert their influences on semen quality (Kotlowska *et al.,* 2007). They vary from those that the farmer can easily constitute, those readily available in the country in commercial quantities, to those that require importation.

Hocking (2009) asserts that the core or fundamental principle used in the preservation of chicken or turkey semen is the use of diluents that are produced based on the ionic environment of the male reproductive tract. This may not be that favourable to spermatozoa as its journey to initiate fertilization is carried out in the female reproductive tract. Thus, mimicking the environment for storage of spermatozoa within the hen would profoundly alter current systems for storing semen for extended periods of time in-vitro as observed by Donoghue and Wishart (2000).

Although most extenders provide the necessary requirements for both energy metabolism and buffering capacity (Hocking, 2009), the type of diluent used in storing semen will most certainly affect its keeping quality. Hence, to ease the farmers plight will be to detect the most suitable diluent that can maintain the semen quality for some time (approximately 72 hours). This will reduce the frequency of handling stags for semen collection and make it possible to use the semen far from the collection site.

Intense labour due to frequent handling of stags for semen collection, limitation of the use of semen far from collection sites and inability to utilize semen outside the optimum reproductive period of the male, are the consequences of the incapability of turkey semen to store for long period of time. However, the need to introduce a fast growing and heavy weight turkey and the quest for a suitable diluent, among the readily available ones, in order to narrow the gap between supply and demand of animal protein will reduce intense labour associated with frequent handling of stags for semen collection and enhance maximum utilization of the reproductive age of the stag. Therefore, this study is designed to identify the most suitable diluent among four different diluents, capable of sustaining optimum turkey semen quality within a storage period of 72 hours at 5^0C.

MATERIALS AND METHOD

The research was carried out in the Livestock Investigation Division of the National Veterinary Research Institute, Vom, Plateau State. Vom, Plateau State is located in North Central Nigeria and lies between latitude 9°44'N and 9°74'E and longitude 8°49'N and 8°80'E with an altitude of 1,222 meters above sea level. It has a temperature range of between 18 and 22°C with mean annual rainfall ranging from 135cm to 146cm (http://www.distanceto.com/coordinates/ng/vom-latitude-longitude/history/46294.html).

Ten (10) Turkey stags aged 48 weeks with mean body weight of 15 kg were used for this study. They were provided with breeders diet of 10 % CP and 2800 Kcal/kg metabolizable energy, All necessary medications were administered throughout the period of study and water was given *ad libitum*.

Semen was collected using the abdominal massage method as described by Donoghue and Wishart (2000) and Yahaya *et al*. (2013). On collection, the semen was pooled and dispensed into four different containers containing four different diluents marked A, B, C and D. Concentration of spermatozoa in each diluent was adjusted to 2×10^9 m/ml (Dumpala *et al*, 2006). Diluent composition are shown in Tables 1 to 4 below. The resulting dilutions maintained at 5°C were subjected to semen analysis at the following intervals; 0 hour, 24 hours, 48 hours and 72 hours. This weekly procedure was repeated over a period of 12 weeks, and in each instance spermatozoa characteristics studied were progressive motility, percentage live spermatozoa and percentage abnormal spermatozoa (Dumpala *et al.,* 2006 and NVRI, 2012).

Spermatozoa concentration was determined using the haemocytometer while live and abnormal cells were determined using a mixture of stains as described by Yahaya *et al*. (2013)

RESULTS AND DISCUSSION

The results are presented and discussed in two parts. The first part highlights the reaction of semen in each of the diluents (A, B, C and D), while the second part compares these reactions. Thus Tables 5 to 8 depicts the first part and Tables 9 to 11, the second part. In each instance semen quality assessments were based on forward progressive movement of spermatozoa, occurrence of morphological defects of sperm cells and their death as storage time increases from 0 hours to 72 hours at a constant temperature of 5°C.

Table 1: Composition of Diluent A

Composition	%
NaHPO4.12H2O	8.54
Tris (hydroxymethyl) aminomethane	50.90
Fructose	17.76
Citrate	1.35
NaOH	19.93
Mg acetate	1.33

Table 2: Composition of Diluent B

Composition	%
Glucose	18.24
Na glutamate	30.29
K citrate	1.59
NaHPO4	25.23
Na2H2PO4	6.39
Inositol	18.27

Table 3: Composition of Diluent C

Composition	%
Fructose	14.47
Citrate	1.10
Na acetate	24.19
Na glutamate	24.19
$Mgcl2.6H_2O$	0.94
$K_2HPO_4.3H_2O$	32.39
KH_2PO_4	2.72

Table 4: Composition of Diluent D

Composition	%
Na glutamate	13.18
Glucose	16.84
K- citrate	1.96
BES	40.70
Na acetate	5.72
Mg acetate.$4H_2O$	1.52
NaOH	17.00
Na_2PO_4	3.00
Streptomycin	0.08

BES- N,N-bis(2-hydroxyethyl)-2 amino ethane acid

Forward progressive movement in all the diluents (A, B, C and D), as shown in Tables 5, 6, 7 and 8 respectively, does not only decreased steadily but significantly ($P<0.05$). These significant decreases are a portrayal of the sperm cell lost of fertilizing ability as storage length increases. Thus with regards to forward progressive movement, it will be best to utilize the semen at 0 hour, followed by 24 hours, 48 hours and finally 72 hours with the exception of diluent D which showed no difference between 0 hours and 24 hours. The decrease in forward progressive movement with storage length which can be attributed to energy depletion among other factors coincides with the findings of Donoghue and Wishart (2000), Iaffaldano *et al.* (2005) and Dumpala *et al.* (2006).

Morphological defects in all the diluents as shown in Tables 5 to 8, increased significantly ($P<0.05$) with increases in storage lenght. Diluents A and D bear no differences with both their initial values on dilution (0 hour) and after 24 hours. The same applies to diluent B but diluent C on the other hand, had a significant ($P<0.05$) increases in the percentage of abnormal spermatozoa from 0 hour to 24 hours. At the end of the storage period, significant ($P<0.05$) differences exist between 0 hour and 72 hours in all diluents. The implications, with regards to percentages abnormal spermatozoa, is that, optimum semen quality is best achieved when the semen is utilized within 24 hours for diluents A,B and D while for diluent C the period lies between 0 hour and 24 hours. Increases in morphological defects during dilution and/or storage attributed to fluctuations in osmotic pressure have been reported by Donoghue and Wishart (2000) and Iattaldano *et al.*(2005).

Spermatozoa mortality increases significantly ($P<0.05$) with increase in storage length in all the diluents (Table 5 to 8). Diluents C and D maintained constant values between 0 hour and 24 hours which are 6 % and 9 %, respectively. Diluents A and B show a significant increase from 0 hour to 24 hours of 6 % to 9 % and 8 % to 11 % respectively. Thus, once more, optimum fertilizing ability of semen with regards to percentage dead spermatozoa is best achieved within 24 hours for diluents C and D and before 24 hours for diluents A and B. similar findings indicating increase in spermatozoa death during liquid storage as storage lenght increase have been reported by Donogue and Wishart (2000) and Dumpala *et al.*(2006).

Before proceeding to the second part of this discussion where the performance of the diluents are compared with the view of identifying the most suitable for maintaining semen viability within the storage period of 72 hours at 5^oC, it is pertinent to note that all the diluents maintain potential semen quality necessary for achieving acceptable level of fertilization. They have maintained forward progressive movement of spermatozoa at/and above 50 %, abnormal spermatozoa less than 20 % and dead spermatozoa not greater than 20 %.These according to Sarah (2002), Malecki and Martin (2002), Zahraddeen *et al.* (2005) and Yahaya *et al.* (2013), are all it takes for acceptable level of fertility.

The highest value for spermatozoa forward progressive movement after the storage period of 72 hours at 5^0C, was achieved in diluent D (65 %-Table 9), followed by diluent B (60 %), then

diluent C (55 %) and finally diluent A (50 %). The least value of abnormal spermatozoa within the study period, occurred in diluents D and B (4 % each) followed by diluents A and C (5 % each- Table 10). The least value of dead spermatozoa occurred in diluent B (11 %- Table 11) followed by diluents A and D (12 %) and finally diluent C (20 %).

In adherence to the criteria outlined earlier of acceptable levels of potential semen quality which are forward progressive movement being 50 % and above; Abnormal spermatozoa not more than 20 % and dead spermatozoa also, not more than 20 %, diluent D is ranked the highest and thus the most suitable for maintaining semen viability within the storage period of 72 hours at 5^0C; followed by diluent B, then diluent A and finally diluent C.

The precise reason(s) for the performance of diluent D above the other diluents is (are) subject for further studies but it would not be out of place to acknowledge the fact that it is the only diluent that contains an antibiotic – streptomycin. Thus microbial activities must have been inhibited (Donoghue and Wishart, 2000; Iaffaldano *et al*, 2005; Dumpala *et al*, 2006).

Table 5: Effects of Diluent A on Semen viability within the storage period of 72hours at 5°C.

	Times (hours)				
	0	24	48	72	SEM
Semen Characteristics (%)					
Forward Progressive Movement	80^a	75^b	60^c	50^d	0.633
Abnormal Spermatozoa	1^c	1^c	2^b	5^a	0.548
Dead Spermatozoa	6^c	9^c	10^b	12^a	0.145

^{a,b,c,d}: Means with different superscripts are significant at 0.05 level

Table 6: Effects of Diluent B on semen viability within the storage period of 72 hours at 5°C

	Times (hours)				
	0	24	48	72	SEM
Semen Characteristics (%)					
FPM	85^a	80^b	70^c	60^d	0.742
AS	2^b	2^b	3^b	4^a	0.500
DS	8^b	11^a	11^a	11^a	0.387

^{a,b,c,d}: Means with different superscripts are significant at 0.05 level

Table 7: Effects of Diluent C on Semen viability within the storage period of 72hours at 5^oC

	Times (hours)				
	0	24	48	72	SEM
Semen Characteristics (%)					
FPM	85^a	75^b	60^c	55^d	0.837
AS	2^c	3^b	5^a	5^a	0.447
DS	10^c	10^c	16^b	20^a	0.592

^{a,b,c,d}: Means with different superscripts are significant at 0.05 level

Table 8 Effects of Diluent D on semen viability within the storage period of 72hours at 5^oC

	Times (hours)				
	0	24	48	72	SEM
Semen Characteristics (%)					
FPM	80^a	80^a	70^b	65^c	0.592
AS	1^b	1^b	4^a	4^a	0.227
DS	6^c	6^c	11^b	12^a	0.447

^{a,b,c}: Means with different superscripts are significant at 0.05 level

Table 9: Comparison of forward progressive movement of spermatozoa(%) as affected by diluents A, B, C and D

	Forward Progressive Movement (%)			
	Times (hours)			
	0	24	48	72
Diluents				
A	80^b	75^b	60^b	50^a
B	85^a	80^a	70^a	60^b
C	85^a	75^b	60^b	55^c
D	80^b	80^a	70^a	65^a
SEM	0.671	0.633	0.806	0.707

^{a,b,c}: Means with different superscripts are significant at 0.05 level

Table 10: Comparison of Abnormal Spermatozoa as generated by diluents A, B, C and D

	Abnormal spermatozoa (%)			
	Times (hours)			
	0	24	48	72
Diluents				
A	1^b	1^c	2^d	5^a
B	2^a	2^b	3^c	4^b
C	2^a	3^a	5^a	5^a
D	1^b	1^c	4^b	4^b
SEM	0.025	0.450	0.387	0.317

^{a,b,c,d}: Means with different superscripts are significant at 0.05 level

Table 11: Comparison of the occurrence of dead spermatozoa occasioned by diluents A, B, C and D

	Dead spermatozoa (%)			
	Times (hours)			
	0	24	48	72
Diluents				
A	6^{a}	9^{b}	10^{c}	12^{d}
B	8^{a}	11^{b}	11^{b}	11^{b}
C	10^{a}	10^{a}	16^{b}	20^{c}
D	6^{a}	6^{a}	10^{b}	12^{c}
SEM	0.592	0.387	0.500	0.387

a,b,c,d: Means with different superscripts are significant at 0.05 level

CONCLUSION AND RECOMMENDATION

The study has shown the possibility of holding turkey semen for up to 72 hours at 5°C. This possibility may open frontiers for marketing turkey semen nationwide and providing the opportunity for the optimum utilization of scarce technical expertise in the field of poultry artificial insemination. It has also been shown that the potential viability of the stored semen is within acceptable limits but the study did not evaluate the actual viability of the semen which can only be determined after insemination in the hen. Thus, it is concluded, based on the findings of this study, that, as far as turkey semen potential viability is concerned, turkey semen can be stored for as long as 72 hours. However, it is recommended that semen stored in all the diluents be utilized within 24 hours if preserved at 5°C, but caution their use after 72 hours because it is only the potential viability of the semen that was studied and not the actual viability. Thus the study of the actual viability is also recommended.

REFERENCES

Donoghue, A. M. and Wishart, G.I (2000). Storage of poultry semen. *Animal Reproduction Science*. 62: 213 – 232.

Dumpala, P.R., Parker, H.M. and McCaniel, C.D (2006). The effect of semen storage temperature and diluents type on the sperm quality index of broiler breeder semen. *International Journal of Poultry Science* 5(9): 838-845

Hockings, P. M (2009). *Biology of Breeding Poultry*. Abingdon: CAB, 2009s 464p. ISBN 978 – 1 – 84593 – 375 – 3.

Iaffaldano, N., Rosato, M.P., Manchisi, A., Centoducati, G. and Meluzzi, A (2005). Comparison of different extenders on the quality characteristics of turkey semen during storage. *Italian Journal of Animal Science*, 4(2): 513-515.

Kotlowska, M., Dietrich, G., Wojtckzak, M., Karol, H. and Ciereszko, A (2007). Effects of liquid storage on amidase activity, DNA fragmentation and motility turkey spermatozoa. *Theriogenology*, **67:** 267 – 286.

Long, J. A. and Bakst, M. R. (2008). The current state of semen storage and AI technology. Biotechnology and Germplasm Laboratory Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Beltsville, MD, USA.

Malecki, I.R. and Martin, G.B(2002). Semen collection in the Emu and Ostrict. *Proceedings of the world Ostrich congress, Warsaw, Poland.* Pp 38-43 (26-29 September, 2002).

NCS (2013). Import Prohibition List. Federal Government of Nigeria, Federal Ministry ofFinance, Nigeria Custom Services (NCS). www.customs.gov.ng/.../importphp.

NVRI (2012). Manual of Poultry Diluent Preparation. Artificial Insemination Laboratory. National Veterinary Research Institute, Vom, Nigeria. Vom, latitude and longitude. http://www.distanceto.com/coordinates/ng/vom-latitude-longitude/history/46294.html

Sarah, M. (2002). Selecting toms by semen quality. *World Poultry. Elsevier* 17(3). 01-08

Slaning, T., Miskeje, M.., Knizots, L., Mirada, J. and Massanyi, P (2012). The effect of Different Concentration of Trehalose on Turkey Spermatozoa Motility in vitro. *Journal of Microbiology, Biotechnology and Food Sciences*.1 (4)**:** 573 – 582.

Weekly Trust, (2014a). Benue's Tiv / Fulani Crisis: The Inside story. http:www.weeklytrust.com.ng/index.php/top-stories/15857-benue-s-tiv-fulani-crises-the-inside-story.

Weekly Trust, (2014b). Kaura Killings How gunmen invaded Kaduna villages killed Over 100. http://www.weeklytrust.com.ng/index.php/top-stories/16055-Kaura-killings-how-gunmen-unvaded-Kaduna-villages-killed-over

Yahaya. M.S., Umaru, M.A. and Aliyu, A (2013). A preliminary study on semen collection, evaluation and insemination in Nigerian local turkeys (*Meleagris gallopavo*). *Sokoto Journal of Veterinary Sciences.* 11(2): 67-70.

Zahraddeen, D., Butswat, I. S. R., Kalla, D. J. U., Sir, S. M. and Bukar, M. T(2005). Effect of frequency of ejaculation on semen characteristic in two breeds of turkeys (*Meleagris gallopavo*) raised in a tropical environment. *International Journal of Poultry Science* (4) 217 – 221.

REPRODUCTIVE PERFORMANCE OF RABBITS FED VARYING LEVELS OF SOYA BEAN MILK RESIDUE

*Alemede, I.C., Abdulsalami, O., Ogunbajo, S.A., Banjo, A.A & Ibrahim, M.J
Dept. of Animal Production, School of Agric. and Agricultural Tech., Fed. University of Tech., Minna, Nigeria.
*e-mail – tee_baby2k6@yahoo.com

Abstract
Twenty (20) female rabbits of mixed breeds aged between 5- 6 months were used to evaluate the reproductive performance of rabbits fed Soya bean Milk Residue (SBMR). They were divided into five dietary groups; formulated with soya bean residue replacing Groundnut Cake (GNC) as a source of protein at 0 %, 8 %, 16 %, 24 %, 32 % levels respectively. The litter size, birth weight, gestation gain, gestation length, kindling loss, neo natal mortality and coefficient of milking capacity were not affected ($p>0.05$) by the dietary treatment. However, significant ($p<0.05$) differences were observed in litter size at weaning, weight gain of kittens, weight of kitten at weaning and survival rate to weaning. It was concluded that soya bean milk residue could be included in the diets of rabbit does up to 24 % without any deleterious effect on both pre-natal and post-natal performance of kittens.

Key words: Rabbits, soya bean milk residue, reproduction.

Introduction

In developing countries, the rapid growth in human population coupled with the competition between human and animals for the few available conventional feed ingredients has necessitated the search for alternative sources of protein to meet up the population challenges. Economic indices indicate that as this population trend continues, more people are to be fed and Agriculture outputs needs to be increased rather through food importation into such countries (Allen, 1993). In order to maximize food production and meet animal protein requirements, viable options need to be explored and evaluated (Owen *et al.*, 2008).These options include the rearing of animals with short gestation periods such as rabbits. The rabbit (*Oryctolagus cuniculus)* is the most productive meat producer among all domesticated animals whose feeding habits offer no appreciable competition with man simply because it can subsist on greens as basal diets. Rabbit meat is acknowledged as being cheap and of high quality protein (about 22 %) and low in fat (4 %) and cholesterol (5 %) (Jones, 1990; Handa *et al.*, 1995) and thus possesses health promoting qualities (Aduku and Olukosi,1990).

Growing rabbits can be maintained satisfactorily on diets of 100-200 g green roughage and 40-60 g of concentrate mixture for maximum production (Ranjhan,1980) and about 4 months are required to produce a 2 kg market rabbit under subsistence condition (NRC, 1990). In addition to this, rabbits have a number of other characteristics that might be advantageous to subsistence farming system such as their small body size and short generation interval with a relatively short gestation period average of 30-31 days. The daily weight gain is high in proportion to the body weight which gives them a rapid growth rate, and sexual maturity is early. These factors result in the rabbit reaching the weight of a sexually mature animal 30% faster than other animals (Ajayi *et al.*,2005) and also make rabbits suitable as meat producing small livestock in developing countries (Arijeniwa *et al.*,2000).

Rabbit grow fast like broiler chickens and can utilize feed protein more efficiently than broilers. Improving the nutrition of breeding females is of primary importance for increasing the productivity of domestic rabbit (Ren *et al.*, 2003). Supplementation with soya bean meal as a source of protein has been suggested for enhanced growth and reproductive performance of rabbit (Rahim *et al.*,1997). The nutrition of rabbit in Nigeria is primarily based on *Tridax procumbens* and or *Centrosema pubescens* whose growth and availability in the dry season cannot sustain all-year rabbit production (Odeyinka *et al.*,2007). Soya bean belongs to the family of *fabaceae* and the kingdom of *plantae.* It is a specie of legume native to Africa. It plays an important role in livestock feeding by providing a reasonable animal protein The by-product of turning soya beans into soya beans milk or tofu which is the ground up fibrous part of the beans is referred to as soya bean milk residue. The soya beans milk residue is a nutritional powerhouse containing soluble and non-soluble fibre, protein, calcium and other minerals (Yang, 2005). However, the use of soya bean milk residue in livestock feeding has not been well documented, rather, it is discarded as waste following soya bean milk extraction. This study will evaluate the reproductive performance of rabbits fed soya bean milk residue.

Materials and Methods

The study was carried out at the Rabbitry unit of the Ministry of Livestock and Fisheries, Minna, Niger State. Minna is located in the Southern

Guinea savannah vegetation belt of Nigeria between longitude $6^0$32 ' E and latitude $9^0$37 ' N, at an elevation of 258.5 m above sea level. Its mean annual rainfall is about 1312 mm, its annual temperature ranges from 19 - 37 ^{0}C. Minna is characterized by two seasons, the wet season (April – October) and the dry season from November to March (Federal University of Technology, Minna Student Handbook ,2008).

Twenty (20) female rabbits of mixed breed, obtained from Minna and its environs, and aged 5 - 6 months were used in the study which lasted for three months. Soya bean milk sievate was collected free of charge from within Minna. The sievate was air dried and ground afterwards to make it into a powdery, ready to use form to be included in the feed composition. The rabbits were randomly assigned in a complete randomized design into five dietary groups; T1, T2, T3, T4 and T5 formulated with soya bean residue replacing groundnut cake as a source of protein at 0%, 8%, 16 %, 24%, 32% level, respectively and were isonitrogenous and isocaloric. The rabbits were housed individually in metallic cages provided with feeders and drinkers. The major source of energy in the diet was maize, while rice bran served as source of fibre. Other ingredients used include bone meal, vegetable oil, salt, premix, lysine and methionine (Table 1). All routine management practices were carefully observed.

Data were collected on the following birth traits: Litter Size at Birth (LS), Litter Birth Weight (LBW), Gestation Length (GL), Gestation Gain (GG), Kindling Loss (KL), Neo- natal Mortality (NNM), Coefficient of milking capacity (M) and Weaning traits: Litter Size at Weaning (LSW), Litter Weight at Weaning (LWW), Litter Weight Gain (LWG), Weaning Sex Ratio (WSR) and Survival Rate to weaning (SRW) in the experimental rabbits. Data collected were subjected to one way analysis of variance. Duncan's multiple range tests was used to separate means using SPSS 16.0 (2006)

Table 1. Composition of the experimental diets

DIETARY TREATMENT					
Ingredients	**0 %**	**8 %**	**16 %**	**24 %**	**32 %**
Maize	42.86	37.67	31.94	30.08	28.91
GNC	28.72	22.99	17.63	11.90	6.15
Rice bran	22.17	25.09	28.18	27.77	26.69
Vegetable oil	2.00	2.00	2.00	2.00	2.00
SBMR	0.00	8.00	16.00	24.00	32.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analysis					
Protein	18.10	18.01	17.99	18.01	18.00
Metabolizable Energy (kcal/kg)	2379	2371	2316	2309	2301

GNC- groundnut cake SBMR- soyabean milk residue

Vitamins: A = 10,000IU; D_3 = 2,000IU; E = 5IU; K = 2mg; Riboflavin = 4.2mg; B_{12} = 0.01mg; Pantothenic acid = 5mg; Nicotinic acid = 20mg ; Folic acid=0.5mg. Minerals: Se = 100mg; Cu = 1.0mg; Fe = 20mg; Iodine = 0.8mg; Choline = 3mg; Mg = 56mg; Co = 1.25mg; Lysine, Methionine and Tetramycine (Broad-spectrum anti-biotics and growth promoters).

Results and Discussion

The proximate composition of the soyabean milk residue and experimental diets as presented in Tables 2 and 3 revealed that soya bean milk residue is very rich in crude protein (34.47 %) and crude fibre (26.00 %) with low level of ether extract (8.50 %). These high levels of protein and fibre are qualities that portray SBMR as an ideal feed ingredient for rabbits. The same trend was observed with the formulated feed where crude protein, crude fibre and ash content were high. The high crude protein and fibre values of SBMR means it is adequate for both growing and breeding rabbits. The high values are in agreement with Pyke *et al.* (1981) and Okoye *et al.* (2008) who reported that legumes are good sources of ash, protein and fibre. The value obtained for crude protein was high and falls within the range of 9 – 20 % and 18.56 % reported by Dairo (2008) and Esonu *et al.* (2006) who fed dried bovine rumen digesta to growing rabbits and broiler finisher respectively.

Table 4 which shows the results obtained for birth traits of rabbits fed varying level of soya bean milk residue revealed that there were no significant ($p>0.05$) differences among the mean values obtained for all the parameters measured (litter

size at birth, litter birth weight, gestation length, gestation gain, kindling loss, neonatal mortality and coefficient of milking capacity). However, Table 5 showed that the values of the average litter size at weaning (LSW), litter weaning weight (LWW), litter weaning weight gain (LWG) and survival rate to weaning (SRW) differed significantly ($P<0.05$), revealing better performance with rabbits fed the test diets. SRW and LSW improved with addition of SBMR while LWW and LWG were significantly ($P<0.05$) better in rabbits fed the diets with 8 % and 16 % SBR level of inclusion. 'The better survival rate to weaning observed in rabbits on the 16% SBMR diet may be attributed to the lower number of kittens in that treatment which paved way and easy access to does nipples without much competition among the kittens thereby enhancing their chances of surviving. Similarly, increase in the average litter size at weaning with increasing level of SBMR in the diet may be attributed to the high level of crude protein and crude fibre in SBMR. According to Aganga *et al.*(1998), crude protein plays an important role in ovulation rates, fertility, development as well as litter size and has an important role in cell growth and transportation of substances in the body.Peteducation.com (2011) reported that because of the unique nature of the digestive system of rabbit, they require diets that are high in fibre while Ngu (2001) noted that high dry matter intake can be improved by supplementary feed with high fibre content.This in turn could facilitate the performance of rabbits

Table 2.Proximate composition of soya bean milk residue (%)

Composition	Soya bean milk residue (%)
Dry Matter	94.1
Moisture	5.9
Crude Protein	34.47
Crude Fibre	26
Ether Extract	8.5
Ash	6.5
Nitrogen Free Extract	18.63
Metabolizable Energy (Kcal/Kg)	2998.9

Conclusion and Recommendation

Based on the results of this study, it is concluded that replacing of groundnut cake with soya bean milk residue as a source of protein has no harmful effect on the birth traits of rabbits, Also, up to 24 % level of soya bean milk residue can be included in the diet of rabbits to achieve a good reproductive performance.

REFERENCES

Allen, C.E (1993).New horizons in animal agriculture: future challenges for animal scientists. *Journal of Animal Science*, 57(2): 16-20.

Aduku, A.O and Olukosi, J.O (1990). Rabbit management in the tropics: processing, utilization, marketing, economics, practical trainning, research and future prospect. *Nigerian Journal of Animal Production*, 25: 34 – 40.

Ajayi, F.O., Balogun,O.O., Ovuru, S.S and Mgrere, O.O (2005).Reproductive performance of rabbits fed maize milling waste based diets. *African Journal of Biotechnology*, 4(5): 439 – 443.

Arijeniwa,A., Otaikhian, S.O And Maseun, J.A (2000). Performance of weaner rabbits fed grass legume rations. In: Proceeding Of The 5th Annual Conference of Animal Science Association of Nigeria (ASAN),Sept 2000:103-105.

Federal University of Technology, Minna Student Handbook , 2008).

Handa,M.C., Sapra,L.A And Shingai, B.K (1995).Rabbits for meat production. *Asian Livestock*, 20:99-100.

Jones, N.D (1990). The developing market for farm bred meat rabbit in Britain, United kingdom. Pp 353- 355.

Ngu, N.T (2001). Improving utilization of market waste from fruits and vegetables in goat feeding.M.Sc Thesis, Swedish University of Agricultural Sciences. Department of Animal Nutrition and Management.Uppsala,Sweden.NRC (1990). Microlivestock. National Research Council.National Academy Press. Washington D.C

Okoye,J.I., Nkwocha,A.C and Ogbonnaya, A.E (2008). Production, proximate composition and consumer acceptability of biscuits from wheat/ soybean flour blend. *Continental Journal of Food Science and Technology*, 2:6-13.

Odeyinka,S.M., Oyedele,O.J., Adeleke, T.O., Odedire, J.A (2007). Reproductive performance of rabbits fed *Moringa Oleifera* as a replacement for centrosema. *9th World Rabbit Congress, June 10-13th, 2008 – Verona – Italy. 7(3)142-147.*

Owen,O.J.,Alawa,J.P.,Wekhe,S.N.,Isirima.N.O., Chuk Uiggwe,E.C., Aniebo,A.O., Ngodigha, E.M And Amakiri, A.O(2008). Incoporating Poultry litter in animal feed: a solid waste management strategy.*Egyptian Journal of Animal Production*, 54:123 – 129.

Table 3. Proximate composition of experimental diets

	DIETARY TREATMENTS				
Parameters	**0%**	**8%**	**16%**	**24%**	**32%**
Dry matter	94.2	93.8	94.8	93.5	94.3
Moisture content	5.8	6.2	5.6	6.5	5.7
Crude protein	18.16	17.73	17.9	17.26	18.26
Crude fibre	13.4	13.8	12.8	13.6	13.4
Ether extract	11.86	12.27	10.2	11.96	13.18
Ash content	19	19.38	18.5	18.42	18
Nitrogen free extract	31.78	30.62	35.4	32.26	31.46
Energy (kcal/Kg)	3185	3118.3	2934	3069.2	3091

Table 4. Birth traits of rabbits fed varying levels of inclusion of soya bean milk residue.

DIETARY TREATMENT							
Parameters	**0 %**	**8 %**	**16%**	**24%**	**32%**	**SEM**	**LS**
Litter size at birth	12	12	10	12	12	0.32	NS
Litter birth weight (g)	49.75	56.25	57.75	54.25	46.50	1.59	NS
Gestation gain (kg)	0.28	0.32	0.39	0.36	0.21	0.04	NS
Gestation length (Days)	30	31	30	31	30	0.11	NS
Kindling loss (kg)	0.26	0.26	0.31	0.29	0.18	0.02	NS
Neo natal mortality (%)	6.25	6.25	0.00	2.08	4.17	1.41	NS
Coefficient of milking capacity	0.31	0.29	0.28	0.27	0.28	0.08	NS

Table 5. Effect of feeding SBMR on weaning traits of rabbits

	DIETARY TREATMENT						
Parameters	**0%**	**8%**	**16%**	**24%**	**32%**	**SEM**	**L**
Average Litter Size at Weaning(LSW)	9^{b}	9^{b}	10^{ab}	11^{a}	10^{ab}	0.34	*
Litter Weaning Weight (LWW) (kg)	0.56^{b}	0.67^{a}	0.61^{ab}	0.55^{bc}	0.50^{c}	0.02	*
Litter Weaning Weight gain (LWG) (kg)	0.51^{b}	0.61^{a}	0.56^{ab}	0.50^{b}	0.47^{c}	0.22	*
Survival Rate to Weaning (SRW) (%)	70.83^{c}	$79.17b^{c}$	100.00^{a}	91.67^{ab}	87.50^{b}	5.17	*
Weaning Sex Ratio (Male: Female)	5:04	6:03	3:07	4:07	6:04	23	

Peteducation.com (2011). Rabbit Nutrition: Diet requirement and feeding at different life stage.Retrieved from www.pet.education.com/article on 20/6/2011.

Pyke, M(1981). *Classification of wheat.*Food Science and Technology.4th edition. John Murray Publishers Ltd. London. PP 44-56.

Rahim,A., Reza,A and Shahjalal, N.F (1997). Comparative study of soyabean meal and the whole grain on growth and reproductive performances of rabbits. *Journal of Animal Science*, 26:89 – 97.

Ranjhan,A (1980). Animal nutrition in the tropics, Vkas Publishing Houses Pvt Ltd, Sahibabab Ghaziabad. Pp 335.

Ren,K.L., Li, Y.P., Ren, J.L., He, D.C and Liang.Q.Z (2003).Study of dietary energy and protein level for reproducing rabbits. *Journal of Applied Rabbit Research*, 8(4):100-115.

Statistical Package for Social Sciences, SPSS Version 6.0(2006).

Yang, C.M.J (2005). Soybean milk residue ensiled with peanut hulls: fermentation acids, cell wall composition and silage utilization by mixed ruminal microorganisms. *Bioresources Technology*, 96(12): 1419-1424

Dairo, F.A.S (2008).Performance and haematological evaluation of weaner rabbits fed loofah gourd seed meal(*Luffa cylindrica*). *African Journal of Food, Agriculture, Nutrition and Development*, 8(4): 451-463.

Esonu, B.O., Opara, M.N., Okoli, I.C.,Obikaonu,H.O., Udedibie,C and Iheshiulor, O.O.M (2006). Physiological responses of laying birds to neem leaf meal based diets, body weight, organ characteristics and haematology. *Online Journal of Health and Allied Sciences*, 2: 4.

RESPONSE OF SOME *ORYZA GLABERRIMA* GENOTYPES TO FLASH FLOODING

Aliyu R.E
Department of Botany, Faculty of Life Science, Ahmadu Bello University, Zaria, Nigeria
Corresponding author email: s.ramatu@gmail.com

ABSTRACT
The tolerance of some Oryza glaberrima genotypes was evaluated against complete submergence at seedling stage and the effects of the water conditions on the genotypes under submergence. High yielding genotypes of Oryza glaberrima (TOG6790A, TOG9266, TOG933, TOG9281, TOG9047, TOG7428), submergence tolerant (SWARNA SUB1) and susceptible (TOG7943) checks were subjected to flash flooding at 21 days after seeding for two weeks. Submergence tolerant genotypes (TOG7428 and TOG9047) showed mean reduced plant growth of 17.43% with significant ($p<0.05$) reductions in all morphological growth parameters. This implies a reduction in energy utilization thus conserving energy by maintaining low growth rate. However, genotypes with escape growth strategies showed rapid shoot elongation and leaf expansions by competing for energy required for the maintenance processes for survival. Thus, elongation ability negatively correlated with submergence tolerance (r-= -.05 and survival percentage (r=-0.31) upon de-submergence. Shoot elongation positively correlated with leaf number (r= 0.51) and leaf width (r= 0.74*). Water conditions during complete submergence (dissolved oxygen- 12.63±0.71mgl^{-1}, total dissolved solids 124.33±7.45mgl^{-1} and electrical conductivity 2.04±2.26dSm^{-1}) were not toxic to the genotypes. Submergence tolerant Oryza glaberrima genotypes could be adopted to mitigate flooding in flood prone areas and can be used in conferring submergence tolerance in breeding programmes for plant advancement.*

Keywords: Submergence, *Oryza glabberrima*, Shoot elongation, desubmergence.

INTRODUCTION

One of the limiting factors to sustainable rice production is poor management of water (Akinwale *et al*., 2012). Rice in West Africa is cultivated in upland, lowland or deep-water conditions with little or no control of water levels. Rainfed uplands occupy around 40% of total rice growing area in West Africa (Ikeda, 2004) but yields are low, compared with those of lowland ecosystems. Only about 10% of the total rice area is irrigated (Setter, 2010). The rainfed lowlands therefore offer the greater potential for raising rice production. Lowlands in Nigeria are susceptible to flooding with average to high rainfall. The resultant damage in yields ranges from 60% to 100%. Specifically, over 80% of lowland rice ecology was inundated by floods in Nigeria in 2011, causing severe economic loss (Akinwale, *et al*., 2012). In rice farms, 100% yield losses have been recorded due to submergence stress in these lowlands.

Most rice cultivars die within several days of being completely submerged, but some cultivars, are more tolerant to submergence (Khan *et al*., 2013). The issue of sea level rise occasioned by global climatic change will exacerbate flooding conditions in growing areas. In many cases, young rice seedlings are too small to escape by means of underwater leaf elongation and cannot successfully develop a canopy above the water surface. Several studies on the African rice drew attention to the potential of the indigenous cultivated rice species which presents a rich reservoir of genes for resistance to several stresses (Futakuchi, 2005; Sarla *et al*., 2005; Bailey-Serres & Voesenek, 2010).

Water-control measures in submergence-prone areas can help reduce the damage caused by flooding (Laurentius *et al*., 2015), but this normally entails huge investment beyond the reach of resource poor farmers normally living in these areas (Ikeda, 2004). Floods also cannot be predicted and the damage could occur at any stage of plant development including germination (Rahman and Zhang, 2016). The achievement of sustainable rice production will therefore be necessary to identify and incorporate adaptability to submergence into rice cultivars used by West African farmers (Ikeda, 2004). This study was therefore designed to evaluate the tolerance of *Oryza glaberrima* to mitigate flash flooding in flood prone ecologies.

MATERIALS AND METHODS

The seeds of *Oryza glaberrima* genotypes (TOG6790A, TOG9266, TOG933, TOG9281, TOG9047, TOG7428) were procured from AfricaRice, Ibadan, Nigeria. Submergence screening was performed in the greenhouse at the botanical garden of Ahmadu Bello University, Zaria, Nigeria. Six *Oryza glaberrima* genotypes along with the susceptible (TOG7943) and tolerant (SWARNA SUB 1) checks were sown in plastic buckets and completely submerged at 21 days old in plastic tanks at a depth of 1.2m. Submergence tolerance was evaluated by adopting a completely randomized design with three replicates. Water level was maintained at 100cm above soil during

submergence. When the susceptible check showed >60% damage, plants were de-submerged and plant survival scored after 14 days of recovery.

Characteristics of the surrounding water were evaluated with a hand held Hanna conductivity meter at a depth of 5cm after manual stirring of water. These included dissolved oxygen (mgl^{-}), temperature (^{O}C), total dissolve solid (mgl^{-1}), electrical conductivity (dsm^{-1}), and pH. These were monitored and evaluated daily for the duration of submergence. Morphological parameters were evaluated fourteen days after submergence. The water in the tanks was let out via the water tap at the base of the tank. Growth parameters evaluated for the submerged plants and the non-submerged controls were: shoot elongation (cm), leaf width (cm), leaf number, tiller number and percent survival (%). Data obtained were subjected to analysis of variance. Where significant, Duncan's Multiple Range Test was used to separate the means. The degrees of association of the morphological parameters were determined using the Pearson's correlation index.

RESULTS

Response of Genotypes to Submergence Stress

Genotypes showed varied response to submergence stress. A significant ($p<0.05$) effect of submergence on shoot elongation amongst the genotypes was observed. Shoot elongation was most rapid in TOG6790 (16.15%) with a survival score of 9 after de-submergence. The survival score was comparable with the susceptible check (TOG7943) which showed a 6% increase in height due to submergence. TOG9266 and TOG9281 also showed reduced growth of -8.1% and -3.2% respectively. However, their survival score upon de-submergence was 7. TOG933 showed moderate tolerance to submergence stress with a score of 5 and a 35.24% reduction in shoot length. SWARNA SUB 1, TOG7428 and TOG9047 with a survival score of 3 showed reductions in shoot length of 21.49%, 23% and 11.86% respectively (Fig1).

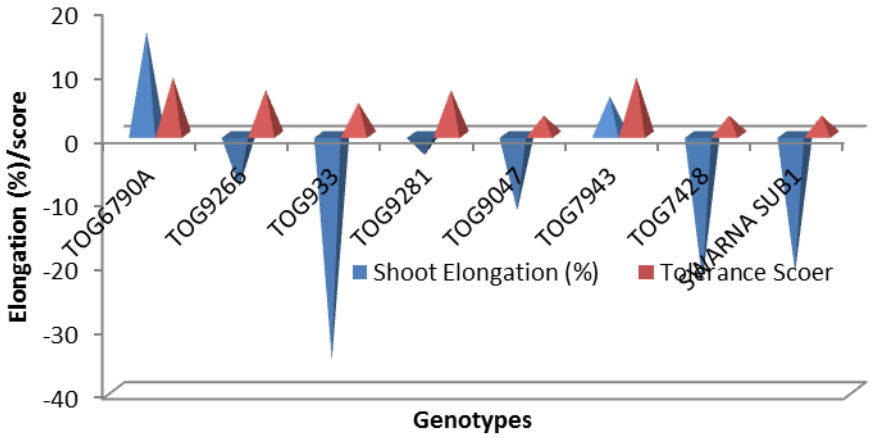


Fig 1: Shoot elongation and submergence tolerance of *Oryza glaberrima* genotypes.

Leaf width, leaf number and tillering ability varied with the genotypes. A significant ($P<0.01$) effect of submergence on leaf expansion rate was observed across genotypes. Leaf width expansion due to submergence stress was highest (5.26%) in TOG9266 and lowest (-34.7%) in TOG933. Sequential leaf reductions of -18.37%, -10.34%, -9.33%, -8.72%, -8.0%, -3.2% were observed in TOG9047, WARNA SUB 1, TOG6790, TOG7428, TOG9281, and TOG7943 respectively (Fig. 2). At 5% probability level, all genotypes showed varied reductions in leaf and tillering ability except for TOG933 whose tillering ability was not affected by complete submergence. Reductions in leaf number and tillering ability ranged from -16.79 to -7.06% in SWARNA SUB 1 and TOG9047 and from -24.81% to 0% in SWARNA SUB 1 and TOG933 respectively (Fig 2).

Survival percentage upon de submergence ranged from 10% to 88%. SWARNA SUB 1 and TOG9047 showed no significant difference in survival percentage. However, TOG7428 showed tolerance to submergence stress with a 60% survival upon de submergence. Other genotypes were susceptible to submergence stress.

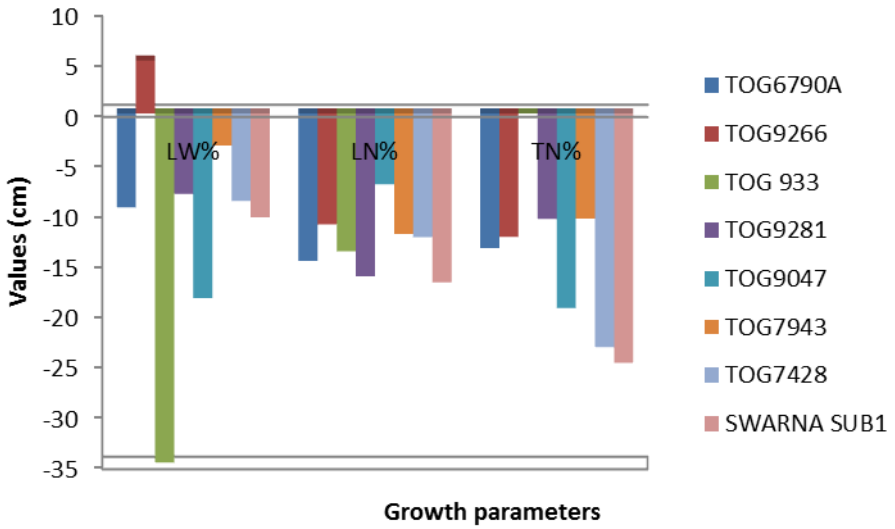


Figure 2: Comparative growth response of *Oryza glaberrima* under submergence stress relative to control treatment. Key: LW=leaf width, LN=leaf number, TN=tiller number

The associations between plant morphological growth parameters showed that shoot elongation positively correlated with leaf number (r= 0.51*) and leaf width (r= 0.74*) at $p<0.05$.

Environmental Characterization of surrounding water.

Temperature values of submergence water obtained ranged from 25.5°C to 28.3°C. The pH was maintained at 5.4 ±0.4 °C. Significant variance in total dissolved solids (TDS) and dissolved oxygen (DO) across the genotypes was obtained. Electrical conductivities were within acceptable limit (<4 dsm^{-1}) for all genotypes and did not significantly vary across genotypes. Values for Dissolved oxygen and TDS ranged from 12.00mgl^{-1} to 13.33mgl^{-1} and 134.6700mgl^{-1} to 11700mgl^{-1} respectively.

Table 1: Characterization of flood water used for Subergence of *Oryza glaberr*ima in Plastic Tanks under Field Conditions.

Tanks	DO (mgl^{-1})	TDS(mg/l^{-1})	EC (dsm^{-1})
1	12.67^{ab}	128.33^{bc}	2.05^{ab}
2	12.67^{ab}	134.67^{a}	1.71^{b}
3	13.33^{a}	132.0^{ab}	2.22^{a}
4	13.01^{ab}	123.00^{de}	2.01^{ab}
5	12.02^{b}	112.67^{a}	2.14^{b}
6	13.33^{a}	126.67^{dc}	2.06^{ab}
7	12.02^{b}	120.06^{fe}	2.08^{ab}
8	12.00^{b}	117.33f	2.06^{ab}
9	12.64^{ab}	124.00^{de}	2.05^{ab}
X ± SDEV	12.63±0.71	124.30±7.45	2.04±2.26
C.V	4.19	2.1	9.99
P VALUE	< 0.02	<0.01	<0.22

Key: DO- Dissolved Oxygen, TDS- Total dissolved solids, EC- Electrical conductivity

DISCUSSION

Factors controlling energy production by plants have an impact depending on how that energy is utilized for the best survival strategy of any induced stress. Submergence tolerant genotypes showed reduced plant growth, with greater reductions in all morphological growth parameters. This implied a reduction in energy utilization, thus conserving energy by maintaining low growth rate. The results obtained suggests that rapid shoot elongation and leaf width expansion may compete for energy required for maintenance processes for survival. This was indicated by a negative correlation between elongation ability, submergence tolerance and reduced survival percentages after de-submergence. Leaf expansion due to submergence stress further corroborate increasing energy utilization in order to increase plant photosynthetic ability. Hence the observed positive association between leaf expansion and shoot elongation. Furthermore, shoot elongation during submergence was probably influenced by the genetic character of the genotype as well as the submergence environment. These findings corroborated several researches on submergence tolerance where it was implied that some genotypes elongated their shoot during total submergence (Luo, 2011). Stem elongation due to submergence have been reported in susceptible varieties (Das *et al*., 2005). In small seedlings, rapid elongation is restricted to emerging leaves. Shoot elongation is one of the escape strategies for adaptation to submergence that promotes a return of part of the foliage to the air (Kende *et al*., 1998; Sarkar & Bhattacharjee, 2011). This helps to ensure adequate supplies of oxygen and carbon dioxide to support vigorous aerobic respiration and photosynthesis

(Bailey-Serres, & Voesenek, 2010). Renewed growth and development in tolerant elite varieties have also been reported. (Khan *et al*, 2013). Singh, *et al*. (2001) and Akinwale, *et al. (*2012) also reported negative correlation between plant elongations with percentage survival.

The submerged water that supported the growth of *Oryza glaberrima* genotypes was not toxic to the submerged genotypes. The electrical conductivity and total dissolved solids of the surrounding water were within acceptable limits (WHO, 2011). However, the water body was slightly polluted due to plant metabolism as observed from water turbidity. Turbid water, in addition to submergence stress must have triggered stem elongation growth process. An interrelationship between gas diffusion and metabolism of rice related to growth and survival during complete submergence have been exemplified by Setter *et al*. (1997) where plant submerged in floodwater in equilibrium with air at 0.03kpa died within 1-2weeks.

REFERENCES

Akinwale, M.G., Akinyele, B.O., Odiyi, A.C., Nwilene, F., Gregorio, G & Oyetunji, O.E. (2012). Phenotypic screening of Nigerian rainfed lowland mega rice varieties for submergence tolerance. Proceedings of the world congress on Engineering 2012 VolI WCE 2012, July 4-6, London, U.K.

Bailey-Serres, J. & Voesenek, L.A.C.J. (2010). Life in the balance: a signaling network controlling survival of flooding. *Current Opinion in Plant Biology,* **13**:489–494.

Das, K.K., Sarkar, R.K. & Ismail, A.M. (2005). Elongation ability and non-structural carbohydrate levels in relation to submergence tolerance in rice. *Plant science*, 131-136.

Futakuchi, K. (2005). Submergence damages in rice and challenges in expanding its adaptability to submerged conditions in West and Central Africa. In: *Rice is life*: Scientific perspectives for the 21st century. International Rice Research Institute and Japan International Research center for Agricultural Sciences, Los Banos, Phillippines, pp 445-447.

Ikeda, R. (2004). *For the development of sustainable rice cultivation in Africa*. JIRCAS Newsletter No. 38. Japan International Research Center for Agricultural Sciences. Pp82

Kende, H., Van der Knaap, E. & Cho, H-T. (1998). Deepwater rice: a model plant to study stem elongation. *Plant Physiology,* 118: 1105–1110.

Khan, T.D., Ham, le-H., Cuc, D.T.K., Linh, L. H and Linh, T.H. (2013) Improving submergence tolerance of Vietnamese rice cultivars by molecular breeding. *Journal of Plant Breeding and Genetics* 01 (03):157-168

Laurentius, A., Voesenek, C.J & Bailey-Serres, J. (2015). Flood adaptive traits and processes: an overview. *New Phytologist.* 206(1) 57–73.

Luo, F.L, Nagel, K.A., Scharr, H., Zeng, B., Schurr, U. & Matsubara, S. (2011). Recovery dynamics of growth, photosynthesis and carbohydrate accumulation after de-submergence: a comparison between two wetland plants showing escape and quiescence strategies. *Annals of Botany*, **107**: 49–63.

Rahman, R.B & Zhang, J. (2016) Flood and drought tolerance in rice: opposite but may coexist. *New Phytologist,* 5(2) 76–88

Sarkar, R.K. & Bhattacharjee, B. (2011). Rice Genotypes with SUB1 QTL Differ in Submergence Tolerance, Elongation Ability during Submergence and Regeneration Ability during Submergence and Re-generation Growth at Re-emergence. *Rice*, **5**:7. Doi:10.1007/s 12284-011-9065-z

Sarla, N. & Mallikarjuna, S. B. P. (2005). *Oryza glaberrima:* A source for improvement of Oryza sativa. *Current science, 89* (6): 955-963.

Setter, T.L., Ellis, M., Laureles, E.V., Ella, E.S., Senadhira, D. & Mishra, S.B. (1997). Physiology and genetics of submergence tolerance in rice. *Annals of Botany*, 79 (Suppl.): 67–77.

Setter, T.L., Bhekasut, P. & Greenway, H. (2010).“Desiccation of leaves after de-submergence is one cause for intolerance to complete submergence of the rice cultivar IR42.” *Function. Plant Biol.* 37:1096-1104

Singh H.P., Singh B.B. & Ram P.C. (2001). Submergence tolerance of rainfed lowland rice: search for physiological marker traits. *Journal of Plant Physiology*, 158: 883–889.

Vartapetian, B.B. & Jackson, M.B. (1997). Plant adaptations to anaerobic stress. *Annals of Botany*, 79 (Suppl. A): 3–20.

WARDA. (1996). Annual Report .Pp 7-17http://www.warda.cgiar.org/publications/wardar96.pdf

WHO. (2011). *Guidline for drinking water quality*. 97892415481_eng.pdf

COMPARATIVE SEED POLYMORPHISM OF SOME GENOTYPES OF SOME RICE SPECIES

Aliyu R.E
Department of Botany, Faculty of Life Science, Ahmadu Bello University, Zaria, Nigeria
email: s.ramatu@gmail.com, *enehezeyi@abu.edu.ng*

ABSTRACT
The seed samples of ninety one (91) rice genotypes from two rice species (Oryza sativa -25), Oryza glaberrima - 48) and an interspecific hybrid (NERICA-18) were evaluated for physical seed characteristics (hull colour, presence or absence of awn, awn length, brown rice length, brown rice width, grain length, grain width, seed colour, seed shape and chalkiness). Ten random seeds were selected from each bulk genotype and evaluated. Correlation studies were also done to analyze the relationship between the seed physical characters. The result showed significant ($p<0.05$) variability between and within rice species and genotypes. Their variability can be linked to their geographical origin of collection and domestication. Four hull (light brown, brown, tawny and black) and seed colours (brown, speckled brown, white and red) were observed across species. Black hull colour was observed in TOG 6203-A only while TOG14357 was the only O. glaberrima genotype with white seed colour. NERICA genotypes were dominated by slender grained seeds (94.44%) while bold seeds (20.83%) were largest amongst Oryza glaberrima genotypes. Seed chalkiness was highest amongst NERICA genotypes (33.33%) followed sequentially by Oryza sativa (28%) and O. glaberrima (0%). The significant positive correlation between hull colour and brown rice length ($r^2=0.74$) and grain length ($r^2=0.65$) suggested that hull colour in NERICA is indicative of the seed lengths of the genotypes. The physical attributes of the light brown hull colour of NERICA makes it preferable for future yield improvement programme of NERICA.

Keywords: Rice, Seed polymorphism, *Oryza sativa, Oryza glaberrima,* NERICA

INTRODUCTION

The morphologies of most *Oryza glaberrima* and *Oryza sativa* genotypes are hardly distinguishable (Semon, 2005). Seed produced within a somatic polymorphism may vary in size, colour and/or external structure. These variations in morphology are frequently accompanied by difference in germination requirement with the consequences that the germination of polymorphic seeds maybe staggered in time (Silvertown, 1984). Visual quality is one of the most important determinants of seed polymorphism and is considered as important breeding objective (Anuradha *et al.*, 2009). Due to wide variation in different agro-climatic conditions and diversified selection for a wide range of uses of rice grain; a great diversity exists for its size and shape (Satoh *et al*., 1990). Researchers like Malavasi (1996), Murali (1997), Mandal *et al*. (1997) and Girish *et al*. (2001) had expressed that physical grading could improve the physiological quality characters of the seeds due to the biochemical variations, which become the causes for the variation observed with physiological characters. Seed polymorphism has been noticed in crops within and between populations with respect to seed coat colour and seed size (Latha *et al.,* 2013). Variation in any one character or character combination could result in the changed quality of rice grain (Siddiqui *et al*., 2007). This variation plays an important role in crop improvement programme since the variability in seed quantitative characters exhibits a direct relationship with the seed yield of the crop (Latha *et al*., 2013). Seed viability may relate to seed polymorphism where seed of a species exhibits two or more distinctly different morphology in size, colour and shape (Baskin and Baskin, 1994). That different form of seeds may show marked difference in plant abiotic stress and identifying useful traits is an important activity in rice improvement (IRRI, 2002). Grain yield of rice is basically determined by genotype, climate and edaphic environment, and management (Slafer, 1994; Richards, 2000).

The seed fetches much value only on possession of seed quality characters and only these characters can improve the nursery and planting value of the seedlings (Swaminathan *et al.,* 1991) Seeds require specific quality characters for optimum performance with uniformity on seedling production (Venudevan and Srimathi, 2013). However, the relative importance and influence of quality related traits on grain quality have changed over time as a result of rice improvement. Moreover, quality potential of a variety is a hypothetical concept determined by a complex series of interaction with the components of the environment it is exposed to (Samita *et al*., 2005). Therefore, classification using multiple morphological characteristics is important for identifying adaptation of a variety and to improve the evaluation of varieties for potential adaptation (Lin and Binns, 1985) and crop improvement (Latha *et al*., 2013)

MATERIALS AND METHODS

SOURCE OF MATERIALS

Ninety one (91) seeds of *Oryza* species comprising of 25 *Oryza sativa*, 48 *Oryza glaberrima* and 18 interspecific hybrid (NERICA) were evaluated for

physical seed characteristics (hull colour, presence or absence of awn, awn length, brown rice length, brown rice width, grain length, grain width, seed colour, seed shape and chalkiness). Ten random seeds were selected from each bulk genotype and evaluated for the study. The seeds were obtained from the cold store of Africa Rice, International Institute for Tropical Agriculture (IITA), Ibadan station. Nigeria.

Study location and Methodology

The determination of seed morphology was carried out at the Department of Biological Sciences, Ahmadu Bello University, Samaru, Zaria.

Seeds were graded according to genotypes and evaluated for polymorphism traits. Ten seeds per genotype were randomly evaluated and replicated thrice. Seed characters were evaluated following the methods described by the International Rice Research Institute (IRRI), 1997.

Data collection

Data on grain length (mm), grain width (mm), brown rice length (mm), brown rice width (mm) were measured with a venire veneer caliper using the formula: (MSR + VSR x LC). Where MSR: Main scale reading, VSR: Venire scale reading and LC: Least count. (IRRI 1997). Seed shape was estimated by Length-width ratio. (IRRI 1997)

Data on seed colour, seed shape, and chalkiness of endosperm, hull color and presence or absence of awn were taken by adopting the standard evaluation system for Rice (IRRI, 1997).

Statistical analyses

Data obtained were subjected to Analysis of Variance (ANOVA) and the means separated by Duncan's Multiple Range Test (DMRT). The inter relationship between seed parameters were correlated using Pearson correlation coefficient.

RESULTS

The seeds of the rice species were polymorphic ($P<0.05$) across species and genotypes (Table 1, 3 and 6). The hull colour of the rice genotypes observed were light brown, brown, tawny and black. The predominant hull colour observed across specie were light brown (68% in *Oryza sativa*, 72.92% in *Oryza glaberrima* and 72.22% in NERICA) followed sequentially by tawny,

Table 1: Standard scale used for evaluation of seed polymorphism of Oryza species

Score	Hull Colour	Awn	Awn length	Seed Colour	Seed Shape	Chalkiness
0		Absent	Absent			Non
1	Light brown	Present		Light brown	Slender	
2	Brown			Brown		
3	Tawny		Short	Speckled/brown	Medium	
4	Green			Whitish		
5	Black		Long	Black	Bold	Small
6				Red		
7						
8						
9						Large

Source: IRRI 1997

brown and black (Figure 1). NERICA had the highest genotype (66.67%) with awns followed by *Oryza glaberrima* genotypes (16.67%) and lastly, *Oryza sativa* (0%) genotypes. Awn length ranged from 0.00-2.33mm within *Oryza sativa* genotypes. While awn length of up to 7mm was recorded in NERICA and *Oryza glabberima* genotypes.

The seed colour observed amongst the rice genotypes were dark brown, white, speckled brown and red. Majority of the *Oryza sativa* genotypes (80%) were white while 16% and 4% were dark brown and speckled brown respectively (Figure 1). This seed colour trend was similar to that observed in NERICA genotypes where 88.89% of the seeds were white and 11.11% were dark brown. Red seed colouration amongst *Oryza glaberrima* genotypes were predominant (97.92%) with only one dark brown coloured genotype (TOG 14357).

Seed shape varied and were significantly different ($p<0.05$) across genotypes and species. Within *Oryza sativa* genotypes, the percentages of slender shaped seeds, medium and bold shaped seeds observed were 68%, 28% and 4% respectively. Similarly, the seed shapes of *Oryza glaberrima* genotypes were slender (43.75%), medium (37.56%), and bold (20.83%). Only slender (94.44%) and medium (5.56%) shaped genotypes of NERICA were observed. Endosperm chalkiness was absent in *Oryza glaberrima* genotypes and highest amongt NERICA genotypes (33.33%).

Brown rice lengths varied but were majorly medium in shape within genotypes and species. NERICA genotypes, with a mean brown length of

1.52mm exhibited the longest brown rice lengths and ranged between 1.18 and 1.81mm (Table 5). Amongst the *Oryza sativa* genotypes, brown rice length ranged between 0.95-1.72mm with a mean length of 1.34mm (Table 1). The grain lengths observed in NERICA genotypes were longest (1.40-2.08mm) and shortest amongst *Oryza glaberrima* genotypes. The mean brown rice length of 1.18mm recorded from *Oryza glaberrima* genotypes was least and ranged from 0.79-1.48mm (Table 3). Mean brown rice width was longest (0.46mm) in *Oryza glaberrima* genotypes (Table 1) and narrowed sequentially from *Oryza sativa* (0.38mm) to NERICA (0.33mm). The grain width was also narrowest (0.43mm) in NERICA and expanded sequentially from *Oryza sativa* (0.46mm) to *Oryza glaberrima* (0.56mm). Generally, a significant reduction of grain length to brown rice length of 0.1 to 0.3 mm of after dehulling was observed.

Significant ($p<0.05$) positive and negative correlations in seed polymorphism were observed within species amongst genotypes (Tables 3, 5 and 7). Across species, the Brown rice length showed positive correlation with grain length. In addition, presence of awn also positively correlated with awn length. However, it was observed that the brown rice length in *Oryza glaberrima* showed negative correlation (-0.43) with brown rice width (Table 4). Furthermore, the grain length showed negative correlation (-0.34) with the seed shape. In NERICA genotypes (Table 7), the hull colour showed a strong positive correlation with the brown rice length (0.74) and the grain length (0.65).

DISCUSSION

Seed polymorphism is a common phenomenon associated with discrete or continuous morphology or physiological variation among individual seeds produced by an individual or population (Latha *et al*., 2013). All physical qualities can be affected by the growth conditions of the plant (Linares, 2002). Grain length, width and thickness vary widely among rice varieties (Maclean *et al.*, 2002). Seed produced within a somatic polymorphism may vary in size, colour and/or external structure. In plants showing seed polymorphism, two or more sharply defined distribution patterns are seen (Xie, 2013). Attributes such as seed size, shape or internal structures are some of the forms in which polymorphism maybe manifested (Siddiqui *et al*., 2007). Seed polymorphism has been noticed in the crop within and between populations with respect to seed coat colour and seed size. Variation in any one character or character combination could result in changed quality of rice grain (Siddiqui *et al*., 2007).

Predominance of light brown hull colour observed across species could be attributed to the ripened brown pigmentation of ripe dried seeds across genus. In addition, differences in seed colour in rice have been attributed to specie domestication and genotype (Latha *et al*., 2013). The red seed colour, awns and bold seed shape observed amongst *Oryza glaberrima* could be attributable to the specie genome and domestication. According to Carney (1998), *Oryza glaberrima* is characterized by its red seed, bold shape and presence or absent of apical Awn. The wide variations in genotype seed lengths across specie could be attributed to individual differences that must have arisen as a result of environmental influences during the growth of the genotype. The ratio of the length and the width is used internationally to describe the shape and class of the variety (Xie *et al.*, 2013). Similar variations in seed lengths within and between species have been reported by Sidddiqui *et al*. (2007). Slender seed shape of *Oryza sativa* and NERICA genotypes have been reported by several researchers (West Africa Rice Development Agency (WARDA) 2008; Sinha *et al*., 2015). Furthermore, Siddiqui *et al*. (2007) reported that seed colour of *Oryza sativa* and NERICA genotypes were either white or brown. The highly undesirable chalkiness in the seeds of a good percentage of NERICA and *Oryza sativa* genotypes might have arisen from malformed starch granules with air spaces between them. Similar observations have been reported by Ward (2009) and Vanaja and Babu (2006). A positive correlation in seed traits in NERICA genotypes suggests that the hull colour influences the brown rice length and the grain length.

In conclusion, the results in general showed that there existed tremendous variability between and within rice species and genotypes which can be directly utilized in rice breeding programme. Their variability can be linked to their geographical origin of collection and domestication. The significant correlation between hull colour and brown rice length and grain length suggested that hull colour in NERICA was detrimental in discerning the seed lengths of the genotypes. Hence, light brown hull colour could be the preferred colour for future yield improvement programme of NERICA.

Table 1: Seed polymorphism evaluated amongst 25 *Oryza sativa* genotypes

S/N	Genotypes	Hull Colour	Awn P/A	Awn length (cm)	SC	SS	C/K	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)
1	BG 90-2	3.00 b	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.72 a	0.32g-J	2.00 a	0.41def
2	BOKUCHI	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	9.00 a	1.64ab	0.33 f-1	1.97ab	0.56 a
3	CISADANE	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.40 def	0.34 f-1	1.59fgh	0.43 c-f
4	EBAGICHI	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	9.00 a	1.14hij	0.38 f-1	1.63 d-h	0.44 c-f
5	FARO 14	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	9.00 a	1.45cde	0.34 f-1	1.82 c	0.44 b-f
6	FARO 35	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.33 d-g	0.33 f-1	1.72 c-f	0.53abc
7	FARO 36	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.22ghi	0.31hij	1.49 g-j	0.42 c-f
8	FARO 37	1.00d	0.00 b	0.00 b	4.00 a	1.00 d	3.00bc	1.28fgh	0.39 c-f	1.55 g-j	0.49 a-d
9	FARO 44	3.33 a	0.33 a	2.33 a	4.00 a	1.00 d	9.00 a	1.34 def	0.42bcd	1.61 e-f	0.48 a-e
10	FARO 50	1.00 d	0.33 a	0.00 b	4.00 a	1.00 d	9.00 a	1.35 d-g	0.33 g-h	1.73 c-f	0.43 c-f
11	FKR 19	3.00 b	0.00 b	0.00 b	4.00 a	1.00 d	9.00 a	1.46cde	0.36 e-h	1.64 d-g	0.54abc
12	GAMBIAKA (L)	1.00 d	0.00 b	0.00 b	2.67 b	3.00 b	6.00ab	0.99jk	0.38 e-h	1.18 k	0.40 def
13	IR 42	1.00 d	0.00 b	0.00 b	4.00 a	3.00 b	0.00 c	1.10 ij	0.46 b	1.48hij	0.44 b-f
14	IR 64	3.00 b	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.46cd	0.30ij	1.79cd	0.36ef
15	IRRI 119	1.00 d	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.64ab	0.27 j	1.85bc	0.34 f
16	LADANCHI	1.00 d	0.00b	0.00 b	4.00 a	3.00 b	3.00bc	1.13hij	0.34 f-i	1.41 j	0.39 def
17	MALEGBELI	1.00 d	0.00 b	0.00 b	2.00 c	3.00 b	0.00 c	1.28fgh	0.45bc	1.43 ij	0.51 a-d
18	MOROBEREKAN	3.00 d	0.00 b	0.00 b	4.00 a	3.00 b	9.00 a	1.42 c-f	0.44bcd	1.64 d-g	0.50 a-d
19	PIE BELEO	2.00 d	0.00 b	0.00 b	2.00 c	1.00 d	0.00 c	1.42 c-f	0.38 e-h	1.65 d-g	0.47 a-e
20	SUAKOKO	3.00 b	0.00 b	0.00 b	4.00 a	3.00 b	0.00 c	1.22ghi	0.45bc	1.53 g-J	0.56ab
21	SWARNA	1.00 d	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.30d f-g	0.31ij	1.59fgh	0.50 a-d
22	SWARNA SUB 1	1.00 d	0.00 b	0.00 b	4.00 a	3.00 b	0.00 c	0.95 k	0.38 d-g	1.22 k	0.41 def
23	TORMA	1.00 d	0.00 b	0.00 b	2.00 c	1.00 d	0.00 c	1.56bc	0.32 g-J	1.75cde	0.43 c-f
24	WITA	3.00 b	0.00 b	0.00 b	4.00 a	1.00 d	0.00 c	1.35d-g	0.35 f-I	1.74 c-f	0.39 def
25	YIRIKIRU	1.00 d	0.00 b	0.00 b	2.00 c	5.00 a	0.00 c	1.30efg	0.91 a	1.21 k	0.54abc
	MEAN	1.61	0.01	0.09	3.63	1.67	3.00	1.34	0.38	1.61	0.46
	CV	7.16	866.03	866.03	6.37	13.86	60.82	6.15	8.78	5.17	13.15
	S.D	0.93	0.12	0.81	0.78	1.11	4.27	0.20	0.12	0.22	0.08
	R^2	0.99	0.35	0.35	0.94	0.97	0.88	0.89	0.95	0.91	0.61
	P VALUE	0.0001	0.4843	0.4843	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003

Means with the same subscript along columns are not significantly different ($p<0.05$) using the Duncan Multiple Range Test.

KEY: Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape, Clk-Chalkiness of Endosperm

Table 2: Correlation coefficients of evaluated seed characters for *Oryza sativa* genotypes

Parameters	HC	Awn P/A	Awn length (cm)	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)	SC	SS	CLK
HC	1									
Awn P/A	0.18	1								
Awn length	0.17	1.00*	1							
BrL (mm)	0.31	0.08	0.08	1						
BrW (mm)	-0.03	0.05	0.05	-0.19	1					
GL (mm)	0.29	-0.05	-0.05	0.82*	-0.49	1				
GW (mm)	0.02	0.22	0.22	-0.00	0.35	-0.11	1			
SC	0.21	0.06	0.66	0.02	-0.45	0.30	-0.11	1		
SS	-0.09	-0.07	-0.07	-0.43	0.79	-0.66	0.26	-0.39	1	
CLK	0.11	0.16	0.16	-0.08	-0.08	0.15	0.14	0.27	-0.17	1

*Significant, P<0.05

KEY: Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape
Clk-Chalkiness of Endosperms

Table 3: Seed polymorphism evaluated amongst 48 *Oryza glaberrima* genotypes

S/NO	Genotypes	Hull color	Awn P/A	Awn length(cm)	SC	SS	CLK	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)
1	TOG 6427	1.00e	1.00a	5.00abc	6.00a	5.00a	0.00a	1.25b-j	0.32hi	1.46a-h	0.49efg
2	TOG12255	2.00c	0.00c	0.00e	6.00a	1.00e	0.00a	1.28b-h	0.40f-i	1.45a-h	0.51efg
3	TOG13714	2.00c	0.33bc	1.67de	6.00a	1.00e	0.00a	1.19c-m	0.34hi	1.59a-h	0.46fg
4	TOG14357	2.00c	0.33bc	1.67de	2.00b	3.00b	0.00a	1.21b-l	0.47e-i	1.35b-g	0.56c-g
5	TOG16780	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	1.03l-q	0.46e-i	1.30e-j	0.56c-g
6	TOG 16803	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.11f-p	0.42f-i	1.61ab	0.77a-d
7	TOG 5317-B	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	1.03L-q	0.51c-g	1.67ij	0.56c-g
8	TOG 5429-A	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.29b-f	0.35hi	1.45a-i	0.49efg
9	TOG 5499-A	2.00c	0.00c	0.00e	6.00a	3.00b	0.00a	1.13e-n	0.45e-i	1.37a-j	0.55c-g
10	TOG 5552	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.22b-k	0.33hi	1.56a-e	0.41g
11	TOG5556-A	1.67cd	1.00a	5.00abc	6.00a	1.00e	0.00a	1.31a-e	0.35hi	1.44a-i	0.48fg
12	TOG 5696-A	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	1.01m-q	0.69bcd	1.13j	0.71a-f
13	TOG 5923	2.00c	0.67ab	3.33bcd	6.00a	1.00e	0.00a	1.27b-i	0.26i	1.55a-f	0.51efg
14	TOG5968	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.36abc	0.47e-i	1.55a-e	0.55c-g
15	TOG 5980-A	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	0.95o-r	0.67b-e	1.32c-j	0.82ab
16	TOG5987-A	2.00c	0.00c	0.00e	6.00a	3.00b	0.00a	1.09h-p	0.44f-i	1.29e-j	0.56c-g
17	TOG 6203-A	5.00a	0.33bc	1.67de	6.00a	5.00a	0.00a	0.93pqr	0.71bc	1.32c-j	0.77a-d
18	TOG 6223-B	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.27b-i	0.50c-h	1.35b-j	0.57c-g
19	TOG 6256	1.00e	0.33bc	2.33cde	6.00a	1.67d	0.00a	1.29b-g	0.39ghi	1.49a-h	0.49efg
20	TOG 6417	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.48a	0.41f-i	1.65a	0.60b-g

S/NO	Genotypes	Hull color	Awn P/A	Awn length(cm)	SC	SS	CLK	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)
21	TOG 6461	3.00b	0.00c	0.00e	6.00a	1.00e	0.00a	1.24b-j	0.39ghi	1.44a-j	0.49efg
22	TOG 6509	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.05k-q	0.44e-i	1.57a-e	0.58b-g
23	TOG 6547	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.18c-m	0.50c-h	1.41a-j	0.53d-g
24	TOG 6603-B	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	1.01m-q	0.78ab	1.41a-i	0.74a-e
25	TOG 6649	2.00c	0.00c	0.00e	6.00a	3.00b	0.00a	1.15d-m	0.44e-i	1.36b-j	0.51efg
26	TOG 6732	1.00e	1.00a	5.ooabc	6.00a	1.00e	0.00a	1.29b-g	0.30hi	1.48a-h	0.48efg
27	TOG 6790-A	2.00c	1.00a	7.00a	6.00a	3.00b	0.00a	1.22b-k	0.47e-i	1.54a-f	0.66a-g
28	TOG 7138	1.00e	0.33bc	1.67de	6.00a	1.67d	0.00a	1.32a-d	0.44e-i	1.53a-g	0.55c-g
29	TOG 7208	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.35abc	0.32hi	1.61abc	0.50efg
30	TOG7213	1.00e	1.00a	5.00abc	6.00a	3.00b	0.00a	0.96o-r	0.39ghi	1.41a-j	0.52d-g
31	TOG7238	1.33de	0.67ab	3.33bcd	6.00a	3.00b	0.00a	1.01j-e	0.44e-i	1.22hij	0.53d-g
32	TOG7249	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	0.90qr	0.61b-f	1.43a-i	0.64a-g
33	TOG7253	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.03l-q	0.72b	1.35b-j	0.87a
34	TOG 7260-A	3.00b	0.00c	0.00e	6.00a	3.00b	0.00a	1.19c-m	0.39ghi	1.43a-i	0.53d-g
35	TOG7279	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.21b-l	0.38hi	1.56a-e	0.55c-g
36	TOG 7323-A	1.00e	1.00a	5.67ab	6.00a	3.00b	0.00a	1.08i-q	0.50c-h	1.37a-j	0.80abc
37	TOG 7386	1.00e	0.33bc	2.33cde	6.00a	5.00a	0.00a	1.22b-k	0.79ab	1.31d-j	0.57b-g
38	TOG 7400	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.17c-m	0.42f-i	1.55a-f	0.56c-g
39	TOG 7412	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.34abc	0.63b-c	1.56a-e	0.81abc
40	TOG 7453-A	2.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.40ab	0.30hi	1.43a-i	0.43g
41	TOG 7986-A	1.00e	0.00c	0.00e	6.00a	2.33c	0.00a	1.34abc	0.46e-i	1.60a-d	0.53dg
42	TOG 7993-A	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.23b-j	0.38hi	1.44a-i	0.50efg
43	TOG 7994	2.67b	0.00c	0.00e	6.00a	1.00e	0.00a	0.97n-q	0.30hi	1.24f-j	0.41g
44	TOG 7995	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.22b-k	0.34hi	1.52a-g	0.44g
45	TOG8347	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.31a-e	0.48d-i	1.59a-d	0.58b-g
46	TOG 9266	1.00e	0.00c	0.00e	6.00a	1.00e	0.00a	1.34a-d	0.33hi	1.62ab	0.45fg
47	TOG9276	1.00e	0.00c	0.00e	6.00a	5.00a	0.00a	0.79r	0.93a	1.53a-g	0.46fg
48	TOG 9331	1.00e	0.00c	0.00e	6.00a	3.00b	0.00a	1.32a-d	0.50c-h	1.53a-g	0.46fg
	MEAN	1.42	0.19	1.03	2.08	2.61	0.00	1.18	0.46	1.44	0.56
	CV	20.18	132.66	135.30	0.00	11.04	0.00	7.91	24.18	9.60	22.09
	S.D	0.80	0.39	2.17	0.57	1.51	0.00	0.17	0.17	0.17	0.15
	R2	0.92	0.73	0.73	1.00	0.98	0.00	0.79	0.72	0.55	0.57
	P VALUE	0.0001	0.0001	0.0001	0.0001	0.0001		0.0001	0.0001	0.0002	0.0001

Means with the same subscript along columns are not significantly different ($p<0.05$) using the Duncan's Multiple Range Test.

KEY:Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape, Clk-Chalkiness of Endosperm

Table 4: Correlation coefficients of evaluated seed characters for *Oryza glaberrima* genotypes.

Parameters	H C	Awn P/A	Awn length	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)	SC	SS
H C	1								
Awn P/A	0.07	1							
Awn length	0.07	0.99*	1						
BrL (mm)	-0.12	0.04	0.05	1					
Brw(mm)	-0.06	- 0.13	-0.010	-0.43*	1				
GL (mm)	-0.18	-0.03	-0.02	0.52*	-0.22	1			
GW (mm)	-0.03	0.04	0.06	-0.20	0.37 *	-0.09	1		
SC	0.11	0.05	0.04	0.03	0.01	-0.008	-0.01	1	
SS	-0.04	-0.03	-0.01	-0.56	0.54	-0.34*	0.26	0.04	1

*Significant, P<0.05

KEY:Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape

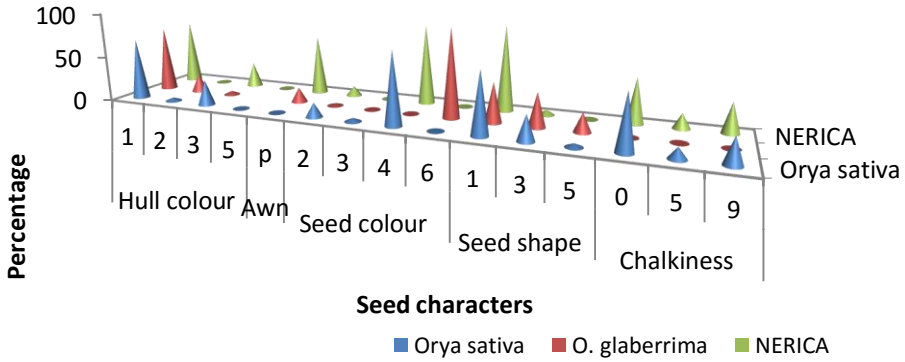


Figure 1: comparative seed polymorphism of three rice (*Oryza* spp) species

Table 5: Seed polymorphism evaluated amongst 18 NERICA genotypes.

S/NO	Genotypes	Hull color	Awn P/A	Awn length	SC	SS	CLK	BrL (mm)	BrW(mm)	GL (mm)	GW (mm)
1	NERICA-L-41	1.00b	0.00b	0.00c	3.67b	1.00b	0.00c	1.40c	0.36abc	1.73cde	0.43abc
2	NERICA-L-11	1.00b	1.00b	0.00c	2.00c	1.00b	0.00c	1.51b	0.31b-g	1.80cd	0.50a
3	NERICA-L-12	1.00b	1.00b	0.00c	2.00c	1.00b	0.00c	1.51b	0.33b-g	1.75cde	0.46ab
4	NERICA-L-15	1.00b	1.00b	0.00c	4.00a	1.00b	5.00b	1.60b	0.41a	2.06a	0.44abc
5	NERICA-L-17	3.00b	1.00b	0.00c	4.00a	1.00b	0.00c	1.72a	0.32b-g	2.08a	0.43abc
6	NERICA-L-2	1.00b	1.00b	0.00c	4.00a	1.00b	9.00a	1.54b	0.30c-g	1.83cd	0.40bc
7	NERICA-L-20	3.00b	1.00b	0.00c	4.00a	1.00b	9.00a	1.76a	0.32b-g	1.99ab	0.41abc
8	NERICA-L-3	1.00b	0.33b	1.67c	4.00a	1.00b	9.00a	1.57a	0.27g	1.87bc	0.42abc
9	NERICA-L-34	3.00b	1.00b	0.00c	4.00a	1.00b	0.00c	1.75a	0.33b-f	2.02a	0.44abc
10	NERICA-L-5	3.00b	0.33b	1.67c	4.00a	1.00b	5.00b	1.73a	0.34b-e	1.98ab	0.44abc
11	NERICA-L-58	3.00b	0.33b	1.67c	4.00a	1.00b	9.00a	1.81a	0.30d-g	2.00ab	0.36c
12	NERICA-L-59	1.00b	1.00b	0.00c	4.00a	1.00b	9.00a	1.56b	0.40a	1.69de	0.46ab
13	NERICA-U-1	1.00b	0.33b	1.67c	4.00a	1.00b	5.00b	1.39c	0.30d-g	1.62ef	0.38bc
14	NERICA-U-2	1.00b	1.00a	5.67c	4.00a	1.00b	0.00c	1.24d	0.29fg	1.51fg	0.37bc
15	NERICA-U-3	1.00b	0.33b	1.67c	4.00a	3.00b	0.00c	1.18d	0.36a-d	1.50g	0.47ab
16	NERICA-U-4	1.00b	1.00b	0.00c	4.00a	1.00b	0.00c	1.23d	0.28g	1.51fg	0.41abc
17	NERICA-U-5	1.00b	1.00a	7.00a	4.00a	1.00b	0.00c	1.61b	0.36ab	1.83cd	0.41abc
18	NERICA-U-7	1.00b	0.67ab	3.33b	4.00a	1.00b	9.00a	1.34c	0.33b-f	1.40g	0.43abc
	MEAN	1.56	0.24	1.35	3.76	1.11	3.83	1.52	0.33	1.79	0.43
	CV	0	141.8	127.40	3.62	0	0	3.47	8.98	4.50	11.55
	S.D	0.91	0.43	2.47	0.64	0.46	4.10	0.19	0.05	0.22	0.05
	R^2	1.00	0.60	0.69	0.97	1.00	1.00	0.95	0.73	0.91	0.46
	P VALUE	0.0001	0.0034	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.14

Means with the same subscript along columns are not significantly different ($p<0.05$) using the Duncan Multiple Range Test.
KEY:Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape, Clk-Chalkiness of Endosperm

Table 6: Correlation coefficients of evaluated seed characters for NERICA genotypes.

Parameters	H C	Awn P/A	Awn length (cm)	BrL (mm)	BrW (mm)	GL (mm)	GW (mm)	SC	SS	CLK
H C	1									
Awn P/A	-0.16	1								
Awn length	-0.17	0.98*	1							
BrL (mm)	0.74*	-0.18	-0.16	1						
BrW(mm)	-0.08	-0.10	-0.06	0.10	1					
GL (mm)	0.65*	-0.27	-0.25	0.85*	0.13	1				

GW (mm)	-O.11	-0.20	-0.19	-0.04	0.43	0.02	1			
SC	0.24	0.21	0.21	0.04	0.04	0.03	-0.34	1		
SS	-O.15	0.05	0.03	- 0.43	0.15	-0.32	0.19	0.09	1	
CLK	-0.04	0.07	0.06	0.28	0.01	0.08	-0.24	0.36	-0.23	1

*Significant, P<0.05

KEY:Brl-Brown rice length, BrW-Brown rice width, GL-Grain length, GW-Grain width, SC- Seed colour, SS- Seed shape, Clk-Chalkiness of Endosperms.

REFERENCES

Anuradha, R., Balamurugan, P., Srimathi, P. & Sumathy, S. (2009). Influence of seed coat Variations on seed quality in bengalgram cv. Co-4 (*Cicer arietinum*). *Legume Research,* 32 (2):136-138.

Baskin, J.M. & Baskin, C.C. (1994). Nondeep simple morpho-physiological dormancy in seeds of the mesic woodland winter annual *Corydalis flavula (*Fumariaceae). *Bulletin of the Torrey Botanical Club,* 121: 40-46.

Carney, J. (1998). The role of African Rice and slaves in the history of Rice cultivated in the Americans. *Human Ecology*, 26(4): 21.

Girish, B., Shahapurmath, G.R., Kumar, A.K.K. & Ganiger, B.S. (2001). Effect of seed size and depth of sowing on seed germination in *Sapindus trifoliatus. My For*, 37:483-489.

Harper, J.L. (1977). Population Biology of Plants (Academic press, London).pp 143.

IRRI, (1997). *Standard Evaluation System for Rice*, 4thedn, IRRI, Philippines. Pp 45-47.

IRRI. (2002). *Rice Almanac*, 3rd IRRI, Philippines. Pp 252.

Latha, M., Suma, A., Asha, K., Nkdwivedi, Mani, S. & Indiradevi, A. (2013). Seed polymorphism in South Indian horsegram (*Macrotyloma uniflorum*(Lam.) Verdc.): A comprehensive study. *Applied Biology and Biotechnology*, 1 (04): 001- 006.

Lin, C.S. & Binns, M.R. (1985). Procedural approach for assessing cultivar-location data: pair wise genotype environment interaction. Lin, C.S., Binns, M.R. and Lefkovitch, L.P. (1986). Stability analysis: where do we stand? *Crop Science,* 26(5): 894-9.

Linares, F. O. (2002). African rice (*Oryza glaberrima):* History and future potential. *Proceedings of the National Academy of Sciences*. 99(25): 16360-16365.

Maclean, J. L., Dawe, D. C., Hardy, B. & Hettel, G. P. editors. (2002). Rice Almanac. Third Edition. Los Barios (Philippines): International Rice Research Institute, Bouake (Cote d'ivoire): West African Rice Development Association, Cali (Colombia): International Center for Tropical Agriculture, Rome (Italy): Food and Agricultural Organization. P 253 of test cultivars with checks. *Canadian Journal of Plant Science*, 65(4): 1065-1071.

Malavasi, M. & Malavasi, U.C. (1996). Effect of seed size on seedling growth of a shade-tolerant tropical tree (*Hymanea stilbocarpa* Haynes). *Tree Plant Notes,* 46: 130-133.

Mandal, B.S., Bahadur, R. & Kaushik, J.C. (1997). Effect of seed size on germination and Seedling growth in *Acacia nilotica* (L.) Willd ex Del. Haryana Agriculture. *University Journal Research*. 27: 125-128.

Murali, K.S. (1997). Patterns of seed size, germination and seed viability of tropical tree species in Southern India. *Biological Tropical,* 29: 271-279.

Richards, R.A. (2000). Selectable traits to increase crop photosynthesis and yield of grain crops. *Journal of Experimental Botany,* 51(1): 447-458.

Samita, S., Anputhas, M. & Abeysiriwardena, D.S. (2005). Accounting for multi traits in Recommending rice varieties for diverse environments. *Experimental Agriculture,* 2:213 225.

Satoh, H., Roland, R.X. & Katayama, T.C. (1990). on the distribution and grain morphology of cultivated rice collected in Madagascar, 1988. Research center for South Pacific, Kagoshima University. *Occational papers,* 18: 63-72.

Semon, M., Nielsen, R., Jones, M.P. & McChouch, S.R. (2005). The population structure of African cultivated rice [*O. glaberrima* (stued.)]: Evidence for elevated levels of linkage disequilibrium caused by admixture with *O. sativa* and ecological adaptation. *Genetics*, 169: 1639-1647.

Siddiqui, U.S., Kumamaru, T. & Saton, H. (2007). Pakistan rice genetic resources-I: Grain morphological diversity and its Distribution. *Pakistan Journal Botany,* 39*(3):841-848.*

Silvertown, J.W. (1984). Phenotypic variety in seed germination behaviour: The ontogeny and evolution of somatic polymorphism in seeds. *American Naturalist*, 124: 1-16.

Sinha A.K., Mallick, G.K. & Mishra P.K. (2015). Diversity of grain morphology on traditional rice varieties (*Oryza sativa* L.) of Lateritic Region of west Bengal. *World Journal of Agricultural sciences,* 11(1): 48-54.

Slafer, G.A. (1994). *Genetic Improvements of Field Crops*. Marcel Dekker Inc., New York, USA. Pp 68.

Souza, E. & Sorrells, M.E. (1991).Relationships among 70 American oat germplasm I. Cluster Analysis using quantitative characters. *Crop Science.* 31(3): 599–605.

Swaminathan, C., VinayaRai, R.S., Sivagnaman, K. & Surendran, C. (1991). Effect of azimuth and crown position on seed germination in *Acacia mellifera* (Vahl)

Benth. Indian. *Journal For Biotechnology*, 14 (3): 220-222.

Vanaja, T. & Babu L.C. (2006). Variation for grain and quality characteristics in rice (*Oryza Sativa* L.). *Indian Journal of Genetics and Plant Breeding*, 66(1): 13-15.

Venudevan, B. & Srimathi, P. (2013). Influence of seed polymorphism on physical, Physiological and biochemical seed quality characters of endangered medical tree Bael *(Aegle marmelos* (L.) corr.*)*. *Academic Journals*, 8(30): 1413-1419.

Ward, R. (2009). Rice cereal quality. *Primefact*, 908.

WARDA, (2008). The New Rice for African-a compendium. West African Rice Development Association, 01 BP 2031 Contonou, Benin. Pp 117.

Xie, L., Tang, S., Chen, N., Luo, J., Jiao, G., Shao, G., Wei, X & Hu, P. (2013). Rice grain Morphological characteristics correlate with grain weight and milling quality. *Cereal Chemistry*. 90(6): 587-593.

PRELIMINARY ASSESSMENT OF PHYSICO - CHEMICAL PARAMETERS OF RIVER KUNKO, DABBAN, NIGER STATE, NIGERIA

Ibrahim, Baba Usman
Department of Biological Sciences Faculty of Natural Sciences Ibrahim Badamasi Babangida University Lapai. Niger State. Nigeria
ibrahimsayuti@yahoo.com
08038273321

ABSTRACT

Study on the effects of human activities on the physico- chemical parameters of River Kunko, Dabban, Niger State was carried out from April, 2016 to July, 2016 which coincide with the raining season. Turbidity (63.26NTU) and temperature (29.11°C) were greater than permissible limits of FEPA (0 -1NTU) and WHO (25°C) respectively for domestic use. Dissolved oxygen (5.30mg/l), Conductivity (86.86 µS/cm), total hardness (32.05mg/l), nitrate (0.62mg/l), total alkalinity (27.79mg/l) and phosphate (0.49mg/l) fell below WHO (2008) tolerable levels, while chloride ion (48.24mg/l) fall within the range allowable for drinking water. There was significant difference (P<0.05) in depth at the various stations, and also in turbidity, temperature, pH, conductivity, chloride, nitrate and transparency between the months. The water of the river was slightly acidic (6.46±0.22) and showed traces of pollution that could pose health concern in the near future. It is recommended that continuous monitoring of water quality parameters should be done for the river. Water from the river should not be consumed without prior treatment.

Key words:- *Human activities, Drinking water, Physico-chemical Parameter, River Kunko*

INTRODUCTION

Water constitutes one of the most precious natural resource without which no form of livelihood is possible. Therefore, quality and quantity of accessible water must be studied to arrive at possible concept of sustainable development. Bamgbose and Arowolo (2007) reported that since scarcity of water is on the increase, there is need for planning, monitoring and management of the existing water bodies. Rivers have become the focal point of much activities and primary candidates as a sink for wastes from all kinds of human activities (Agbede, 1991).

This has resulted to pollution, which is a major problem facing most developing nations including Nigeria. It is a common practice for people living along the river banks to discharge their domestic wastes as well as human excreta into such river. According to Jain (2009), wild and domestic animals drinking from the water can also contaminate the water through direct defecation and urination. Poor drinking water has led to numerous health problems such as diarrhoea, cholera and guinea worm (Jain, 2009). In order to mitigate the impact of human activities on natural waters, it is becoming increasingly important to implement comprehensive monitoring regimes (Bellingham, 2012). However, information on the quality of River Kunko is relatively scanty, which is of great concern. The river is a major source of water to Dabban community because it is used for drinking and other domestic purposes. However, human activities such as washing, bathing, indiscriminate disposal of wastes in water course, and farming activities around the river could pollute the water. This could pose health concern to the people of the community. This study tends to determine the physico-chemical parameters of the river and compare with allowable limits of Federal Environmental Protection Agency FEPA (1998) and World Health Organization WHO (2008).

MATERIALS AND METHOD

Study Area

Dabban Community is located in Lavun Local Government Area of Niger State, Nigeria which lies between latitude: $9^0 16' 03.79'' N$ and Longitude: $5^0 44' 20.96'' E$. Major farming activities that take place include cultivation of guinea corn, banana, and fish farming and the domestic activities include washing of cloth, plate and bathing.

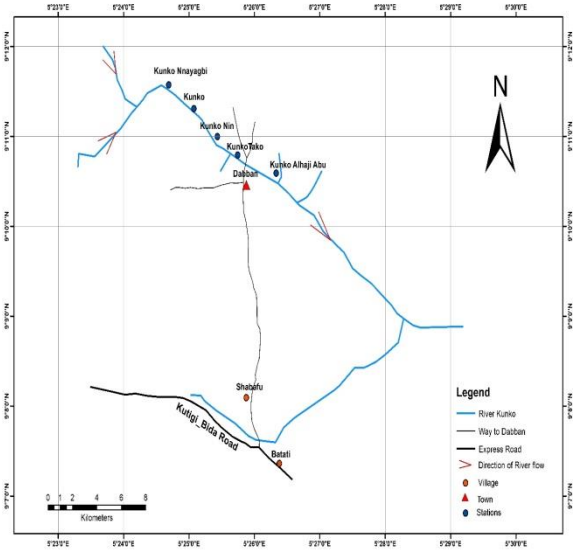


Figure 1: Showing the samplings station on River Kunko, Dabban, Niger State, Nigeria

Sampling stations and Water collection
Water sample were collected from five sampling stations (Kunko Nnayagbin, Kunko Egbako, Kunko Langifu, Kunko Zukomitsun, Kunko Alhaji Abu) on the River Kunko bimonthly from April, 2016 to July, 2016.

DETERMINATION OF PHYSICO – CHEMICAL PARAMETERS

Dissolved oxygen and temperature determination: Dissolve oxygen was determined in mg/l, using dissolved oxygen meter (Jenway 9150). Temperature was determined on site at the time of samples collection using mercury in glass thermometer calibrated in Degree Centigrade. This is in accordance with HACH company laboratory manual (1992).

pH determination: The pH of the samples was determined using Eco Test pH Meter. pH meter was calibrated at 7.0 using buffer solution before measurement. (HACH company laboratory manual, 1992)

Conductivity determination: Electrical conductivity meter (Search Tech, DDS – 307, Manufacture and Model Number) was used to determine the conductivity of water samples. This is done in accordance with HACH company laboratory manual (1992).

Turbidity determination: Turbidity was determined using Turbidimeter (Lovibond turbidirect Model 13/2028) as described by HACH Company Laboratory Manual (1992). A 10 ml of each sample was measured into the curvette of turbidity meter and the respective reading taken. This was done three times and the mean value taken.

Chloride ion determination: The titrant (Silver nitrate[$AgNO_3$]) is titrated against the analyte (water sample) contain potassium dichromate as an indicator, and observed the colour change from yellow to brick red (end point) as described by APHA (2005).

Total hardness and Total alkalinity determination: The titrant EDTA (Ethylene diaminetetraacetic acid) is titrated against the analyte (water sample) contains Net solution (Eriochrome black T) and K10 buffer as an indicator and observed the colour change purple light blue (end point) (APHA (2005). The titrant (Alkalimetric reagent) is titrated against the analyte (water sample) contain Methyl orange as an indicator and observed the colour change from yellow to sunset orange (end point (APHA (2005).

Transparency determination: Transparency was determined using Secchi disc. Transparency was measured by gradually lowering the Secchi disc at respective sampling stations. The depths at which it disappears (A) and reappears (B) in the water were noted. The transparency of the water was computed as follows,

Secchi disc light penetration = A + B / 2

Where, A = depth at which Secchi disc disappears.

B = depth at which Secchi disc reappears.

Trace element determination: Nitrate and Phosphate determination were done using spectrophotometer and the reading was recorded (APHA (1985). Sulphate and Iron were also determined using spectrophotometer and the reading recorded (APHA (1985).

STATISTICAL ANALYSIS
Analysis of variance (ANOVA) was used to test for differences at 5% level of significance. Duncan Multiple Regression was used to separate the means where necessary.

RESULTS AND DISCUSSION
Turbidity (63.26 NTU) recorded (Table 1) was higher than WHO standard of 5 NTU and FEPA (0-1NTU) for domestic use. This did not meet up with the standard guidelines. This could be due to the suspended materials because turbid water has many suspended particles such as silt and clay/mud. According to DWAF (1998) turbid water is usually associated with microbiological contamination. Conductivity (86.86µS/cm) recorded was lower than WHO recommended value of 1250 µS/cm. Andem *et al.* (2012) reported value of 288.76 µS/cm, which was higher than the value of this study. This could be due to the difference in total ions, degree of dissociation and season. The conductivity of River Kunko, Dabban fall within the range 50 - 600µS/cm. This is in line with the findings of Andem *et al.* (2012), who recorded a similar conductivity range value (48 - 600µS/cm) in Ona River, Oyo State. Also total hardness (32.05mg/l) was lower than WHO recommended values of 500mg/l for freshwater. Andem *et al.* (2012) recorded 109.96mg/l total hardness in Ona River, Oyo State. This observation could be due to high concentration of calcium and magnesium ions in the water and utilizing these ions by organisms decrease hardness (Mustapha, 2008). Chlorides concentration of 48.24 mg/l recorded was higher than 0.12mg/l, 1.17mg/l and 0.095mg/l reported by Ugwu and Wakawa (2012) from River Usman, although falls within the range allowable for drinking water (<250mg/l). Phosphate and nitrate are important element that occurs in natural and in

waste water. Phosphate (0.49mg/l) and nitrate (0.62mg/l) were less than the WHO recommended of 6.5mg/l and 50mg/l respectively. The low concentrations could be due to rate of water flow, dilution level and poor algal bloom. Dissolved oxygen (5.30 mg/l) was greater than that of Andem *et al*. (2012) that reported 2.80mg/l. Unpolluted water has dissolved oxygen ranged between 8 and 10mg/l (Rao, 2005). There is trace of pollution, which could be due to high human activities, photosynthesis or diffusion from atmospheric air. Total alkalinity is the buffering capacity of water. 27.79mg/l reported in this study was less than the acceptable range of 30-500mg/l for natural waters. Mean alkalinity (77.5mg/l) was reported by Andem *et al*. (2012), which is higher than the findings of this study. High alkalinity in water is undesirable because it is associated with excessive hardness. The temperature (29.11°C) was greater than 25°C recommended by WHO but fall within the acceptable range (21^{o}C and 32^{o}C) as reported by Olukunle (2000) for aquatic life in tropical waters. Temperature of any water body is dependent upon the sun light, climate and depth according to Atobatele and Ugumba (2008). The pH value obtained (6.46) shows that the water was slightly acidic. This was less than the WHO standard for drinking water (6.5-8.5). pH of water is very important for many biological activities and any variation beyond acceptable range could be fatal to organisms.

Mean water quality parameters varied at the various stations in River Kunko, Dabban (Table 2). Transparency between stations was not significantly different (P>0.05), with highest value at Kunko Nnayagbi (7.58 cm) and lowest at Kunko Langifu (6.53cm). Oso and Fagbuaro (2008) reported that decrease sunlight intensity due to heavy cloud in the atmosphere reduce the quantity of light reaching the water. This could also be the reason for such observation in addition to run-off or flood caused by higher amount of rainfall. Mean temperature did not show significant difference (P>0.05) between the stations with highest at Kunko Nnayagbi (29.19^{o}C) and lowest at Kunko Zukomitsun (29.06^{o}C). This could be due to the cooling effects of the rains and high relative humidity that reduce evaporation of water. The result agreed with the findings of Ayoade *et al*. (2006) that reported temperatures in tropics to vary between 21^{o}C and 32^{o}C. Conductivity in natural water is influenced by dissolved salts such as potassium and sodium chlorides. The absence or low concentration of these salts could be the reason for the insignificant differences observed between stations. Turbidity values recorded at these stations were not within the recommendation of WHO, though Kunko Nnayagbi had the highest mean (80.67mg/l) and lowest at Kunko Zukomintsun (44.75mg/l). This could be due to run-offs and other human activities such as washing, bathing and source of drinking water for animals. Nitrate levels at the stations did not differ significantly (P>0.05) between the stations. Nitrate is among the important parameter of river water showing the pollution status and anthropogenic load in river (Khan and Khan, 1997). Source of nitrates include fertilizers, livestock and waste water discharges. Although these activities were going on around and in the river, the concentration is still within the tolerable level. The values of chloride observed at the stations were not significantly different (P>0.05), and less than the recommendation of WHO. Therefore, chloride contents in the river did not pose any health concern at the stations. The highest depth was recorded at Kunko Zukomintsun (50.06cm) and lowest at Kunko Langifu (12.00cm). The significant difference (P<0.05) could be due to the gradient of the river, volume of water received from source or siltation.

Monthly variation in physico-chemical parameters is a common observation in aquatic environment. The highest turbidity recorded in July, followed by June and lowest in April, which differ significantly (P<0.05) could be due to increase in rainfall that causes high runoffs (Table 3). The lower turbidity experienced in April was probably due to the onset of the rains. Highest temperature (30.12^{o}C) was recorded in April and the lowest was in May (27.90^{o}C), which also show significant differences (P<0.05). This could be due to progression in rainfall increase, which also increase water level. Conductivity increases from April (44.51µS/cm) to July (109.32µS/cm). Asuquo (2000) reported conductivity of freshwater to range from 10µS/cm - 1000µs/cm but can exceed 1000µS/cm. This is within the range recorded during the study. The gradual increase of conductivity with time could be due to the uptake of ions by organisms for their metabolism as reported by Mustapha and Omotosho (2005) or increase in suspended solids and ions. The significant difference (P<0.05) of pH observed could also be due to dilution as a result of increase in water level. Chloride ions increased in May and decreased in June through July, which also differ significantly (P<0.05). Ugwu and Wakawa (2012) reported chloride ions for wet season as 1.17mg/l, which was lower than values for this study. Nitrate also follow the same pattern with chloride and also differ significantly (P<0.05). This observation could be due to increase in water volume, which resulted to more dilution. This is a common phenomenon often observed in many freshwater bodies. Also, Ovie and Adeniji (1993) reported high nitrate during low water level, which was attributed to calm water and low water level that favours settlement of suspended materials and dissolved salt concentration in Shiroro Lake. River

Kunko, Dabban is at the stage of turbulence, hence low nitrate concentration. Transparency decreased across the months, which differ significantly ($P<0.05$). This may be due to increased rainfall that resulted in more mixing thereby making the water more turbid.

CONCLUSION AND RECOMMENDATIONS

This study gave an insight of the physico-chemical parameters of River Kunko, Dabban. Turbidity and temperature were not within the suitable range for aquatic organisms and drinking water as recommended by WHO. Conductivity, total hardness, chloride, pH and dissolved oxygen were below the recommended levels. It is therefore recommended that continuous monitoring of water quality parameters of the river should be done; water from the river should not be consumed without prior treatment. Further study is also hereby recommended to cover the dry season, since the present study was conducted in the rainy season.

Table 1: Mean water quality parameters of River Kunko, Dabban, Niger State, Nigeria

Parameter	Minimum – Maximum	Mean ± Standard Deviation
Turbidity (NTU)	6.23-152.00	63.26±48.78
Temperature (^oC)	26.9-30.8	29.11±0.98
pH	5.9-6.8	6.46±0.22
Dissolved oxygen (mg/l)	4.10-8.21	5.30±0.69
Conductivity (US/cm)	35.70-114.00	86.86±26.62
Total hardness (mg/l)	14.00-74.00	32.05±15.10
Total alkalinity (mg/l)	22.00-44.00	27.79±5.18
Chloride ion (mg/l)	12.60-113.60	48.24±28.51
Phosphate (mg/l)	0.24-0.57	0.49±0.10
Nitrate (mg/l)	0.20-1.50	0.62±0.47
Transparency (cm)	5.00-9.50	7.37±1.04
Depth (cm)	5.00-62.80	30.97±16.23

Table 2: Mean water quality parameters of sampling stations in River Kunko, Dabban, Niger State, Nigeria

Parameter	Kunko Nnayagbi	Kunko Egbako	Kunko Langifu	Kunko Zukomitsun	Kunko Alhaji Abu
Turbidity (NTU)	80.67±65.80	67.69±51.08	51.21±37.50	44.75±31.24	72.01±54.03
Temperature (^oC)	29.19±1.13	29.03±0.90	29.06±0.97	29.19±1.01	29.10±1.15
pH	6.54±0.28	6.38±0.22	6.44±0.18	6.50±0.21	6.45±0.19
Dissolved oxygen (mg/l)	5.44±0.32	5.25±0.22	4.87±0.68	5.38±0.76	5.55±1.09
Conductivity (µs/cm)	88.34±29.40	83.55±26.28	85.78±26.77	88.33±29.24	88.29±28.33
Total hardness (mg/l)	41.25±16.21	27.50±15.25	28.00±14.26	34.75±10.70	28.75±17.26
Total alkalinity (mg/l)	29.25±4.89	26.13±5.99	27.13±6.03	29.63±6.19	30.24±8.55
Chloride ion (mg/l)	45.43±32.47	52.84±35.25	44.90±21.87	44.29±18.65	53.76±36.15
Phosphate (mg/l)	0.51±0.09	0.45±0.12	0.48±0.09	0.51±0.11	0.50±0.10
Nitrate (mg/l)	0.69±0.51	0.58±0.54	0.63±0.39	0.66±0.52	0.54±0.47
Transparency (cm)	7.58±0.89	7.56±1.17	6.53±0.95	7.54±1.03	7.64±0.97
Depth (cm)	17.63±6.21	34.74±7.94	12.00±5.32	50.06±12.05	40.44±6.46

Table 3: Mean monthly water quality parameters of River Kunko, Dabban, Niger State

Month	April	May	June	July
Turbidity (NTU)	7.38±1.37	65.17±41.61	69.11±42.06	111.4±26.83
Temperature (^oC)	30.12±0.48	27.90±0.69	29.09±0.74	29.34±0.35
Ph	6.23±0.28	6.44±0.10	6.56±0.12	6.61±0.10
Dissolved oxygen (mg/l)	5.77±1.14	5.19±0.46	5.26±0.19	4.97±0.41
Conductivity (µS/cm)	44.51±8.54	95.41±11.93	98.18±7.95	109.32±3.88
Total hardness (mg/l)	39.80±26.24	29.40±9.29	30.40±7.78	28.60±7.92
Total alkalinity (mg/l)	31.25±8.93	26.20±2.57	26.50±2.32	27.20±2.53
Chloride ion (mg/l)	29.53±19.20	65.46±32.38	63.28±30.40	34.70±2.71
Phosphate (mg/l)	0.42±0.15	0.51±0.09	0.50±0.08	0.54±0.01
Nitrate (mg/l)	0.31±0.12	0.90±0.54	0.89±0.54	0.37±0.07
Transparency (cm)	8.73±1.78	7.10±0.16	7.03±0.13	6.97±0.12
Depth (cm)	20.44±12.22	29.60±15.68	35.39±15.89	38.46±16.85

REFERENCES

Agbede, O. A. (1991). *Water pollution in Ibadan.* 17th WEDC Conference on Infrastructure, Environment, Water and People, Nairobi, Kenya. 9-12 pp.

Andem, A. B., George, U. U. and Eyo, V. O. (2012). Length Frequency Distribution of (*Chrysichthys nigrodigitatus)* (*Chrysichthys*, Bagridae) from Itu Head Bridge, Akwa Ibom State, Nigeria. *International Journal of Science and Research*, 2 (9):258-260

APHA (1985). Standard methods for the examination of water and wastewater. *American Public Health Association. Washington DC.*

APHA (2005). Standard methods for the examination of water and wastewater. 21st edition, *American Public Health Association. Washington DC.*

Asuquo, P. E. (2000). *Diet composition of Chrysichthys nigrodigitatus and Psedotolithuselongates in Cross-River Estuary, Nigeria.* M.Sc. Thesis, Department of Fisheries and Aquaculture, University of Calabar, Calabar, Nigeria.153pp.

Atobatele, O. E. and Ugwumba, O. A. (2008). Seasonal variation in the physico - chemistry of a small tropical reservoir, Aiba Reservoir, Iwo, Osun State, Nigeria. *African Journal of Bio-technology*,7 (12): 1962-1971

Ayoade, A. A, Fagade, S. O. and Adebisi, A. A. (2006). Dynamics of Limnological features of two man-made lakes in relation to fish production. *African Journal of Biotechnology* 5(10): 1013-1021.

Bamgbose, O. O. And Arowolo, T. A.(2007). Water quality assessment of Ogun River, South west, Nigeria. *Environmental monitoring Assess , Spriger Bussiness Media:* 473 – 478.

Bellingham, K. (2012). *Physico-chemical Parameters of Natural Waters.* Stevens Water Monitoring Systems, Inc.452-5272. http://www.stevenswater.com.

DWAF (1998). *Quality of Domestic Water Supplies. Assessment Guide. 1* (2nd. Ed.) Department of Water Affairs and Forestry, Department of Health and Water Research Commission.

Federal Environment Protection Agency (FEPA) (1998). Report of the Committee on Water Quality Criteria, Federal Water Pollution Administration, pp. 9-10.

HACH (1992). *Water Analysis Handbook.* DR/2010 spectrophotometer manual. HACH Company. USA

Jain, A. K. (2009). *River Pollution.* 1st Edition., APH Publishing, New Delhi, 330 pp.

Khan, S. A. and Khan, M.(1997). Water quality characteristics of the Kabul River in Pakistan under high flow conditions. *Pakistan Journal of Chemical Society*, 19: 205-210.

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.

Mustapha, M. K. and Omotosho, J. S. (2005). An Assessment the Physico-Chemical Properties of Moro Lake, Kwara State, Nigeria. *African Journal of Applied Zoology and Environmental Biology* 7: 73 – 77.

Olukunle, O. (2000). *Homestead Pond Management.* John Archers Publishers Limited, Ibadan, 34pp.

Oso, J. A. and Fagbuaro, O. (2008). An Assessment of the Physico- Chemical Properties of a Tropical Reservoir, South western, Nigeria. *Journal of Fisheries International*, 3(2): 42 - 45.

Ovie, S. I. and Adeniji, H. A. (1993). Zooplankton and environmental characteristics of Shiroro Lake at the extremes of its hydrological cycle. *Hydrobiologia*, 286:175-182.

Rao, P. V. (2005). *Textbook of Environmental Engineering*. Eastern Economy Ed., Prentice-Hall of India Private Limited, New Delhi, Chapter 3, 280pp.

Ugwu, A. I. and Wakawa, R. J. (2012). A study of seasonal physicochemical parameters in River Usuma. *American Journal of Environmental Science*, 8 (5): 569-576

World Health Organization (WHO) (2008). Safer Water, Better Health: Costs, benefits, and sustainability of interventions to protect and promote health : Updated Table 1.

GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY OF WILD GUINEA FOWLS (*Numidea meleagris galeata) FED* DIETS CONTAINING GRADED LEVELS OF FERMENTED CASSAVA (*Manihot palmata*) PEEL MEAL

Alabi, O.J., Ijaiya A.T., Wodi, D.A and Ayanwale, B.A.
Department of Animal Production, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria.
Shola.alabi@futminna.edu.ng

ABSTRACT
The study was carried out to ascertain the growth performance and nutrient digestibility of wild guinea fowls fed diets containing graded levels of Fermented Cassava Peel Meal (FCPM). One hundred and twenty guinea fowls aged three weeks were used. Complete Randomized Design (CRD) was used as the experimental design. Four experimental diets were formulated such that FCPM replaced maize at 0, 25, 50 and 75 % levels. The guinea fowls were randomly allotted to these four experimental treatments, each dietary treatment had three replicates with ten (10) guinea fowls in each replicate. Feed and water were provided ad libitum. The fermented cassava and experimental diets were analysed to determine their proximate composition and energy value. Data on growth performance and digestibility were collected and analysed by one way analysis of variance. Where difference occurred at P<0.05, they were separated using Duncan Multiply Range Test Significant (P<0.05) differences were observed for the final body weights which were 853.33, 873.33, 820.00 and 693.33 g for diets with 0, 25, 50 and 75 % FCPM, respectively. Daily weight gain of 8.33, 8.65, 8.06 and 6.63 g were obtained for diets with 0, 25, 50 and 75 % FCPM respectively with value being significantly (P<0.05) lower for guinea fowl fed 75 % FCPM. The feed conversion ratio (FCR) showed no significant (P>0.05) differences in all the treatment diets. The highest (P<0.05) apparent nutrient digestibility of dry matter, crude protein and crude fibre were obtained at 50 % maize replacement with fermented cassava peel meal in the diet of guinea fowl. It was therefore, recommended that FCPM can be used to replace up to 50 % of maize in the diet of guinea fowls for optimum performance.

Key words: Ferment, cassava (*Manihot palmata*), peel, performance and digestibility

INTRODUCTION

Guinea fowl is a bird with a great potential for providing much needed animal protein in human diets in the developing countries (Adeyemo and Ojejola, 2004). This is because of their high productive potential, short generation interval and valuable nutrient contents (Ayanwale, 2006). They can be used to bridge the gap between demand and supply of animal protein. The potential of poultry in alleviating the problem of protein inadequacies in human nutrition in developing countries is, however, becoming less realizable (Ari, 2006). This is because of insufficient supply and high cost of certain conventional ingredients such as soybeans, groundnut, maize, and fish meal among others. Studies have shown that feeding account for over 60 % of the cost of poultry production. To lower this cost some operators of livestock feed industries compromised standards of the commercial feeds (Kudu *et al.*, 2010). The compromise in most cases leads to lower output, and in some cases total loss of poultry investment as a result of inadequate or nutrients imbalance. Effort has been made toward the reduction of feed cost; one of such is the use of non-conventional feedstuffs. Non-conventional feedstuffs have the potential to reduced cost of feeding if properly utilized. Various non-conventional feed ingredients have been tried on broiler chickens; Maize cob (Adeyemi and Familade, 2003), cassava peel (Dairo. 2011) and yam peel (Akinmutimi and Onen (2008). The uses of some of these non-conventional feedstuffs have some disadvantages such as high anti-nutritional content, high fibre and low protein content. Research works have shown that processing of some of these feedstuffs can reduce the anti-nutritional contents (Adeyemi and Familade, 2003, Dairo. 2011). However, the use of fermented cassava peel has not been tried on guinea fowls. Therefore, this study will determine the effect of graded level of fermented cassava peel meal diets on growth performance and nutrient digestibility of wild guinea fowl.

MATERIALS AND METHODS

Location of Study: The research work was carried out at the Teaching and Research Farm of the Department of Animal Production, Federal University of Technology, Bosso Campus, Minna, Niger State, Nigeria. Minna lies between latitude 28°N to 37°N and longitude 23°E to 33°E with annual rainfall of 1000- 1500 mm. Minna is located in the Southern Guinea Savanna Vegetation Zone (Niger State Agricultural Development Project, 2009).

Processing and Feed Formulation: Fresh cassava (*Manihot palmata*) peels were collected from a local cassava processing factory in Gwari Market, Minna. The cassava peels were washed and soaked in water inside a closed plastic drum for three days for fermentation. The fermented peels were air-

dried for seven days on spread polythene bags. The dried fermented peels were ground to pass through 2 mm disc using electrical grinding machine (6F-P150 Grinding Machine and Flour Mill (Tofu Making Machine).

Maize, groundnut cake (GNC) and other micro ingredients were purchased from Kure Modern Market, Minna. The four (4) experimental diets were formulated such that the control diet contained no fermented cassava peel meal while diets 2, 3 and 4 contained weight for weight 25, 50 and 75 % fermented cassava peel meal respectively as replacement for maize (Table 1)

Experimental Design and Animal Management

One hundred and twenty guinea fowls of three weeks of age were used for the experiment. They were hatched at the Department Farm. The birds were sorted and randomly allotted into the four dietary treatments in a Completely Randomized Design (CRD) layout. Each treatment had 30 guinea fowls that were divided into three replicate groups each. The dietary treatments were fed for 12 weeks.

The birds were raised on a deep litter. The birds were vaccinated against Gumboro disease at the first week of age and this was repeated at the second week of age. At fourth to eight week, Newcastle vaccine (NDV Lasota) was administered. All other management practices such as administration of anti-coccidial (coccidiostat), anti-stress and anti-biotic were strictly adhered to against outbreak of any poultry disease. Routine management operations were carried out on daily basis which include cleaning of drinkers, feeders, provision of clean water and feeds. The feed given and leftover were weighed and recorded daily.

Data collection: Feed intake was measured daily by subtracting the weight of feed leftovers from the feed offered, and the difference was divided by the total number of birds per pen per day. The initial live weights of the birds were taken when the birds were three weeks old and thereafter, mean live weight per pen was measured at weekly interval by weighing the birds in each pen and dividing the weight by the total number of birds in the pen. Feed conversion ratio was calculated by dividing the average feed intake by the average weight gain in each pen.

Table 1 Composition of the experimental guinea fowl diets

Ingredients	$FCPM_0$	$FCPM_{25}$	$FCPM_{50}$	$FCPM_{75}$
Maize	44.40	33.30	22.20	11.10
FCPM	0.00	11.10	22.20	33.30
Groundnut cake	38.90	38.90	38.90	38.90
Maize bran	10.00	10.00	10.00	10.00
Fish meal	2.00	2.00	2.00	2.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values				
ME (kcal/kg)	2565.62	2409.77	2255.70	2100.75
Crude protein%	23.91	23.48	23.05	22.62
Crude fibre%	3.76	4.51	5.27	6.02
Methionine	0.20	0.24	0.22	0.23
Lysine	0.88	0.85	0.82	0.79

Keys: FCPM – Fermented cassava peel meal; $FCPM_0$ - 100 % maize: 0 % FCPM; $FCPM_{25}$ – 75 % maize: 25 % FCPM; $FCPM_{50}$ – 50 % maize: 50 % FCPM; $FCPM_{75}$- 25 % maize: 75 % FCPM

Digestibility: Apparent nutrient digestibility was carried out when the birds were 12 weeks old; the total collection method was used. It was conducted in specially designed metabolic cages having separated watering and feeding troughs. Four birds were selected from each replicate and transferred to metabolic cages for the measurement of apparent nutrient digestibility. A three-day acclimatization period was allowed prior to a four-day collection period. Droppings voided by the bird were collected on a daily basis at 9.00 hours. Care was taken to avoid contamination from feathers, scales, debris and feeds. Apparent nutrient digestibility was calculated as nutrient in feed consumed minus nutrient in faeces voided divided by nutrients in feed consumed multiply by 100 (AOAC, 2005).

Proximate Analysis: The fermented cassava peel meal, experimental diets and the faecal samples were analysed for crude protein, ether extract,

crude fibre, ash and nitrogen free extract contents using AO AC (2010) analytical methods.

Statistical Analysis
Data on feed intake, growth rate, feed conversion ratio and apparent nutrient digestibility of the birds were analysed using the General Linear Model procedures for statistical analysis of variance (SAS, 2010). Duncan test for multiple comparisons was used to test the significance of differences between treatment means (P<0.05).

RESULTS
The results of the chemical composition of Fermented Cassava Peel Meal (FCPM) used in this research are shown in Table 2. The fermented cassava peel meal had dry matter content of 89.50 %, crude protein 5.70 %, crude fibre 14.83 %, ether extract 0.47 %, ash 9.47 % and nitrogen free extract 59.03 %. Fermentation reduced the Hydrogen cyanide (HCN) content by 59.88%. The fermented cassava peel had a calculated metabolizable energy (ME) value of 288.68 kcal/kg.

The results of the proximate and energy composition of the experimental diets fed to the guinea fowls are presented in Table 3. All parameters measured were influenced (P<0.05) by FCPM treatments. Dry matter of the diets ranged between 90.41 % and 91.28 %, the highest being that of diet with $FCPM_{25}$ (91.28 %) and diet with $FCPM_{50}$ had the lowest value. Crude protein contents was between 24.18% and 27.30 %, the highest been for diet $FCPM_{75}$ and control diet had the lowest crude protein (CP) value. Diet $FCPM_{75}$ had the highest crude fibre (CF) while diet $FCPM_{50}$ had the least. Ether extract results showed that diet $FCPM_{25}$ had the highest value while the least value was recorded for diet $FCPM_{50}$. The ash value result was between 9.70% ($FCPM_{50}$) and 13.35 ($FCPM_{25}$). Nitrogen free extract results in the diets ranged from 41.59 % ($FCPM_{25}$) to 45.10 % ($FCPM_0$). Diet $FCPM_{75}$ had the highest metabolizable energy while $FCPM_{50}$ had the lowest.

Feeding of graded levels of fermented cassava peel meals had no significant (P>0.05) difference on initial body weight and feed conversion ratio of the guinea fowls (Table 4) However, the final body weight, daily weight gain and feed intake were significantly (P<0.05) influenced by FCPM treatments. The final weight and daily weight gain results showed that birds on $FCPM_0$, $FCPM_{25}$ and $FCPM_{50}$ diets had similar (P>0.05) values. However, their values were higher (P<0.05) than birds on $FCPM_{75}$ diet. Results of daily feed intake showed that birds on $FCPM_0$, $FCPM_{25}$, and $FCPM_{50}$ diets had similar (P>0.05) values. Birds on $FCPM_{50}$ and $FCPM_{75}$ diets also had similar (P>0.05) feed intake. However, birds on $FCPM_0$ and $FCPM_{25}$ diets had higher (P<0.05) daily feed intake than those birds on $FCPM_{75}$ diet.

Apparent nutrient digestibility results showed that all parameters measured were influence (P<0.05) by FCPM treatments except the ether extract (Table 5). The dry matter digestibility results showed that birds on $FCPM_0$, $FCPM_{50}$, and $FCPM_{75}$ diets had similar (P>0.05) values. Birds on $FCPM_0$ and $FCPM_{25}$ diets also had similar (P>0.05) results. However, birds on $FCPM_{50}$, and $FCPM_{75}$ had higher dry matter digestibility than those birds on $FCPM_{25}$ diet. The crude protein and crude fibre digestibility results showed that birds on $FCPM_{50}$ had the highest value; their values were , however, only higher (P<0.05) than birds on $FCPM_0$ and $FCPM_{25}$ diets. Birds on $FCPM_{25}$ had the lowest ash and nitrogen free extract (NFE) digestibility and were significantly lower (P<0.05) than those birds on $FCPM_0$, $FCPM_{50}$ and $FCPM_{75}$ diets which had similar (P>0.05) values.

Table 2: Chemical composition of fermented cassava peel meal (FCPM)

Parameter	Composition
Dry matter %	89.50
Crude protein %	5.70
Crude fibre %	14.83
Ether extracts %	0.47
Ash %	9.47
Nitrogen free extracts %	59.03
HCN of fresh cassava peel meal (Mg/kg)	17.20
HCN of fermented cassava peel meal (Mg/kg)	6.90
Reduction in HCN (%)	59.88
Energy in kcal/kg (ME)	288.64

Table 3: Proximate and energy composition of the experimental diets (%)

Component	$FCPM_0$	$FCPM_{25}$	$FCPM_{50}$	$FCPM_{75}$	SEM
Dry matter	90.82[b]	91.28[a]	90.41[d]	90.83[c]	0.092
Crude protein	24.18[d]	24.92[c]	26.25[b]	27.30[a]	0.371
Crude fibre	4.89[b]	4.47[c]	4.20[d]	6.87[a]	0.311
Ether extract	6.85[b]	6.95[a]	4.25[d]	4.45[c]	0.285
Ash	9.80[c]	13.35[a]	9.70[d]	11.15[b]	0.278
Nitrogen free extract	45.10[a]	41.59[d]	43.34[c]	43.73[b]	0.442
Energy in kcal/kg (ME)	338.77[b]	328.59[c]	316.61[d]	364.22[a]	5.301

[a, b, c, d] Means of the same row with different superscript are significantly (P<0.05) d different

Keys: FCPM – Fermented cassava peel meal; $FCPM_0$ - 100 % maize: 0 % FCPM; $FCPM_{25}$ – 75 % maize: 25 % FCPM; $FCPM_{50}$ – 50 % maize: 50 % FCPM; $FCPM_{75}$- 25 % maize: 75 % FCPM

Table 4: Performance of guinea fowl feed diets containing graded levels of fermented cassava peal meal

Parameters	$FCPM_0$	$FCPM_{25}$	$FCPM_{50}$	$FCPM_{75}$	SEM
Initial weight (g)	143.33	146.67	143.33	146.67	0.135
Final weight (g)	853.33[a]	873.33[a]	820.00[a]	693.33[b]	0.272
Daily weight gain (g)	8.33[a]	8.65[a]	8.06[a]	6.63[b]	0.306
Daily feed intake (g)	4.55[a]	4.56[a]	4.33[ab]	3.96[b]	0.280
FCR	1.83	1.91	1.86	1.68	0.183

[a, b] Means of the same row with different superscript are significantly (P<0.05) d different

Keys: FCR- Feed conversion ratio; SEM - Standard error mean ; FCPM – Fermented cassava peel meal; F FCPM – Fermented cassava peel meal; $FCPM_0$ - 100 % maize: 0 % FCPM; $FCPM_{25}$ – 75 % maize: 25 % FCPM; $FCPM_{50}$ – 50 % maize: 50 % FCPM; $FCPM_{75}$- 25 % maize: 75 % FCPM

Table 5: Apparent nutrient digestibility of guinea fowl fed diets containing graded level of fermented cassava peel diets

Parameters	$FCPM_0$	$FCPM_{25}$	$FCPM_{50}$	$FCPM_{75}$	SEM
Dry matter	94.01[ab]	93.09[b]	95.84[a]	95.49[a]	0.082
Crude protein	91,30[bc]	89.51[c]	94.36[a]	93.93[ab]	0.722
Crude fibre	75.01[c]	80.69[bc]	92.14[a]	86.34[ab]	0.054
Ether extract	96.94	96.15	95.83	96.86	0.086
Ash	90.50[a]	85.68[b]	90.50[a]	91.06[a]	0.728
NFE	98.85[a]	97.43[b]	98.39[a]	98.33[a]	0.091

[a, b, c, d] Means of the same row with different superscript are significantly (P<0.05) d different

Keys: FCPM – Fermented cassava peel meal; $FCPM_0$ - 100 % maize: 0 % FCPM; $FCPM_{25}$ – 75 % maize: 25 % FCPM; $FCPM_{50}$ – 50 % maize: 50 % FCPM; $FCPM_{75}$- 25 % maize: 75 % FCPM

DISCUSSION

The low protein (5.70 %) and high crude fibre (14.83) of fermented cassava peel meal obtained in this study is similar to the 6 % and less than the 30 % earlier reported by Aro *et al.* (2010) for crude protein and crude fibre levels of cassava peel meal respectively. Wood (1992) also recommended that levels of cassava usage should be lower than 50 % inclusion or less than 50 mg HCN per kg in feed of poultry birds.

The calculated energy values of between 316.61 and 364.22 kcal/kg for all experimental diets was higher than 2990 and 3200kcal/kg metabolizable energy recommended by Ayanwale and Kudu (2001) for growing guinea fowl. The range of crude protein content of the experimental diets was higher than the ranged (18-26 %) recommended by Ayanwale and Kudu (2001) and Hunton (2007). The high crude protein observed in diet containing 75 % FCPM could be attributed to higher FPCM inclusion level. The result showed that the CP content increased with inclusion level increment. The increase in crude fibre in the diet might be as a result of high fibre content of FCPM which is in agreement with the report of Adesehinwa (2008). The author reported that cassava peel meals are fibrous in nature. This implies that the higher content of fermented cassava peel meal in the diets have tendency to reduce nutrient utilization which in turn affects the final weight, daily weight gain and daily feed intake of the guinea fowl, as observed by Salami (2000) that the birds showed aversion to cassava peel meal especially at the higher inclusion levels in diets.

Weight gain decreased as maize is been replaced with fermented cassava peel meal at 25, 50 and 75 % though only significantly at 75 % replacement. The lowest feed intake observed in 75 % FCPM treatment group was similar to the findings of Eruvbetine *et al* (2003) who reported that birds cannot tolerate cassava peel meal at levels beyond 50 % replacement at the expense of dietary maize. Sogunle *et al.* (1994) also observed that the growing pullets performed poorly with increasing levels of cassava peel meal in the diets. Final and daily weight gains showed similar

trend. Pido *et al.* (1997) reported that replacement of maize with cassava meal up to 50 % in broiler chickens' diets resulted in higher body weight gain.

The digestibility of the guinea fowls indicated differences in all the parameters measured except ether extract. The dry matter, crude protein and crude fibre were better digested by the guinea fowls fed diets containing fermented cassava peel meal at 50 %. From the growth performance result, birds on this treatment had better utilization. This result is in line with the findings of Sogunle *et al.* (1994) who reported that feeding cassava peel to poultry birds resulted in better nitrogen utilization and nutrient digestibility. The findings of this digestibility experiment which indicated significance differences ($P<0.05$) in most of the parameters measured is in agreement with the report of Urbano *et al.* (2005) who reported that fermentation of cassava peel meal improved not only the nutritional quality of the cassava, but equally improves the nutrient bio-availability in livestock. The crude fibre digestibility values were lower in all the treatments; this is similar to the findings of Oduguwa *et al.* (2007) who reported that birds are less efficient at digesting of fibre. The lower digestibility could be due to the type of fibre in the diets, since fibre from different sources could vary in their digestibility depending on the proportions of cellulose, hemicelluloses and lignin. The low values of NFE digestibility observed in this study is not well understood; it might mean that the guinea fowl digestive system is not well developed enough to handle the high content of fermented cassava peel meal in the diets.

Conclusion and Recommendation

There were no differences in the weight gain, feed intake and feed conversion ratio of birds fed the control, 25 and 50 % FCPM diets. This suggests that this non-conventional feedstuff (fermented cassava peel meal) can be used to replace maize up till 50 % in the diets of guinea fowls without negative impact on the weight gain, feed intake and feed conversion ratio. However, at higher level of 75 % replacement of maize with FCPM, the weight gain and feed intake were impaired.. It could be, thus, recommended for improve weight gain, feed intake and feed conversion ratio maize can be replace up to 50 % with FCPM.

References

Adesehinwa, A.O.K. (2008). Energy and protein requirements of pigs and the utilization of fibrous feedstuffs in Nigeria: A review. Afr J Biotech. 7:4798–4806.

Adeyemi, O.A. and Familade F.O. (2003). Replacement of Maize by Rumen Filtrate Fermented Corn-Cob in Layer Diet. *Bioresource Tech*. 90: 221- 224.

Adeyemo, A.I and Ojejola, O. (2004). Performance of guinea fowl fed varying levels of poultry droppings. *International Journal of poultry science* 3 (5): 357 - 360.

Akinmutimi, A.H. and Onen, G.E. (2008). The response of broiler finisher birds fed graded levels of yam peel meal in place of maize-based diets. Int. J. Poult. Sci., 7: 474-479.

AOAC. (2005). Official Method of Analysis of Association of Official Analytical Chemists, International (18th ed.), Washington D.C.

Ari, M.M (2006). An evaluation of the effect of various processing methods on the utilization of soybeans (Glycine maximum) by broiler Ph.D thesis submitted to Postgraduate School. Federal University of Technology, Minna.

Aro, S.O., Aletor, V.A., Tewe, O.O. and Agbede, J.O. (2010). Nutritional potentials of cassava tuber waste: a case study of cassava starch processing factory in South- Western Nigeria. *Livestock Research and Rural Development.* 24(3).

Ayanwale, B.A. (2006). Growth and carcass characteristics of broiler fed alkali Processed soybeans. *Nigeria Journal of Animal Production* 33(1): 40 - 44.

Ayanwale, B.A. and Kudu, Y.S. (2001). The response of Wild West Africa guinea fowl to varying levels of dietary protein under intensive management. *Tropical Journal for Animal Science* 4(2): 13-19

Dairo F.A.S.(2011). Utilization of ensiled metabolizable mixture of cassava peel and caged layers' manure as energy source in broiler diets. Afr J Food Agric Nutr Dev, 11 (5) (2011).

Eruvbetine, D., Tajudeen, I.J., Adeosun, A.I and Olejede A.A (2003). Cassava *(manihot esculenta)* leaf and tuber concentrate in diets for broiler chickens. *Bio resources Technology*. 86 :277–281.

Hunton, P. (2007). Poultry production world Animal Science Series C9.Elsevier. ISBN- 13-978-0-444 - 88965-2, ISBN-100 444 - 88965 – 5

Kudu, Y.S., Ayanwale, B.A.,. Shiawoya, S.L., Aremu, A., Jiya E.Z and Masodomi, V. (2010). Growth performance of wild indigenous guinea fowls (Numidea meleagris galeata) fed graded levels roasted negro coffee (*Senna occidantalis*) seed meal. Proceeding of 35th Annual Conference of the Society for Animal Production. (NSAP) University of Ibadan, Nigeria. 14th-17th March, 2010.315-318

Niger State Agricultural Development project. (2009). Quarterly Farmers' magazine, 27 series.

Oduguwa, B.O., Jolaosho, A.O. and Ayakoso, M.O (2007). Effect of ensiling on the physical properties, chemical composition and mineral contents of guinea grass and cassava tops silage. *Nigeria Journal of Animal Production,* 34(1): 100-106.

Pido, P.P., Adeyanju, S.A and Adegbola, A.A (1997). The effect of graded levels of fermented

cassava meal on broilers. Poult. Sci. 58: 427-431.

Salami, R.I (2000).Preliminary studies on the use of parboiled cassava peel meal as a substitute for maize in layer diets. *Tropical Agriculture (Trinidad) 11:199* -204

SAS, 2010. Statistical Analysis System. SAS User Guide: Release 9.2. SAS Institute Inc, Cary NC, USA

Sogunle, O.M., Fanimo, A.O., Abiola, S.S. Bamgbose, N.K Tewe, O.O. (1994). Indices of cassava safety for livestock feeding. *Act Horticulture*. 375:241-249.

Urbano, G., Arada, P., Vilchez, A. and Arada, C. (2005). Effect of germination on the composition and nutritive value of proteins in pisum sativum, L. *Food Chemistry*, 93(2005)671-679

Wood, J.F. (1992). Quality aspects of tradable cassava products including problems of in Proceeding of the FAO Expert Consultation, on Roots, Tubers Plantation and Bananas in Animal Feeding Cl AT Cali Colombia 67-80.

FISH DIVERSITY AND PHYSICO-CHEMICAL PARAMETER ASSESSMENT OF RIVER YAURI, KEBBI STATE, NIGERIA

Ibrahim, Baba Usman
Department of Biological Sciences, Faculty of Natural Science, Ibrahim Badamasi Babangida University, Lapai, Nigeria
ibrahimsayuti@yahoo.com, 08038273321

ABSTRACT
Studies on the fish diversity and physico-chemical parameters of River Yauri was carried out between April 2016 and September 2016. Twenty - five species belonging to sixteen (16) families were recorded. Mormyridae and Alestidae were the most diverse with 4 species, followed by Cichlidae, Claroteidae, Cyprinidae and Mochokidae with 2 species each. Oreochromis niloticus was the most abundant (15.58%) while Polypterus senegalus was the least (0.05%). On the overall Zamare sampling station was the most diverse in fish species, followed by Yelwa while the lowest was Bakin Ruwa. There was no significant differences (P>0.05) in fish abundance at the sampling stations in River Yauri during the period of study. Yelwa was highest in fish richness, followed by Bakin Ruwa and lowest in Kangiwa. In terms of eveness index, Yelwa was the most even, followed by Kangiwa while the least was Bakin Ruwa. Mean physico-chemical parameters at the sampling stations showed variations in the river during the period of study. There were significant differences (P<0.05) in alkalinity, DO_2, PO_4, total dissolved solids, and the values fall within acceptable limits for aquatic life, although depletion of DO_2 was recorded at Yelwa and Kangiwa. Water quality parameters need to be monitored, and also assessment of fish catch on routine basis should be done in order to ascertain any changes that occur in fish diversity.

Keywords: Water quality, Fish diversity, River Yauri, Nigeria

INTRODUCTION
Nigeria is endowed with abundant natural resources, comprises of fresh, brackish and marine water bodies, similarly are plant and animal communities including fishes. Fish is an important resource exploited by human over the centuries. Fisheries involve fishermen, types of fish species, area of water body, methods of fishing, types of boats and purposes of activities (FAO, 2013). Fishes are found in the aquatic environment such as reservoir, river, stream, lake, and swamps. They vary widely in their physiology, morphology, tolerance and response to the surroundings**.** According to Karr *et al.* (1986) a number of physical factors such as, water quality, its quantity, and habitat structure can limit the ecological success of fish population. Fish accounts for 30% of animal protein consumed in Asia, 20% in Africa and 10% in Latin America and the Caribbean and globally (Prein and Ahmed, 2000).

Diversity is the species quality or state of having many different varieties of fish species in abundance, forms and types.. The importance of water to fish can be equated to that of air to terrestrial animals. Therefore, water quality does not only determine how well a fish is growing, but also whether or not they will survive in a particular aquatic environment. Ufodike and Garba (1992) emphasized that changes in these properties will affect the growth, survival, diversity and distribution of fishes.
This study was conducted to assess the water quality of the river Yauri and its fishery diversity.

MATERIALS AND METHODS
Study Area
River Yauri falls within the wetland and floodplain of the Niger/Sokoto River Basin. It's seasonally flooded by the interwoven connection of River Sokoto and River Rima, which are tributaries of river Niger (Hughes and Hughes, 1991). River Yauri lies in the Northern Guinea Savannah zone between Latitude $4^0$46'40" East and Longitude 10^0 44'5" North. (Figure 1). The climate is characterized by distinct dry and rainy season.

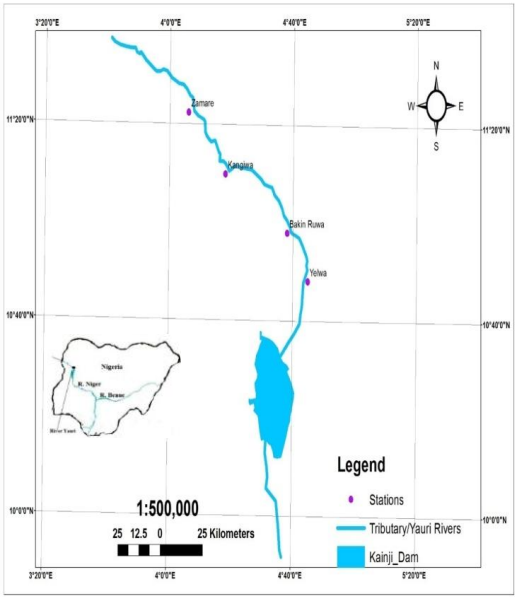


Figure 1: Showing the sampling stations on River Yauri, Kebbi State, Nigeria. (Source: Google earth Maps, 2016).

Collection of fish and water samples

Fish and water samples were collected bimonthly between April 2016 and September, 2016 at four landing sites designated as station I (Bakin ruwa), station II (Yelwa), station III (Kangiwa) and station IV (Zamare). Fish samples were obtained from the fishermen that make use of different kind of fishing gears such as gill nets of various mesh sizes, cast nets and clap nets. They were counted, identified and classified using distinctive features described by Idodo-Umeh (2003). Water samples for quality analysis were collected in two polythene rubber of one liter capacity at each station.

Biodiversity Parameters

Diversity:- evenness and richness indices were calculated using the following formulas:

Shannon-Weaver diversity index, $H = -\Sigma$ Pi ln Pi, (Shannon and Weaver, 1949)

Evenness index, $e =$ H/ln s, (Pielou, 1966)

Where H is the diversity index, *Pi* is the relative abundance (s/N), *s* is the number of individual for each species, *N* is total number of individuals, *D* is the richness index, *S* is the total number of species, *e* is the similarity or evenness index and *ln* is the natural logarithm.

Physico-chemical parameters

The following physico–chemical parameters were determined; Water temperature was determined on the field using digital mercury thermometer (Model Ts – 2) calibrated in degree centigrade (°C). The dissolved oxygen was determined by using the modified Winkler Azide method (Lind, 1979, APHA, 1992). The pH of the water was determined with a pH meter (Pye Unicam model 392) at 25 (^{O}C). The electrical conductivity of the water sample collected from the four sampling stations were measured in the laboratory using a conductivity meter (Model Pye Unicam 292). The electrical conductivity of water sample taken was expressed in micro–ohms per second (µs/cm). Total alkalinity was determined by measuring 100ml of water sample in 250ml Elenmeyer flask, three drops of phenolphthalein indicator were added. If the sample turned pink, it would be titrated with 0.02N H_2SO_4, until the pink colour just disappear and the millilitre(s) (ml.) of acid used recorded for alkalinity calculation. Nitrate and Phosphate determination was done as follows:- distilled water was used to rinse the cuvette, and 10ml of distilled water were measured into it and spectrophotometer was adjusted to the zero level. 10ml of water sample was poured into the cuvette, followed by nitrate powder pillow added into the water sample in the cuvette, shake it for few second and analysed it using spectrophotometer, and the Nitrate reading recorded. While for Phosphate – phosphorus, distilled water was used to rinse the cuvette and 10ml of distilled water was measured into it and spectrophotometer adjusted to zero level. 10ml of water sample was added into the cuvette, and phosphate powder pillow added into the water sample in the cuvette. It was shake for few second, and analyzed using spectrophotometer and the reading was recorded (APHA (1992).

Statistical analyses

Means, percentages, standard deviations and ranges were computed from the data collected using descriptive statistics. Analysis of variance (ANOVA) was used to test for significant difference in parameters determined. Least Significant difference (LSD) and new Duncan Multiple Range Test (NDMRT) was carried out to rank means.

RESULTS AND DISCUSSION

The composition of fish from River Yauri is shown on table 1. Twenty-five species of fish belonging to sixteen families were recorded. Dan-kishiya *et al*. (2013) and Ibrahim *et al*. (2010) reported 11 species belonging to 5 families in Lower Usuma Reservoir, and 7 species belonging to 9 families in Kontagora Reservoir respectively, which are lower than the present study. Water body size, species abundance, fish migration, availability of food, and better water quality could have led to this observation. Fish species diversity is a measure of the productivity of a given water body. The families Mormyridae and Alestidae were the most diverse with 4 species each. This could be due to the ability to escape predators, better adaptation, availability of food and season. Although Cichlidae did not record highest diversity, *Oreochromis niloticus* was the most abundant by number in the river. Balogun (1986) reported the dominance of Cichlidae on Kainji Lake, which is in line with the result of this this study because the water body falls within River Niger. Balogun (2005) also reported the dominance of family Cichlidae in Kangimi Reservoir. This is attributed to their high prolific nature and tolerance to environmental condition changes. The low number of *Polypterus senegalus* recorded could be due to their population and preference to swampy environment. Fish diversity was higher in Yelwa sampling station than Yauri and also Bakin Ruwa (Table 2). It is a common observation reported in most water bodies that fish diversity differ based on location. Such observation was also reported by Dan-kishiya (2013) in Lower Usuma Reservoir. This could be attributed to fish distribution, abundance, structure and environmental conditions. *Oreochromis niloticus* was the most abundant in all the sites. This could be due to their adaptive ability to the condition of the river. Dan-kishiya reported the dominance of Cichlids in Lower Usuma Reservoir, which is in line with the finding of this study.

. On species diversity, Simpson's (1-D) indices was highest in Yelwa (0.93) and lowest in Bakin Ruwa (0.86). Mergalef Index describes species richness

and this was highest in Yelwa (3.35) and lowest in Kangiwa (2.75). This implies that Kangiwa had the least species richness and also the poorest species diversity (Table 3). This could be due to difference in the topology and environmental conditions of the sampling sites amongst other factors.. The intermediate fish diversity index of Shannon Wirner was found significant at Bakin Ruwa while it was lowest at Yelwa. Evenness index value was significantly high at Yelwa (0.7) , followed by Kangiwa (0.69) while the least even (0.59) was Bakin Ruwa. Dan-kishiya *et al.* (2013) reported values of species richness, species diversity and species evenness of 0.76, 1.64 and 0.76 respectively, which were lower than the values of the present study. Although these indices were different at the sites, the river has high diversity of fish species.

The water in River Yauri showed range of variations of physico-chemical parameters. Electrical conductivity, NO_3 and total alkalinity showed wider ranges (Table 4). This could be due to high quantity of suspended solids or ions, domestic activities, sewage disposal and agricultural activities around the river. Electrical conductivity (60.81 µs/cm), NO_3 (5.12mg/l) and total alkalinity (101.56mg/l) fall within the limits suitable for aquatic life. pH, and total dissolved solids did not show wide range of fluctuations, though also falls within the acceptable range for fish survival and production. The slightly acidic nature of the river could be due to acidic earth metals, mixing of pollutants in the river from human activities such as, washing of clothes, garbage dumping, farming activities among others. Similar observation was reported by Ugwu and Wakawa (2012) in River Usuma. Temperature recorded (30.56^{o}C) was greater than WHO standard (25 ^{o}C) but falls within acceptable range for aquatic life in the tropics. While Bakin Ruwa recorded the highest alkalinity, Kangiwa was lowest, which differ significantly ($P<0.05$). This could be due to difference in the amount of suspended ions and runoffs at these sites. DO_2 with highest value at Zamare (5.85mg/l) and lowest at Kangiwa (3.27mg/l) indicates significant difference ($P<0.05$) between sites. DO_2 above 4mg/l is good and 5mg/l is permissible level in water while below 4mg/l is detrimental to aquatic life. Hence Yelwa and Kangiwa were depleted of oxygen. This could be due to organic load from human activities. PO_4 also differ significantly ($P<0.05$) at the sites where Bakin Ruwa recorded the highest value (5.99mg/l) and Kangiwa lowest value (3.46mg/l). This could be as a result of the level of human activities at sites because domestic activities, runoff from agricultural activities are major sources of phosphates discharge. The significant difference ($P<0.05$) observed in total dissolved solids at sites could be due to the regular discharge of domestic waste and runoff as this work was done during the wet season.

Table 1: Fish composition (%) by number in River Yauri, Kebbi State, Nigeria (April, 2016 - September, 2016)

Family/Fish	No	%
Citharinidae		
Citharinus citharus	143	3.63
Cichlidae		
Sarotherodon galilaeus	321	8.14
Oreochromis niloticus	614	15.58
Clariidae		
Heterobranchus bidorsalis	188	4.77
Claroteidae		
Auchenoglanis occidentalis	155	3.93
Chrysichthys auratus	22	0.56
Latidae		
Lates niloticus	79	2
Mormyridae		
Hyperopisus bebe	201	5.09
Marcusenius senegalensis	152	3.86
Mormyrus rume	434	11.01
Mormyrops anguilloides	235	5.96
Alestidae		
Hydrocynus forskalii	53	1.44
Brycinus nurse	194	4.92
Cyprinidae		
Labeo coubie	276	7
Labeo senegalensis	38	0.96
Mochokidae		
Synodontis gambiensis	109	2.77
Synodontis membranaceus	504	12.79
Bagridae		
Bagrus bayad	88	2.27
Distichodontidae		
Distichodus rostratus	9	0.23
Schilbeidae		
Schilbe mystus	29	0.74
Osteoglossidae		
Heterotis niloticus	76	1.93
Malapteruridae		
Malapterurus electricus	8	0.3
Polypteridae		
Polypterus senegalus	2	0.05
Channidae		
Parachanna obscura	8	0.2
Gymnarchidae		
Gymnarchus niloticus	4	0.1
Total	**3942**	**100**

Conclusion and Recommendation

River Yauri recorded 26 fish species belonging to 16 families with Mormyridae and Alestidae being the most diverse. Fish diversity of the river is high compared with other water bodies within the region. There were differences in fish species richness and evenness at the sampling sites. Physico-chemical parameters of the river

Table 2: Fish composition (%) by number at the sampling sites on River Yauri, Kebbi State, Nigeria (April, 2016 - September, 2016)

Family/Fish	Bakin Ruwa		Yelwa		Kangiwa		Zamare	
	No.	%	No.	%	No.	%	No.	%
Citharinus citharus	38	10.6	100	7.76	5	0.71	196	11
Sarotherodon galilaeus	38	10.6	85	6.59	70	9.94	128	7.2
Oreochromis niloticus	102	28.4	120	9.31	100	14.2	292	16
Heterobranchus bidorsalis	10	2.79	68	5.27	39	5.54	71	4
Auchenoglanis occidentalis	3	0.84	47	3.65	47	6.68	58	3.2
Lates niloticus	1	0.28	25	1.94	18	2.56	35	2
Hyperopisus bebe	8	2.23	80	6.21	13	1.85	100	5.6
Marcusenius senegalensis	-	-	50	3.88	47	6.68	55	3.1
Labeo senegalensis	4	1.11	98	7.60	68	9.66	106	5.9
Hydrocynus forskalii	18	5.01	10	0.77	10	1.42	15	0.8
Mormyrus rume	45	12.5	120	9.31	81	11.5	188	11
Mormyrops anguilloides	15	4.18	79	6.13	42	5.97	99	5.5
Synodontis gambiensis	10	2.79	45	3.49	13	1.85	41	2.3
Labeo coubie	13	3.62	73	5.66	23	3.27	85	4.8
Chrysichthys auratus	5	1.39	3	0.33	9	1.28	5	0.3
Synodontis membranaceus	31	8.64	186	14.43	97	13.8	190	11
Bagrus bayad	5	1.39	32	2.48	16	2.27	35	2
Distichodus rostratus	-	-	4	0.41	1	0.14	4	0.2
Schilbe mystus	-	-	10	0.77	-	-	19	1.1
Brycinus nurse	3	0.84	15	1.22	-	-	20	1.1
Heterotis niloticus	10	2.79	28	1.94	5	0.71	33	1.8
Malapterurus electricus	-	-	3	0.23	-	-	5	0.3
Polypterus senegalus	-	-	1	0.08	-	-	1	0.1
Parachanna obscura`	-	-	3	0.23	-	-	5	0.3
Gymnarchus niloticus	-	-	4	0.31	-	-	-	-
Total	**359**	**100**	**1289**	**100**	**704**	**100**	**1590**	**100**

Table 3: Fish diversity indices at various sampling sites on River Yauri, Kebbi State, Nigeria (April, 2016 - September, 2016)

Diversity indices	Bakin Ruwa	Yelwa	Kangiwa	Zamare
Number of species	359	1289	704	1786
Fish taxa	18	25	19	24
Simpson"s (1-D)	0.86	0.93	0.91	0.92
Mergalef Index (M)	2.89	3.35	2.75	3.07
Shannon Wiener Index (H)	2.36	2.78	2.58	2.7
Evenness Index (E)	0.59	0.7	0.69	0.62

Table 4: Mean physico – chemical parameters of River Yauri, Kebbi State, Nigeria (April, 2016 - September, 2016)

Parameter	Mean±SD	Min – Max
Temperature (^oC)	30.56±1.34	28.00-32.00
DO_2	4.03±0.99	2.24-5.85
pH	6.78±0.20	6.30-7.00
Electrical Conductivity (µS/cm)	60.81±12.05	45.00-91.00
Total Alkalinity (mg/l)	101.56±43.04	50.00-200.00
NO_3 (mg/l)	5.12±1.10	2.36-7.36
PO_4 (mg/l)	4.16±1.31	2.44-6.86
Total Dissolved Solids	0.03±0.007	0.024-0.048

Min: Minimum; Max: Maximum; SD: Standard Deviation; DO: Dissolved Oxygen

Table 5: Mean physico-chemical parameters of sampling sites in River Yauri, Kebbi State, Nigeria (April, 2016 - September, 2016)

Parameter	Bakin Ruwa	Yelwa	Kangiwa	Zamare
Temperature (^oC)	30.88±1.55	30.50±1.51	29.88±1.13	31.00±1.07
DO	4.36±0.93	3.67±0.59	3.27±1.01	4.82±0.72
pH	6.76±0.10	6.85±0.18	6.75±0.33	6.75±0.17
Electrical Conductivity (µS/cm)	58.38±7.60	61.25±14.20	61.00±17.23	62.63±8.53
Total Alkalinity (mg/l)	150.00±53.45	81.25±25.88	75.00±26.73	100.00±0.00
NO_3 (mg/l)	4.74±1.13	5.64±0.63	5.29±1.63	4.83±0.63
PO_4 (mg/l)	5.99±0.69	3.83±0.84	3.46±0.98	3.36±0.42
Total Dissolved Solids	0.041±0.007	0.03±0.005	0.03±0.005	0.03±0.002

DO: Dissolved Oxygen

fluctuated, depletion of DO might have affected fish richness at Kangiwa.

It is therefore, recommended that similar study should be carried out ne for dry season, water quality parameters should be monitored on routine basis and assessment of fish catch on routine basis should also be done in order to ascertain any changes that occur in fish diversity.

REFERENCES

Ajayi, S.S. (1971). Panyam fish farm and the introduction of the European carp (*Cyprinus carpio*). *Nigeria Field,* 36:23-31.

APHA(1992). *Standard methods for examination of water and wastewater*, 20th edition, American Public Health Association. Washington D.C.

Balogun, J. K. (1986). Fish Distribution in Kainji Lake, Nigeria. *Journal of Fish Biology*. 29:489- 498.

Balogun, J. K. (2005). Fish distribution in a small domestic water supply Reservoir: case study of Kangimi Reservoir,Nigeria. *Journal of Applied Science and Environmental Management.* 9 (1): 93-97.

Dan-kishiya, A.S., Olatunde, A. A. and Balogun, J. K. (2013). Ichthyofaunal composition and Diversity of a tropical water supply reservoir: A case study of Lower Usuma Reservoir in Bwari, Abuja, Nigeria. *American Journal of Research Communication*, 1(9):188-203.

FAO(2013).The state of world fisheries and aquaculturewww.fao.org/fi/glossary/default.asp.retrieved.on (24 May, 2013).

Hughes, R. H. And Hughes, J. S. (1991). Directory of African wetlands, IUCN, Switzerland Publication *on Argungu Fishes and Festival, Kebbi State*, Nigeria.

Ibrahim, B.U., Auta, J. A. and Balogun, J. K. (2010). Survey of the fish diversity of Kotangora Reservoir, Niger State,

Nigeria. *Nigeria Journal of Fisheries Science and Technology* 1(1): 77 – 81.

Idodo-Umeh, G. (2003). *Freshwater fishes of Nigeria (Taxonomy, Ecological Notes, Diet and Utilization).* Idodo-umeh publisher limited, Benin City, Nigeria. 232pp.

Karr, J. R., Fausch, K. D., Angermeier, P. L., Yant, P. R. and Schlosser, I. J. (1986). Assessing Biological Integrity in running waters: A method and its rationale. *Illinois Natural History Survey Special Publication 5*, 125pp. Champaign.

Lind, O. T. (1979). *A handbook on limnological methods.* C.V. Mosby Co. St. Louis \publishers, 199pp.

Ufodike, E. B. C. and Garba, A. J. (1992). Seasonal variations in limnology and productivity of a tropical highland fish pond in Jos, Plateau, Nigeria. *Journal Aquatic Science* 7:29-34.

Ugwu, A. I. and Wakawa, R. J.(2010). A study of seasonal physico – chemical parameters in River Usuma. *America Journal of Environmental Science*,8 (5): 569 – 576.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, 13: 131 – 144.

Prein, M. and Ahmed, M. (2000).Integration of Aquaculture into Smallholder Farming Systems for Improved Food Security and Household Nutrition. *Food and Nutrition Bulletin* 21(4):466 - 471.

Shannon, C. E. and Weaver, W. (1949). The mathematical theory of communication. University of Illinois Press, Urbana 45 – 47.

AWARENESS AND KNOWLEDGE LEVEL OF LOCUST BEAN PROCESSING TECHNIQUES AMONG RURAL WOMEN IN SELECTED LOCAL GOVERNMENT AREAS OF KWARA STATE, NIGERIA

[1]Adefalu, L.L., [1]Adisa, R.S., [1]Aderinoye-Abdulwahab, S.A., [2]Balogun, M.A. and [1]Owolabi, O.A.
[1]Department of Agricultural Extension and Rural Development, Faculty of Agric., University of Ilorin, Nigeria
[2] Department of Home Economics and Food Science, Faculty of Agriculture, University of Ilorin, Ilorin, Nigeria
Corresponding Author's E-mail: adefalulateef@yahoo.com
Phone number: 08063468477

ABSTRACT

This study analyzed the awareness of locust-beans processing techniques among rural women in selected LGAs of Kwara State, Nigeria. Four-stage sampling technique was used for selection of respondents. The first stage involved purposive selection of two Local Government Areas (LGAs) based on their prominence in locust bean production in Kwara state. Snow-ball sampling technique was employed to identify the most prominent locust bean processor in each of the selected communities. Each of the identified locust bean processor was used to identify ten locust bean processors in their respective domains, giving a total sample size of 120. Data were subjected to both descriptive and inferential statistics The results showed that the mean age of women processor in the study was 41 years, a little above half (55.0%) of them had no formal education, household size was 7 persons, average processing experience stood at 31.5 years, while the average monthly income of the processors was ₦7,001.00 per. Only 18.3% of the processors indicated awareness of FRIN method while none of them had attempted using it. Respondents' knowledge level on the use of appropriate processing techniques using 5 point likert-type scale shows that salting ranked 1st, while washing after de-hulling was poorly ranked (9th). Limited credit facility was the most severe constraint militating against high productivity of locust bean. Pearson correlation analysis showed that age (p=0.05, r=0.245) was significant and positively related to the constraint faced in locust-bean production while educational level (p=0.004, r=-0.367) and household income (p=0.001, r=-0.405) were significant but inversely related to constraint to locust-bean production among respondents. The study therefore concluded that processing of locust-bean is mostly done using traditional method, while low literacy and income levels were probably responsible for poor adoption of improved methods of processing locust bean. Extension agents are therefore encouraged to carry out awareness campaign on the advantages inherent in the use of improved locust bean processing methods so as to enhance productivity.

Key words: Locust bean, Processing techniques, Improved methods, Rural women.

INTRODUCTION

Nigeria is blessed with abundant agricultural produce but poverty is still widespread in the country and has increased since 1990s. Above 70% of Nigerians live on less than 1.25USD per day (International Fund for Agricultural Development, 2009). The situation is further worsened simply because local condiments such as *dawadawa/iru*, with high nutritional value are gradually been neglected at the expense of foreign condiments like cubes of different brands even though, they are more expensive with less nutritional values compared to the latter. Although, what people eat vary, just as there are different ethnic groups with different culture, the consumption of dawadawa cuts across ethnic groups and even transcends international borders. Notwithstanding, every region has its own peculiar food which may depend primarily on culture, heritage, tradition and religious belief (Abdel et al., 2009; Adebayo et al., 2010).

African locust bean processing into food condiment has been an age-long occupation in the rural areas and has served as a means of income generation and food security among women. However, locust bean processing has suffered a low occupational status as the processors are somewhat associated with poverty despite the widespread demand for their products. Traditionally, processing of Africa locust bean seed among the rural women and children still remains tedious, time consuming and highly labour intensive (Olaoye, 2011). Several challenges are faced in the processing techniques of locust-bean seeds to food condiment (*dawadawa/iru)*. These include among others, production of locust bean seed on a small scale due to the local processing method used, associated with high wood consumption and poor hygienic practices employed by the processors. This situation is capable of making the consumers of indigenous foods including condiments such as *dawadawa* to be suspicious of the level of hygiene employed in the production process *(Adefalu and Fawole, 2014*). Consequently, the usage and consumption of this condiment may decline, especially among the growing urban population leading to rapid increase in the patronage of imported condiments. In view of the foregoing, this study therefore sought to analyze the locust bean processing techniques among rural women in Kwara State, Nigeria. Specifically, the study described the socioeconomic characteristics of locust bean processors in the study area, examined

the available locust bean processing techniques in the study area, determined the knowledge level of the respondents on the use of locust bean processing techniques and analyzed the constraints to the use of improved locust bean processing techniques among respondents. The study also tested a hypothesis to ascertain if a relationship exist between selected socio-economic characteristics of respondents and the constraints to locust bean production.

Review of available locust bean processing techniques

According to Sadiku and Olajide (2010), six main methods of locust bean processing have been identified and they are discussed below:

Ajibode method: Under this method, the yellow pulp is removed by soaking the pulp-coated seeds for 30 minutes in sun before being soaked in water for 10 minutes and later pounded in mortar with little coarse sand to remove pulp. Washing after pounding is done via a sieve that is almost completely immersed in water. If traces of pulp still remain, pounding is done once more followed by final washing and cleaning of the seeds. De-hulling which is the next stage is the removal of the testa from cotyledon. This is done by soaking the seeds in water for 10-20 hours, followed by cooking which is done for 8 hours with the addition of wood ash and pounding in mortar with little coarse sand to facilitate effective de-hulling. Washing follows de-hulling to recover the milk colored cotyledons. With the addition of potash (K_2Co_3), the clean cotyledons are further parboiled for 30 minutes, packed and kept in a warm cupboard for fermentation.

Saki method: The process employed is similar to that of Ajibode method, except for the addition of wood ash during cooking. Parboiling is done for 35 minutes with the addition of potash.

Forestry Institute of Nigeria (FRIN) method: This method is also very similar to the Ajibode method except that pre-dehulling cooking is done for 6 hours; parboiling of cotyledons is done for 45 minutes; while potash and salt (NaCl) are added during parboiling.

Traditional method: The same procedure as found in the Saki method is employed for this method except that no chemical substance or preservatives is added during processing.

Steam method: This method involves steaming the seeds for four and a half hours immediately after pod shelling, that is seeds coated with the pulp. In the laboratory, a steamer is improvised using cooking pot and metal sieve. The water level in the pot does not reach the base of the sieve and steamed with the pot covered. This method ensures no direct cooking of seeds in water. The steamed seeds are de-hulled by pounding in a rough-surfaced mortar without any addition of coarse sand. Parboiling follows for 30 minutes without addition of potash. The clean beans or cotyledons are fermented for 72 hours. All the methods were carried out in the laboratory under hygienic conditions, using plastic bowls and buckets, cooking pots, coarse sand, hygrometer, thermometer, clean water, electric/kerosene stoves, sieve, weighing balance, measuring cylinders, beakers, small wooden mortar and pestle. Fermentation was done at an average ambient temperature of 28C and 86% relative humidity. The coarse sand used for pulp removal and de-hulling was thoroughly washed and dried before use. Samples of products were analyzed at the International Institute of Tropical Agriculture, Ibadan.

Improved method: This method differs from the Ajibode method because there is 8-10 minutes pre-cooking of the seeds before pulp removal. De-pulped seeds are soaked in water for 72-96 hours, washed and cooked for 3 hours without wood ash before de-hulling. Parboiling of cotyledons takes 30 minutes before being fermented. In this method, some seeds are collected after 15 minutes of parboiling (before the addition of potash) for fermentation as the non-marshy type. However, it is important to note that Kabba and Yam-flour/Shaff methods were discovered on the field in the course of the field work. Kabba method of processing locust bean does not require fermentation and hence, the final product is coarse while yam-flour method employs the use of yam flour instead of sand to facilitate the process of de-hulling of the locust bean.

METHODOLOGY

The study area: The study was carried out in Kwara State, Nigeria. Its capital is Ilorin and other prominent towns in the State include Offa, Omu-aran, Oro, Jebba, Patigi, Lafiagi, Shonga and Kaiama. The State is located between Latitude 8◦ 30′N and Longitude 5 0′E. The primary ethnic groups in Kwara State are Yoruba, Nupe, Fulani, Baruba and Hausa while the population of the State stood at 2,371,089 (National Population Commission, 2006). Agriculture is the main source of the state's economy and the main cash crops are cotton, cocoa, coffee, kolanut, tobacco, beniseed, walnut, and palm produce and few other food crops like cashew, rice, and yam. Mineral resources in the state are gold, limestone, marble, feldspar, clay, granite rocks and quartz. There is abundant spread of African locust-bean tree (*Parkia biglobossa*) across the length and breadth of the state, while

locust-bean processing is a common vocation in most of the rural communities.

Sampling procedure: Four stage sampling technique was used for selection of respondents for the study. The first stage involved selection of two Local Government Areas (LGAs) which were purposively selected based on their prominence in locust bean production in the State. These are Asa and Ilorin east LGAs. The next stage involved the purposive selection of six communities from each of the two LGAs. The Kwara State Agricultural Development Programme (KWADP) could not provide a sampling frame for locust bean processors as they did not have registered association. Therefore, snow-ball sampling technique was employed to identify one most prominent locust bean processor each from the 12 selected communities. Finally, each of the identified prominent locust bean processors was later used to identify nine other locust bean processors in their respective domains, giving a total sample size of 120.

Analytical techniques

Data obtained was subjected to both descriptive and inferential statistics. The descriptive statistics that was employed for analysing data were frequency counts, percentages, mean scores and five point Likert scale, while the inferential statistics was Pearson product moment correlation. The formula is presented below:

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

Where:

- N = number of pairs of scores
- Σxy = sum of the products of paired scores
- Σx = sum of x scores
- Σy = sum of y scores
- Σx^2 = sum of squared x scores
- Σy^2 = sum of squared y scores

RESULTS AND DISCUSSION

Table 1 shows that a typical locust bean processor in the study is an average of 41 years. However, 48.3% of the respondents were within the age bracket of 46-56 years while only 8.3% were within the age bracket of 68-78 years; 88.3% of the respondents were Muslims while 11.7% of them were Christians. In terms of education, 55% of the respondents had no formal education, 20% indicated Quranic education while 25% of the respondents had primary education. The low literacy level among the respondents could have a serious implication for adoption of improved technologies. The distribution of the respondents based on their household size shows that 51.7% had between 4 and 6 persons, but the average household size among the respondents was 7

Table 1: Socio-economic characteristics of the respondents

Variables	Freq (N=120)	%	Mean
Age			
35-45	24	20	
46-56	58	48.3	41
57-67	28	23.3	
68-78	10	8.3	
Religion			
Islam	106	88.3	
Christianity	14	11.7	
Educational level			
No formal education	66	55.0	
Quranic education	34	20.0	
Primary	30	25.0	
Household size			
4-6	62	51.7	
7-9	52	43.3	8
10-12	6	5.0	
Average monthly income			
4,000-6,000	48	40.0	
6,001-8,001	22	18.3	7,001.00
8,002-10,002	30	25.0	
≥10,003	20	16.7	
Experience			
20-30	28	40.0	
31-41	46	18.3	31.5
42-52	34	28.3	
53-63	12	10.0	

Source: field survey, 2015

persons which is typical of a rural community in Nigeria. The average monthly income as indicated in Table 1 shows that 40% of the respondents earn ₦4,000-N6,000 while only 16.7% earn between ₦13,000 and ₦15,000. A typical locust bean processor in the study area earns ₦8, 000 monthly. This shows that money earned by the locust-bean processors was far lower than the national minimum wage of ₦18,000 (Tee, Oguche and Ikyangba, 2009) compared to the stress of the activities but it is manageable to survive in a rural community as they mostly live with less than 1.25 USD per day (IFAD 2009). In terms of work experience, 40% of the respondents indicated 20-30 years of experience while 10% of them indicated 53-63 years of experience. The mean years of working experience among the respondents was 39 years. This is a clear indication that these women take up locust-bean processing early on in their lives and possibly hold-on to the job for as long as they live.

Table 2 presents the processing technique currently in use by the respondents, those that they have used before, those that they have only heard about and those that they have never heard anything about. The table shows that 63.3% of the respondents have once used Ajibode method, while 36.7%% of the respondents have only heard of it, all the respondents have heard of Saki method (100%) but none of the respondents are neither using it as at the period of the field work nor reported that they have used it before. The result also shows that 61.7% of the respondents have heard of improved method while only 6.7% have once used it, The yam-flour shaft is known to be currently used in just a particular community (Olukolu community) and this is probably the reason for the low level of usage in the study.

Respondents' knowledge level of locust bean processors on the use of processing techniques

The variable washing after de-hulling is compulsory ranked first and this implied that the processors view this task as very relevant and highly necessary to ensure a healthy and neatly processed locust bean. Their knowledge level of this fact is further proved by the result of the variable de-hulling can be skipped. This variable ranked last signifying that processors are not of the opinion that such a task

Table 2: Respondents' awareness of processing techniques in the study area

Processing techniques	Currently in use	Once used	Only heard of it	Never heard of it
Ajibode	0 (0.0%)	76 (63.3%)	44 (36.7%)	0 (0.0%)
Saki	0 (0.0%)	0 (0.0%)	120(100.0%)	0 (0.0%)
Improved	38 (31.7%)	8 (6.7%)	74 (61.7%)	0 (0.0%)
Steam	0 (0.0%)	0 (0.0%)	0 (0.0%	120 (100.0%)
FRIN	0 (0.0%)	0 (0.0%)	22 (18.3%)	98 (81.7%)
Traditional	66 (55.0%)	54 (45.0%)	0 (0.0%)	0 (0.0%)
Kabba	0 (0.0%)	0 (0.0%)	120 (100.0%)	0 (0.0%)
Machine	6 (5.0%)	0 (0.0%)	114 (95.0%)	0 (0.0%)
Shaft	10 (8.3%)	46 (38.3%)	64 (53.3%)	0 (0.0%)

Source: field survey, 2015

Table 3: Knowledge level of respondents on the use of locust bean processing techniques (n=120)

Areas of Knowledge	SA (5)	A(4)	U (3)	D (2)	SD (1)	Mean	Rank
Seed selection is required	20(16.7%)	100(83.3%)	0(0.0%)	0(0.0%)	0(0.0%)	4.17	4th
Pre-boiling is optional	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	120(100.0%)	1.0	8th
Cooling is important	50(41.7%)	30(25.0)	0(0.0%)	34(28.3%)	6(5.0%)	3.7	6th
De-hulling can be skipped	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	120(100.0%)	1.0	8th
Washing after de-hulling is compulsory	102(85.0%)	18(15.0%)	0(0.0%)	0(0.0%)	0(0.0%)	4.85	1st
It is necessary to separate seed from the coat	90(75.0%)	30(25.0%)	0(0.0%)	0(0.0%)	0(0.0%)	4.75	2nd
Seeds are subjected to another round of boiling	80(66.7%)	40(33.3%)	0(0.0%)	0(0.0%)	0(0.0%)	4.67	3rd
Fermentation of boiled seeds requires patience	8(6.7%)	112(93.3%)	0(0.0%)	0(0.0%)	0(0.0%)	4.07	5th
Salting is for preservation	4(3.3%)	30(25.0%)	70(58.4%)	16(13.3%)	0(0.0%)	3.18	7th

Source: field survey, 2015

Score is the summation of frequencies as per the Likert scores. Given that 5 indicates the highest knowledge level and 1 the least possible score, then the highest score possible is 600 while the least score possible is 120. Hence, the nearer to 600 the higher the knowledge level of the respondent to the particular variable, while the nearer to 120, the lower their level of knowledge of the variable in question.

Table 4: Severity of constraints faced by Locust bean processors

Constraints	Most severe (4)	Severe (3)	Moderately severe (2)	Not severe (1)	Score	Rank
Poor credit facility	120(100.0%)	0(0.0%)	0(0.0%)	0(0.0%)	480	1st
Poor storage system	2(1.7%)	0(0.0%)	20(16.7%)	98(81.7%)	146	7th
Seasonal water source	0(0.0%)	4(3.3%)	26(21.7%)	90(75.0%)	154	6th
Bad odour	0(0.0%)	0(0.0%)	0(0.0%)	120(100.0%)	120	8th
Drudgery	120(100.0%)	0(0.0%)	0(0.0%)	0(0.0%)	480	1st
Bad pricing	88(73.3%)	32(26.7%)	0(0.0%)	0(0.0%)	448	3rd
Lack of association	44(36.7%)	74(61.7%)	2(1.7%)	0(0.0%)	402	4th
Poor packaging	0(0.0%)	4(3.3%)	28(23.3%)	88(73.3%)	156	5th

Source: field survey, 2015

should be avoided, hence, the result further goes to show that de-hulling is necessary and the locust bean should equally be washed to remove impurities. From the table, it is obvious that women processors are not inclined towards salting as a means of preservation as more than half of the respondents are undecided while only about 3% are favourably disposed to salting. This variable is ranked very low and this could mean that they are well versatile with the processing unit and they all claim that it's only a marketer that preserve her dawadawa/iru after production. It could be assumed that the processors have an in-depth knowledge of the processing units in that they believed it is necessary to separate seeds from coat (2nd in rank) while the seeds will be subjected to another round of boiling (ranked 3rd). It is therefore safe to conclude that the processors in this study have mastered the art of locust bean processing and they apply a level of dexterity in carrying out their task.

Constraints limiting the use of improved locust beans

Table 4 shows the level of severity of the constraints faced by the respondents. The constraints were ranked using the parameters: most-severe as the highest in rank with a score of 4, severe has a score of 3, while moderately-severe was scored 2 and not-severe is 1. The locust bean processors in the study perceives drudgery and poor credit facilities immediately followed by bad pricing as the most limiting challenges. It has been observed that rural women do not get to sell dawadawa/iru at higher price compared to the level of energy input in its processing (Akande *et al.*, 2010) and this serves as low source of income to the rural women locust-bean processors (*Adisa, Olatinwo and Simeon, 2011*). Bad odor ranked the last among the constraints. This could possibly imply that the women processors have grown used to the odour so much so that it no longer pose any source of worry to them. Another reason why it may not be a problem to the processors is because most of them were born into the business except in rare cases where they believe a menstruating woman that touches the locust bean gives it a foul smell (*Shao, 2002)*

Hypothesis

Testing hypothesis: there is no significant relationship between some selected socio-economic characteristics and the constraints to locust-bean production among the respondents:

Pearson correlation analysis in Table 5 shows that age (p=0.05, r=0.245) was significant and positively related to the constraint faced in locust-bean production among the respondents in the study area. The implication of this result is that the older a typical rural woman locust-bean processor becomes, the more likely she is predisposed to the constraints faced by them in locust-bean production. For example, an aged locust bean processor will be highly affected by drudgery and may not be able to cope with the demands of locust bean processing. Furthermore, such a woman is not likely to have the energy to negotiate out of bad pricing. Educational level (p=0.004, r=-0.367) and household income (p=0.001, r=0.405) were significant but inversely related to constraint to locust-bean production among respondents. Thus, the higher the educational level

Table 5: Relationship between selected socioeconomic characteristics of respondents and constraints faced in the production of locust-bean in the study area

Variables	**Coefficient (r)**	**p-values**	**Decision**
AGE	.245	.050*	S
REL	.003	.980	NS
EDU	-.367	.004**	S
H/SIZE	-.145	.271	NS
INCOME	-.405	.001**	S
EXP	.266	.040*	S

** Significant at the 0.01 level * Significant at the 0.05 level (2-tailed)

and household income, the less the constraint faced by the processors. This means that the less educated women may have the least access to credit facilities whilst women with low household income would not have the means to maneuver out of drudgery.

CONCLUSION AND RECOMMENDATION

The study found that the women processors very much aware of the various methods of processing locust bean and therefore draws a conclusion based on the findings that the women have mastered the art, are conversant with the processing techniques and they engage in their tasks with dexterity. It was further established that processing of locust-bean is laborious and time consuming due to the use of traditional method of processing that majority of the rural women use during this process. The processors were found to have low literacy level which could signify a serious implication for adoption of improved technology. The study therefore recommended that relevant stakeholders such as rural development based NGOs should make frantic effort to supply the rural areas with processing machines such as de-hullers and press cookers to ease the stress and to increase production as this would go a long way in reducing the drudgery. Locust bean processors in the area could also be encouraged to form themselves into cooperative groups in order to increase their access to credit facilities as well as engage in workshops to educate themselves on how to deal with bad pricing and other challenges facing locust bean production.

REFERENCES

Abdel, A.A. & Dardir, H. A. (2009). Hygienic quality of local traditional fermented skimmed milk (laban rayb) sold in Egypt. *World Journal of Dairy and Food Sciences* 4(2) 205-209

Adebayo, G. B., Otunola, G. A. & Ajao, T. A. (2010). Physicochemical, microbiological and sensory characteristics of kunu prepared from millet, maize and guinea corn and stored at selected temperature, advance J*ournal of Food Science and Technology* (1), 2010, 41-46.

Adefalu, L. L. & Fawole, O. (2014). Analysis of indigenous food consumption among teenagers in Ife East Local Government Area, Osun State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 10(3):77-82

Adisa, R. S., Olatinwo, K. B. & Simeon, O. A. (2014): Economic analysis and constraints of traditional processing of African locust bean in Kwara State. *Kasetsart Journal of Social Sciences.* Vol 35; 124 - 133 (2014).

Sanni, M. S., (2014). Kwara on kaleidoscope available at http://www.theheraldnews.info/kwara-on-kaleidoscope.

International Fund for Agricultural Development (IFAD), (2009). Rural poverty portal.

National population commission Nigeria (2006)

Olaoye, J. O. (2011). Development of small scale equipment for de-pulping locust bean seeds. *International Journal of Engineering & Technology,* 11(6), 173-186.

Sadiku, O. A. (2010). Processing methods influence the quality of fermented Africa locust bean (Iru/Ogiri/Dadawa) *Parkia biglobosa: Journal of Applied Sciences Research*, 6 (11): 1656-1661.

Tee, T.N., Ogwuche, J.A. & Ikyaagba, E.T. (2009). The role of locust bean and iron wood trees in human nutrition and income in Nigeria. *Pakistan J. Nutrition.* 8(8): 1172-1177.

GROWTH PERFORMANCE AND BODY COMPOSITION OF *Clarias gariepinus* (Burchell 1822) FED GRADED LEVELS OF DETOXIFIED *Jatropha curcas* MEAL

[1]Orire, A .M. [1]Amupitan, O.O. and [2]Daniyan, S.Y.
[1] Department of Water Reources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria.
[2] Department of Microbiology, School of Life Sciences, Federal University of Technology, Minna, Nigeria.
Corresponding Author's E-mail: abdul.orire@futminna.edu.ng
Phone number: +2347032552295

Abstract
This research investigated into the growth performance, survival and body composition of Clarias gariepinus fingerlings (4.30±0.01g) fed five diets containing 40% crude protein and varying inclusion levels of detoxified Jatropha curcas meal (DJCM) at 0%, 25%, 50%, 75% and 100% replacement for fishmeal (FM). The results obtained indicated significant differences (P<0.05) in the growth parameters, survival and biological values evaluated. Diet 1 (0% DJCM and 100% FM) gave the best growth parameters in terms of Mean weight gain (10.53±1.95), Feed Conversion Ratio (FCR) (2.73±0.55), Specific Growth Rate (2.19±0.23) and survival rate (73.33±10.41) this followed by diet 2 (25%DJCM and 75%FM) with MWG (0.88±0.33), FCR (12.00±4.67), SGR (0.33±0.11) and survival rate (56.67±16.07). The body crude protein was significantly high (P<0.05) for diet 1 (65.63%) and lowest for diet 5 (48.13%). The lipid content was also high for diet 1 (21.40%). and lowest for diet 3 (16.30%) while the ash content was found high in diet 1 (29.10%) and low in fish fed diet 5 (16.10%). The growth performances and survival rate became decreased with increment in the inclusion levels of detoxified Jatropha curcas meal. It can be concluded that detoxified Jatropha curcas meal can be included in the diet of Clarias gariepinus up to 25% beyond which there is detrimental effect on fish growth.
Key words: *Detoxified, Jatropha curcas meal, Clarias gariepinus*

INTRODUCTION

Fish has been reported to be a good source of food and means of livelihood to many African populace (Mustapha, 2013). However, this industry is constrained by availability of alternative nutritive protein source as replacement for fish meal (NCR, 1993); Naylor *et al.*, 2000; Mabahinzireki *et al.*, 2001). Several studies have revealed the use of some plant protein sources like Moringa leaf meal, Soybean meal and so on as fish meal replacement in fish diets (Hossain *et al.*, 2001; Dongmeza *et al.*, 2006; Kumar *et al.*, 2008, 2010a,b,c; Makkar *et al.*, 2009 and Yue and Zhou, 2009). Moreover, the inclusion level of these plant protein sources requires careful consideration for processing for fish to utilize its nutrients (Pillay, 1990; Francis *et al.*, 2001). Nutritional values of plant protein sources as supplement in animal diets have been studied and some of the reported studies were found with cotton seed meal replacing fish meal in tilapia ration at 50% inclusion rate (Ofojekwu and Ejike, 1984; Mbahinzireki *et al.*, 2001). *Jatropha curcas* is a plant protein source which is abundant in the tropics and subtropics (Becker and Makkar, 2008: Kumar *et al.*, 2008). It is useful in bio-diesel production (Makkar *et al.*, 2008: Parawira *et al.*, 2010), its oil extract is a good nutrient source for animal diet when properly treated to reduce the anti-nutritional factors (Reddy and Pierson, 1994: Aderibigbe *et al.*, 1997). The seed maintains its weight of 50% as press cake with crude protein between 58-62% and an excellent amino acid profile and carbohydrate (Becker and Makkar, 2008). Saturated and unsaturated fatty acids that includes the polyunsaturated fatty acid (PUFA) containing acid (18:2n-6) and alpha linoleic acid (18:3n-3) fatty acids (Becker and Makkar, 2008). However, *Jatropha curcas* has been posited as future important feed ingredient to replace fish meal and soya bean but the anti-nutritional substance such as (lectin, phytic acid, saponins and trypsin inhibitors) and the toxic substance (phorbol esters) would limits the protein content, amino acid profile and carbohydrate level and functionality in the feed (Makkar and Makkar, 2008). There is the need for further investigation into alternative plant protein sources for fish feed (FAO, 2012: Madalla, 2008) that will have no interference with human interest with regard to issue of food security (Tacon and Foster, 2000). This research thus, investigated the growth performance of *Clarias gariepinus* fed detoxified *Jatropha* curcas meal.

Materials and Methods

The experimental work was carried out in the Laboratory of Water Resources, Aquaculture and Fisheries Technology Department, Gidan Kwano Campus of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State, Nigeria.

Experimental Protocol

Clarias gariepinus fingerlings (4.30±0.01g) were purchased and transported to the Laboratory from *Eco*-Rehab Environmental Service Limited (Fishery Section) Kuje, Federal Capital Territory, Abuja. The fishes were acclimatized in plastic tank for one week before commencement of the

experiment. The feedstuffs comprising detoxified *Jatropha* curcas meal which was obtained from the department of Microbiology, School of Life Sciences, Federal University of Technology, Minna, while, fishmeal, maize meal, soybean meal, vitamin-mineral premix and vegetable oil were purchased from Minna Central Market, Niger State. The feed ingredients were milled separately and their proximate compositions were analysed for Moisture, Crude protein, crude fat, Cride fibre and Ash according to the method of AOAC (2000). Five diets containing 40% crude protein at five different inclusion levels of 0%, 25%, 50%, 75% and 100% of detoxified *Jatropha curcas* meal were formulated and compounded as in Table 1.

Experimental Procedure

Twenty fishes were distributed randomly in triplicate of 15 tanks in a complete randomized design. The fish were fed thrice daily starting with 3% body weight and adjusted fortnightly for the feeding trial period of 8weeks. Water quality parameters were maintained by daily changing of water and monitored weekly for temperature, conductivity and pH using standard methods (Table 2).

Table 1: Formulated diets with their proximate compositions

Feedstuffs	Diet 1 (0%DJCM)	Diet 2 (25%DJCM)	Diet 3 (50%DJCM)	Diet 4 (75%DJCM)	Diet 5 (100%DJCM)
Fish Meal	460.40	345.30	230.20	115.10	0.00
DJCM	0.00	115.10	230.20	345.30	460.40
Maize Meal	389.60	389.60	389.60	389.60	389.60
Soybean Meal	100.00	100.00	100.00	100.00	100.00
Vitamin premix	20.00	20.00	20.00	20.00	20.00
Vegetable Oil	30.00	30.00	30.00	30.00	30.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Proximate Composition of Formulated Diets (%)					
Crude Protein	45.52	45.60	45.25	45.4.2	45.50
Crude Lipid	11.05	12.15	14.35	15.54	17.55
Crude Fibre	0.55	0.95	0.95	1.15	1.30
Ash	8.10	6.95	7.30	6.10	4.30
Moisture Content	36.28	34.64	26.20	33.62	38.18

Table 2: Water Quality Parameters for week 1-8

Parameters	Temp (^{o}C)	pH	Conductivity (µM/cm)
T1	25.1-28.2	7.28-8.49	274-475
T2	25.1-28.4	7.30-8.48	275-464
T3	25.1-29.0	7.27-8.43	273-466
T4	25.1-28.3	7.30-8.50	275-465
T5	25.1-28.3	7.47-8.49	276-467

Chemical analysis

The carcass contents for initial and final treatments were analysed for their proximate compositions according to the method of AOAC (2000).

Biological evaluation

The biological parameters which included mean weight gain, feed conversion ratio, specific growth rate and protein efficiency ratio were evaluated according to the method of Maynald, 1979, and Halver 1989, as describe below;

Weight gain: Weight gain = Final body weight - initial body weight

Specific Growth Rate (SGR): According to Brown 1957 was measure with the formula

SGR = Ln Mean Final Weight x Ln Mean Initial Weight x 100 /Duration of experiment (Days)

Feed Conversion Ratio (FCR): This is measure with the formula

$$FCR = \frac{\text{Weight of feed fed (gram)}}{\text{Weight gain of fish (gram)}}$$

Protein Efficiency Ratio (PER): This is express as:

$$PER = \frac{\text{Weight gain of fish}}{\text{Protein fed}}$$

$$\text{Apparent Net Protein Utilization (ANPU)} = \frac{\text{Carcass Protein gain (g)}}{\text{Protein fed}} \times 100$$

Mortality was evaluated as the expressed as

$$\%\text{Mortality} = \frac{\text{No of fish left in the tank}}{\text{No of fish stocked}} \times 100$$

Statistical Analysis

The result for the feeding trials were subjected to one-way Analysis of Variance (ANOVA) (Steel and Torrie, 1980) and the average means for the treatments were compared with each other for significance difference ($P<0.05$) with the aid of a statistical software package Minitab release 14. The graphical analysis was plotted with Microsoft excel

window 2007. Multiple parameters mean comparison of treatment was done according to Duncan multiple tests (Duncan, 1995).

RESULT

The initial mean weight among the fishes were not significantly different (P>0.05) from each other at the commencement of the feeding trial. Table 3 showed the performance of *Clarias gariepinus* fed detoxified *Jatropha* curcas meal which indicated significant differences (P<0.05) among treatments. It was observed that diet 1 (0% detoxified *Jatropha* curcas meal) gave the best performances in terms mean weight gain 10.53g, this was followed by diet 2 (25% DJCM) with 0.88g while diets 3, 4 and 5 were significantly low (P<0.05) -1.11g, -1.89g and -1.79g respectively with no significant differences (p>0.05) among them. The feed conversion ratio for diet 2 and 3 showed the highest mean value of 12.00g and 12.17g which were not significantly different (P>0.05) from each other but significantly different (P<0.05) from diet 1 (2.73). However, diets 4 and 5 exhibited negative FCR (-7.18g and -0.99g respectively) P>0.05. The specific growth rate (SGR) was significantly high (P<0.05) for diet 1 (2.19) followed by diets 2, 3 and 5 (0.33; 0.13 and 0.13 respectively) while diet 4 gave a significantly low (P<0.05) SGR value (-0.21). The percentage survival of fishes fed detoxified *Jatropha curcas* meal was also significant (P<0.05). Diet 1 and 2 had the highest mean survival rate of 73.33% and 56.67% with no significant difference (P>0.05) between them while diet 3 and 4 recorded significantly low (P<0.05) mean survival rate of 16.67%, 11.67% and 6.67% with no significant (P>0.05) difference between them but were significantly different from diet 5 with lowest survival rate of 6.67%. On the tissue protein analysis, the protein efficiency ratio (PER) evaluated indicated that diets 1 and 2 were significantly different (P<0.05) from other treatments which had negative protein efficiency ratios. Similarly, the apparent net protein utilization (ANPU) expressed significant difference (P<0.005) among treatments. Diet 3 had the best ANPU value (178.27%) followed by diet 1 (88.59%) while other diets gave a significantly low ANPU values.

Body compositions: Table 4 showed the body composition of initial and final carcass with significant differences (P<0.05) among treatments. Diets 1 and 3 were significantly higher (P<0.05) in carcass crude protein values (65.63% and 62.13% respectively) than the initial value (55.00%) while diet 5 gave a significantly low crude protein value (48.13%). However, the body crude lipid for diets 1 (20.09%) and 2 (21.40%) were not significantly different (P>0.05) from each other but are significantly (P<0.05) different from other treatments. Diet 1 gave a significantly high (P<0.05) body crude fibre content (4.00%) while diet 4 (1.20%) was significantly low (P<0.05) however, with no significant difference (P>0.05) to diets 5 and the initial fibre value of 1.29% and 1.40% respectively. The carcass ash content for all treatments were significantly higher (P<0.05) than the initial, moreover, diet 3 gave a significantly high (P<0.05) ash content (29.10%) than other treatments while diet 5 was significantly low (P<0.05) in ash with 16.10%. The moisture content was significantly low for diets 2 (2.64%) and 3 (3.92%) with no significant difference (P>0.05) while diet 5 was significantly different from other diets with high moisture content (5.24%) (Table 4).

Discussion

The experimental fish feeding behavior and the feed palatability were observed during the period of the experiment and was noticed that fish fed the control diet (0% Detoxified *Jatropha* curcas meal, 100% Fishmeal) and Diet 2 (25% Detoxified *Jatropha* curcas meal 75% Fishmeal) were more active in feeding behavior than those fed other diets as evident in the feed fed (Table 1). Therefore, the variation recorded in all treatments with reference to biological values measured indicated that, *Clarias gariepinus* performances were affected by the dietary inclusion of *Jatropha* meal (Table 1). The results from the study also indicated that, inclusion of *Jatropha* meal at various levels in the diet of *Clarias gariepinus* fingerlings impacted negatively on the diet palatability, feeding behavior, growth performance, feed utilization and survival rate of the fish (Tables 1, 3 and 4). The acceptability of diets 1 and 2 (0% detoxified *Jatropha* curcas meal,100% Fishmeal) and (25% detoxified *Jatropha* curcas meal 75% Fishmeal) respectively can be as a result of low level of anti-nutritional factors that might have effect on the palatability of the diets and its utilization. However, high phytate level in the Jatropha kernel has been reported to have ability to decrease the bio-availability of mineral (especially Ca^{2+} and Fe^{2+}) and protein digestibility through complex formation and enzyme reactions (Reddy and Pierson, 1994). The experimental fish fed diet 1 (0% detoxified *Jatropha* curcas meal,100% Fishmeal) had superior growth performance in term of mean weight gain and specific growth rate, body crude protein and body lipid followed by fishes fed diet (25% detoxified *Jatropha* curcas meal 75% Fishmeal) and were significantly (P<0.05) different from other treatments which could be as a result of high levels of toxin (Phorbol ester) and anti-nutritional compounds in the detoxified *Jatropha* curcas meal as the inclusion levels increases in the diets which confirms the report of Azzaza *et al.,* 2011; Reddy and Pierson, 1994; Hajos *et al.,* 1995; Aderibigbe *et al.,* 1997) that, feed containing high concentration of anti-nutritional factor would decrease nutrient available in the diet with attendant implication on reduction of growth

performance of fish. It was observed that diet 1 and 2 fed diet containing (0% detoxified *Jatropha* curcas meal/100% Fishmeal) and (25% detoxified *Jatropha* curcas meal/ 75% Fishmeal) respectively achieved the highest survival rate (73.33% and 56.67%) than those fed high inclusion of detoxified Jatropha curcas meal. This could be as a result of increased level of anti-nutritional factors such as phytates, trypsin inhibitor, lectin and the toxic substance (phorbol esters) as reported by (Hajos *et al.*, 1995). He further explained that reduction in metabolic activities of the fish and growth performance can be affected by increased level of anti-nutritional factors and toxic substances (phorbol ester).

CONCLUSION

It can be concluded that, since inclusion level up to 25% detoxified *Jatropha* curcas meal can reduced survival rate by about 50%, a lower inclusion level might be adopted for fishmeal replacement in the diet of *Clarias gariepinus* fingerlings.

Recommendation

From this study, it is therefore recommended that detoxified *Jatropha* curcas meal can be included in the diet of *Clarias gariepinus* fingerlings up to 25% beyond which there would decline in growth as well as survival rate. Further research should be conducted on the detoxification of the kernel to ensure high inclusion level in the diets of fishes.

Contribution of authors

Dr. A.M. Orire (Aquaculture Nutritionist), was the major supervisor of the research on the use of *Jatropha curcas* oil in the diets of *Clarias gariepinus*.

Ms. Amupitan O.O. was the mentee on the experiment.

Dr. S.Y. Daniyan (Microbilogist) assisted with the detoxification of *Jatropha curcas* kernels used for the experiment.

Acknowledgments

Researchers express appreciation to the Department of Microbiology of the Federal University of Technology, Minna for assisting with detoxification of the extracted *Jatropha curcas* kernel, the result of which has formed a bond of research collaborations with the Department of Water Resources, Aquaculture and Fisheries Technology of the Federal University of Technology, Minna.

Conflict of interest

There was not any form of conflict of interest during the experimental work, rather it was a collaborative research between Department of Water Resources, Aquaculture and Fisheries Technology and Department of Microbiology

References

Aderibigbe, A. O., Jonson, C. O., Makkar, H. P. S., Becker, K. and Foidl, N. (1997). Chemical composition and effects of heat on organic matter- and nitrogen-degradability and some antinutritional components of *Jatropha* meal. *Animal Feed Science Technology*, 65: 223-243.

AOAC (2000): Official Methods of Analysis of AOAC International Volume 1. Agriculture Chemicals, Contaminants, Drugs. 16th Edition, AOAC Intl; Arling, V.A.

Azzaza, N. A. E., El-Nasr, N. A., Elsharkawy, E. E. and Elmotleb, E. A. (2011). Chemical and Pathological Evaluation of *Jatropha* curcas Seed Meal Toxicity with or without heat and Chemical Treatment. Australian Journal of Basic and Applied Sciences, 5: 49-59.

Becker K, Makkar HPS (2008). *Jatropha curcas*: A potential source for tomorrow's oil and biodiesel. Lipid Tech 20: 104-107.

Dongmeza, E.; Siddhuraju, P.; Francis, G.;Becker, K., (2006). Effects of dehydrated methanol extracts of moringa (*Moringa oleifera* Lam.) leaves and three of its fractions on growth performance and feed nutrient assimilation in Nile tilapia (*Oreochromis niloticu*s L.). *Aquaculture* 261, 133–148.

Duncan, D.B. (1995). "Multiple Range and Multiple F. Test" Biometrics 11:1-42

FAO (2012) The State of the World Fisheries and Agriculture Part World Review of Fisheries and Agriculture, Rome, Italy.

Francis G, Makkar H.P.S, Becker K; (2001). Anti-Nutritional Factors Present in Plant Derived Alternate Fish Feed Ingredients and Their Effects in Fish. Agriculture 199, 197-227.

Hajos, G., Gelenser, E., Pusztai, A., Grant, G. and Sakhri, M. (1995). Biological Effects and Survival of Trypsin Inhibitors and Agglutinin from Soybean in Small Intestine of the Rat. *Journal of Agriculture and Food Chemistry*, 43: 165-170.

Hossain, M.A.; Focken, U.; Becker K. (2001): Evaluation of an Unconventional Legume Seed Sesbenia Ackulata, as a Dietary Protein Source for Common Carp, *Cyprumus cappio*. Agriculture 198, 129-140.

Kumar, V., Makkar, H. P. S. and Becker, K. (2008). Detoxification of *Jatropha* curcas seed meal and its utilization as a protein source in fish diet. *Composition Biochemistry and Physics*, 151: 13-19.

Table 3: Growth Performance of *Clarias gariepinus* fed graded inclusion levels of Detoxified *Jatropha curcas* meal for 56days

Growth Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SD±
Mean Initial Weight (g)	4.33±0.01^{a}	4.31±0.02^{a}	4.33±0.02^{a}	4.33±0.03^{a}	4.34±0.03^{a}	0.26
Mean Final Weight (g)	14.85±1.94^{a}	5.19±0.34^{b}	3.22±2.79^{b}	2.44±2.15^{b}	2.55±0.63^{b}	1.83
Mean Weight Gain (g)	10.53±1.95^{a}	0.88±0.33^{b}	-1.11±2.77^{c}	-1.89±2.16^{c}	-1.79±0.66^{c}	1.82
Feed Fed (g)	26.23±3.84^{a}	9.52±1.12^{b}	8.84±0.29^{b}	3.64±1.41^{c}	2.15±0.90^{c}	1.94
Feed Conversion Ratio	2.73±0.55^{ab}	12.00±4.67^{a}	12.17±11.84^{a}	-7.18±9.21^{b}	-0.99±1.05^{b}	7.05
Specific Growth Rate (SGR, %/day)	2.19±0.23^{a}	0.33±0.11^{a}	0.13±0.11^{b}	-0.21±0.26^{b}	0.13±0.44^{b}	0.26
Protein Efficiency Ratio (PER)	0.88±0.08^{a}	0.21±0.10^{b}	-0.28±0.68^{c}	-1.62±2.15^{c}	-2.08±0.10^{c}	1.10
ANPU (%)	88.59±0.52^{a}	-57.60±0.01^{c}	178.27±0.03^{b}	-45.50±0.08^{c}	-234.48±0.01^{d}	0.23
Survival Rate (%)	73.33^{a}±10.41	56.67^{a}±16.07	16.67^{b}±15.28	11.67^{b}±10.41	6.67^{b}±2.89	11.97

Mean data on the same raw carrying different superscripts differ significantly from each other (P<0.05)

Table 4: Body Composition of *Clarias gariepinus* fed graded inclusion levels of Detoxified *Jatropha curcas* meal for 56days

Body Composition (%)	Initial	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SD±
Crude protein (CP)	55.00±0.00^{c}	65.63±0.00^{a}	52.50±0.00^{c}	62.13±0.00^{b}	54.25±0.00^{c}	48.13±0.00^{d}	0.00
Lipid	20.09±0.00^{a}	21.40±0.00^{a}	17.50±0.00^{b}	14.30±0.00^{d}	15.60±0.00^{c}	15.90±0.00^{c}	0.00
Crude Fibre (CF)	1.29±0.00^{d}	4.00±0.00^{a}	2.00±0.00^{c}	2.8±0.00^{b}	1.20±0.00^{d}	1.40±0.00^{d}	0.00
Ash	11.11±0.00^{d}	16.80±0.00^{c}	23.90±0.00^{b}	29.10±0.00^{a}	23.91±0.00^{b}	16.10±0.00^{c}	0.00
Moisture Content (MC)	3.70±0.00^{c}	2.64±0.00^{d}	3.62±0.00^{c}	3.92±0.00^{c}	4.64±0.00^{b}	5.24±0.00^{a}	0.00

Mean data on the same raw carrying different superscripts differ significantly from each other (P<0.05)

Kumar, V., Makkar, H. P. S., Amselgruber, W. and Becker., K. (2010c). Physiological, haematological and histopathological responses in common carp (Cyprinus carpio L) fingerlings fed with differently detoxified *Jatropha curcas* kernel meal. *Food and Chemical Toxicology* 48, 2063–2072.

Mabahinzireki, G.B; Dabroski, K; Lee, K.J; El-Saidy, D.; Wisner, E.R; (2001): Growth, Feed Utilization and Body Composition of Tilapia (Oreochromis Spp.) Fed with Cotton Seed Meal Based Diets in A Recycling System. Agriculture Nutrition 7, 189-200. 42, 601-604.

Madalla N (2008) Novel Feed Ingredients for Nile Tilapia (*Oreochromis niloticus)* PhD, Dissertation, Striling University, Scotland UK.

Makkar HPS, Francis G, Becker K (2008) Protein concentration from Jatropha curcas screwpressed seed cake and toxic and anti-nutrimental factors in protein concentrate. J Sci Food Agr 88: 1542-1548

Makkar, H. P. S.; Kumar, V.; Shkelqim, K. S.; Kratzeisen, M.; Tipraqsa, P.; Muller, J.; Berger, T.; Amselgruber, W.; Becker, K., (2009). Sustainable land development and ecosystem conservation through enhancing economic viability of the Jatropha curcas based biodiesel production chain using a bio-refinery concept. In ERSEC (2009). Sustainable Land Use and Ecosystem Conservation, International Conference Proceeding, Beijing. Nigeria (First Edition). Published by Ministry of Agriculture Northern Nigeria. 226pp.

Mustapha M.K, (2013) Potential Impacts of Climate on Artisanal Fisheries of Nigeria. J Earth Science Climate Change 4:131.

NRC (National Research Council), (1993): Nutrient Requirements of Warm Water Fishes and Shellfishes. National Academy of Sciences, Washington D.C. USA, P. 114.

Ofojekwu, P.C. and Ejike, C. (1984) Growth response and feed utilization in the tropical cichlid, *Orechromis niloticus* (Linn) fed on cottonseed based artificial diets. Aquaculture 421: 27-36.

Parawira W (2010) Biodiesel production from Jatropha curcas: A Review Science Research and Essays 5: 1796-1808.

Pillay T.V.R., (1990). Aquaculture principles and practices. Fishing News Books.

Reddy, N. R. and Pierson, M. D. (1994). Reduction in anti-nutritional and toxic components in plant foods by fermentation. *Food Resources International*, 27: 281-290

Steel, R.D. and Torrie, J.H. (1981). Principles of statistics. A Biometrical Approach 2nd edn. McGraw-Hill International, Auckland, 102 pp.

Tacon AGJ, Foster IP (2000) Global trends and challenges to aquaculture and aqua-feed development in the new millennium. International Aqua-feed Directory and buyers Guide 2001, Trust RAL, Uxbridge Middlesex, UK.

Yue, Y. and Zhou, Q. 2009. Effect of replacing soybean meal with cottonseed meal on growth, feed utilization, and hematological indexes for juvenile hybrid tilapia, *Oreochromis niloticus*, *Oreochromis aureus*. *Aquaculture* 284, 185–189.

NUTRIENT AND NUTRIENT-INHIBITOR COMPOSITIONS OF STANDARDIZED BAMBARA-NUT (*Vigna substerranea*) BASED DISHES COMMONLY CONSUMED IN NIGER STATE, NIGERIA

*Folorunso, A. A. [1], Oguntona, E. B.[2], Afolabi, W. A.[2], Idowu, O. M. O.[3] and Omoniyi, S. A.[4]
[1]Department of Family, Nutrition and Consumer Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria.
[2]Department of Nutrition and Dietetics, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[3]Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[4]Department of Home Science and Management, Federal University, Gashua, Yobe State, Nigeria
*Corresponding Author: kunlefolly2@yahoo.com, +2348038084579

ABSTRACT
The study standardized bambara nut based dishes commonly consumed in Niger State, Nigeria and assessed the nutrient and nutrient-inhibitor compositions of the dishes. Five bambara nut based dishes (bambara porridge, bambara ball, bambara moinmoin, bambara soup and bambara and rice) were selected from five different zones in Niger State, Nigeria using purposeful, random and snowball approaches and were standardized in accordance with the Standardization Procedures . The selected dishes were prepared using the standardized recipes and presented for consumer acceptability. The proximate, mineral, vitamin C and nutrient inhibitor composition were analyzed using standard methods. The dishes were also evaluated for microbiological quality using Aerobic Plate Count (APC). The result of the proximate composition of standardized bambara nut dishes were significantly different ($p < 0.05$) with the values ranging from 41.9 to 75.6%, 0.9 to 6.4%, 0.9 to 18.7%, 0.2 to 10.6%, 0.3 to 1.3%, 14.4 to 44.9% and 82.5 to 262.9% for moisture, crude protein, crude fat, crude fibre, ash, carbohydrate and energy value content respectively. Also, the results of mineral contents were significantly different ($p < 0.05$) with the values ranging from 3.1 to 110.1 mg/100g, 10.3 to 239.6 mg/100g, 13.8 to 70.0 mg/100g, 4.9 to 30.1 mg/100g, 0.0 to 27.0 mg/100g and 6.0 to 40.5 mg/100g for phosphorus, potassium, sodium, zinc, iron and calcium respectively while the vitamin C contents of the dishes ranged from 0.2 to 0.5mg/100g. The result for nutrient-inhibitor contents were significantly different ($p < 0.05$) with the values ranging from 94.2 to 202.6 mg/100g, 0.0 to 0.2 mg/100g and 1.8 to 8.0 mg/100g for phytate, tannin and oxalate contents respectively.

Key words: Standardization, nutrient composition, nutrient-inhibitor, bambara nut, dishes.

INTRODUCTION
The role of indigenous or traditional food crops in the improvement of food security in Nigeria cannot be over emphasized. Kunyanga, Imungiand & Vellingiri (2013) described indigenous foods as foods that have their origin in a region, are culturally acceptable and adapted to the local climatic conditions which have been consumed traditionally by the inhabitants as opposed to exotic foods which have been introduced from other regions of the world. It is necessary to sensitize Nigerian people about the need to promote the production and consumption of traditional food crops, neglecting them and their knowledge could lead to the loss of the entire gene of nutritive crop (Mwaura, 2004).

Bambara nut (*Vigna substerranea*) is important local food crop in the north central part of Nigeria where it is staple legume food. The people of Niger State in North Central Nigeria may consume Bambara nuts or their products thrice a day because these foods are palatable, cheap and easy to prepare (Alabi, 2007). The availability of these local foods in their socially acceptable forms, seem to be the key to overcoming the major constraints towards consumer utilization of locally available foods. With the abundance of local foods in the north central part of Nigeria, the goal of optimal nutrition is affordable and achievable.

The benefits in utilizing local foodstuffs was highlighted by FAO (1995) that traditional foods reduce problems related to seasonal fluctuation of food supplies as they are adapted to their environments and so can fill seasonal food gaps. This study therefore intends to generate both the baseline and additional information on these local dishes that will enable policy makers, researchers and developmental agencies to formulate policies, sustainable interventions and nutrition security through advocacy that will improve on the nutritional status of the people of Niger state, north central Nigeria. The study is aimed to standardize five bambara nut based dishes (bambara porridge, bambara ball, bambara moinmoin, bambara soup and bambara and rice) commonly consumed in Niger state of Nigeria and evaluate the nutrient and nutrient-inhibitor compositions of the dishes.

METHODOLOGY
Five bambara nut based dishes (bambara porridge, bambara balls, bambara and rice, bambara moinmoin, and bambara Soup) commonly consumed in Niger state were selected from five different zones in Niger state, Nigeria.. Bambara porridge, bambara balls, bambara and rice, bambara moinmoin and bambara soup was selected from Minna, Suleja, Kotangora, New Bussa and Bida respectively. All the ingredients used for the

preparation of dishes were purchased from Central Market, Bida, Niger state, Nigeria.

Standardization and preparation of bambara nut based dishes

Based on the information on the several local foods available in Niger State (Alabi, 2007; Fejiokwu, 1997; NBS, 2012), the five zones and the five local dishes produced from bambara nut were identified using purposeful, random and snowball approaches. These dishes formed the basis of the survey in all the zones under study which was based on the availability, accessibility and affordability of their ingredients in the markets and farms. The dishes were prepared with the standardized recipes using the procedures described by Okhiria (2010) and Folorunso (2015) at the kitchen facilities of the Department of Hospitality Management of the Federal Polytechnic, Bida, Niger State, with the assistance of selected native housewives who were well versed on the methods of preparation of the selected dishes.

Determination of Proximate composition of standardized bambara nut based dishes

The moisture, crude protein, crude fat, crude fibre and ash were determined by the methods of AOAC (2005) while carbohydrate content was determined by difference. Energy values were calculated according to method described by FAO/WHO (1998).

Determination of Mineral and Vitamin C contents of standardized bambara nut based dishes

Potassium and Sodium were determined by digesting the ash of sample with perchloric acid and nitric acid and readings were taken on digital flame photometer/spectronic 20 (Gallenkamp). Calcium, iron, zinc and phosphorus were determined spectrophotometrically by using 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) and compared with absorption of standards of these minerals (AOAC, 2005). Vitamin C content was determined using the method described by Harris (1997).

Determination of Nutrient-inhibitor contents and aerobic plate count of standardized bambara nut based dishes

The phytate, oxalate and tannin contents of the dishes were determined by method of AOAC (2005) while aerobic plate count was done using the procedure described by the International Organization for Standardization (2004).

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and where there is significant difference, means were separated using Duncan's multiple range test. Statistical analysis was carried out with the use of SPSS version 21.0 software.

RESULTS AND DISCUSSION

Proximate Composition of standardized bambara nut based dishes

Table 2 shows the proximate composition of standardized bambara nut dishes. The values were significantly different ($p < 0.05$) with the values ranging from 41.9 to 75.6%, 0.9 to 6.4%, 0.9 to 18.7%, 0.2 to 10.6%, 0.3 to 1.3%, 14.4 to 44.9% and 82.5 to 262.9% for moisture, crude protein, crude fat, crude fibre, ash, carbohydrate and energy value content respectively. The result showed that all the dishes generally had high moisture contents. The amount of moisture is dependent on the type of dish and also the amount of water used in the preparation (Aliyu & Muhammed, 2000). The range of crude protein content obtained was greater than the range of protein content (0.8 to 2.5%) reported for fast food and indigenous dishes by Mojekwu & Anyafulu (2014). Bambara ball had the highest crude fat content and this may probably due to the deep frying methods used in the cooking. The low values of ash contents in the dishes could be attributed to the method of processing or cooking which includes de-husking, soaking and heat treatment, and is in line with study reported by Aliyu & Muhammed (2000). A relatively high caloric value was observed in bambara and rice and this is in agreement with study reported by Aliyu & Muhammed (2000). Although most of dishes had low carbohydrate values, the caloric values of some dishes were high due to the contributions of other nutrients such as lipids.

Mineral and Vitamin C contents of standardized bambara nut based dishes

Table 3 shows the Mineral and Vitamin C content of standardized bambara nut based dishes. The values were significantly different ($p < 0.05$) with the values ranging from 3.1 to 110.1 mg/100g, 10.3 to 239.6 mg/100g, 13.8 to 70.0 mg/100g, 4.9 to 30.1 mg/100g, 0.0 to 27.0 mg/100g and 6.0 to 40.5 mg/100g for phosphorus, potassium, sodium, zinc, iron and calcium content respectively. The values of Vitamin C content were significantly different ($p < 0.05$) with the values ranging from 0.2 to 0.5 mg/100g. The dishes observed to have low ash content were also observed to generally have low mineral contents. The lower ash and consequently lower minerals contents as compared to the raw might be due to loss of vegetative parts of the crops during processing (Echendu et al., 2009). The selected dishes were high in sodium, iron and zinc contents; fair in phosphorus, and low in potassium and calcium when compared to the safe level of intake for various micronutrients in low-income countries (FAO, 1988). Otemuyiwa & Adewusi (2014) reported that zinc is an important trace

element whose function is associated with growth, normal embryogenesis, foetal growth and colostrum production during lactation. The vitamins C values were low in all the dishes.

Nutrient-inhibitor content and aerobic plate count contents of standardized bambara nut based dishes

Table 4 shows the nutrient-inhibitor content of standardized bambara nut based dishes. The values were significantly different ($p < 0.05$) with the values ranging from 94.2 to 202.6 mg/100g, 0.0 to 0.2 mg/100g and 1.8 to 8.0 mg/100g for phytate, tannin and oxalate content respectively. Table 5 shows the aerobic plate count contents of standardized bambara nut based dishes with the values ranging from 4.0×10^4 to 3.90×10^6. Phytate content were significantly low in bambara nut-based dishes. This trend of decreased phytate contents are in line with the study reported by Echendu et al (2009). Tannin is located mainly in the seed coat of bambara-nut; therefore domestic food processing techniques can reduce tannin content in bambara nut foods. The low levels of tannins in bambara nut-based dishes showed that the anti-nutrient could be reduced to safe level in foods using cooking and fermentation processing techniques and this is in lines with study reported by Echendu et al. (2009). The lower values might also be due to the breakdown of tannin -protein and tannin-enzyme complexes by enzymes of fermenting organisms and subsequent leaching out of free toxin (Obizoba & Atil, 1994). Oxalate contents were also low in bambara-based diets. The low level of nutrient inhibitor factors and toxicants in the dishes make them safe for consumption even in high quantity. Table 5 shows the aerobic plate count of bambara-based diets. Microbiology contamination leading to infections and poor nutrients associated with local foods consumption may contribute significantly to deaths (Oluwafemi & Ibeh, 2011).

In Nigeria, due to poor food-handling, poor storage facilities (power outage), and unhygienic practices by the food hander, foods can easily be contaminated within short period of time before getting to the consumer. Among the dishes, only Bambara *moinmoin* got contaminated within twenty-four hours of preparation. The sources of contamination might be attributed to poor handling, risk foods and cross-contamination (Oluwafemi & Ibeh, 2011).

CONCLUSION

The study showed that the bambara nut dishes have low nutrient-inhibitor composition; this is an indication that the dishes can make the essential nutrients available for the body use and the dishes were also safe for human consumption.

Table 1. **Standardized recipe for bambara nut based dishes**

Dishes/ingredients	Converted weight/ volume	Local weight/ volume
Bambara porridge		
Roasted Bambara nut powder	250g	3 milk cups
Liquid milk/Nunu	225g	1½ milk cups
Sugar	50g	½ milk cup
Water	950ml	5½ milk cups
Ground potash	5g	½ teaspoon
Bambara ball		
Dehulled Bambara nut	262.5g	2½ milk cups
Chopped Onions	75g	1 small size
Chopped Red pepper	100g	3 medium sizes
Groundnut oil	200ml	½ beer bottle
Salt	15g	To taste
Bouillon cube	1cube	1cube
Bambara moinmoin		
Dehulled bambara-nut	350g	3 milk cups
Fresh pepper	100g	3 medium sizes
Fresh onion	110g	2 small sizes
Groundnut oil	75ml	2 table spoons
Salt	10g	to taste
Whole Cray fish	15g	½ milk cup
Water	200ml	1 milk cup
Bouillon cubes	2 cubes	2 cubes
Ground potash	5g	½teaspoon
Bambara Soup		
Dehulled bambara nut	350g	3 milk cups
Fresh red pepper	100ml	3 medium pieces
Fresh onion	75g	1 small size
Fresh tomatoes	50g	2 small pieces
Smoked fish	350g	4 medium pieces
Locust bean	25g	2 table spoons
Bouillon cubes	2cubes	2 cubes
Potash powder	5g	½ teaspoon
Red palm oil	100g	¼ beer bottle
Whole cray fish	15g	½ milk cup
Salt	15g	To taste
Water	1650ml	10 milk cups
Bambara and rice		
Rice	350g	2½ milk cups
Bambara nut	175g	1½ milk cups
Water	1650ml	10 milk cups
Onion	75g	1 small size
Salt	15g	to taste

Table 2. Proximate Composition (% DM) of standardized Bambara nut based dishes

Sample	Moisture	Crude protein	Crude fat	Crude fibre	Ash	carbohydrate	Energy (Kcal)
Bambara porridge	67.7±2.9^{b}	0.9±0.1^{c}	1.3±0.0^{c}	2.9±0.3^{d}	0.8±0.3^{b}	24.8±0.1^{b}	115.0±3.3^{c}
Bambara ball	45.8±3.0^{c}	6.1±1.4^{a}	18.7±0.0^{a}	10.6±0.4^{a}	1.3±0.0^{a}	17.6±4.2^{c}	262.9±12.1^{a}
Bambara moinmoin	75.6±0.8^{a}	3.2±0.4^{b}	1.3±0.0^{c}	4.5±0.5^{c}	0.6±0.2^{bc}	14.4±0.3^{c}	82.5±2.9^{d}
Bambara Soup	70.1±1.4^{b}	1.1±0.2^{c}	1.8±0.0^{b}	0.2±0.0^{e}	0.3±0.4^{c}	26.5±1.2^{b}	126.4±5.5^{c}
Bambara and rice	41.9±1.1^{c}	6.4±0.9^{a}	0.9±0.0^{d}	5.6±0.0^{b}	0.3±0.0^{c}	44.9±1.9^{a}	213.5±4.5^{b}

Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 3. Mineral and Vitamin C contents (mg/100g) of standardized bambara nut based dishes

Sample	Phosphorus	Potassium	Sodium	Zinc	Iron	Calcium	Vitamin C
Bambara porridge	3.1±0.0^{e}	239.6±0.9^{a}	13.8±0.3^{e}	30.1±0.1^{a}	24.2±6.9^{b}	35.1±0.5^{b}	0.2±0.1^{d}
Bambara ball	110.1±0.0^{a}	25.1±0.0^{b}	54.4±0.3^{b}	12.4±0.0^{c}	12.0±0.4^{c}	40.1±0.0^{a}	0.3±0.0^{c}
Bambara moinmoin	5.3±0.1^{d}	10.3±0.0^{d}	39.9±0.2^{c}	4.9±0.0^{e}	0.0^{d}	40.5±0.0^{a}	0.4±0.0^{b}
Bambara Soup	8.0±0.3^{c}	19.0±2.0^{c}	70.0±0.1^{a}	6.5±0.0^{d}	27.0±0.3^{a}	6.0±0.7^{d}	0.3.0±0.0^{c}
Bambara and rice	85.0±0.0^{b}	27.0±0.0^{b}	36.0±0.0^{d}	20.2±0.1^{b}	0.0^{d}	15.0±0.0^{c}	0.5±0.0^{a}

Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 4. Nutrient-inhibitor (mg/100g) contents of standardized bambara nut based dishes

Sample	Phytate	Tannin	Oxalate
Bambara porridge	116.8±4.1^{c}	0.2±0.0^{a}	7.7±0.3^{b}
Bambara ball	202.6±1.1^{a}	0.0^{c}	1.8±0.0^{c}
Bambara moinmoin	113.2±3.1^{c}	0.1±0.0^{c}	6.7±0.1^{b}
Bambara Soup	94.2±2.6^{d}	0.1±0.0^{b}	1.8±0.0^{c}
Bambara and rice	167.6±4.6^{b}	0.0^{d}	8.0±0.0^{a}

Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 5. Aerobic plate count of standardized Bambara nut based dishes

Sample	Number of colony (Cfu/g)
Bambara porridge	3.2×10^{6}
Bambara ball	TNTC
Bambara moin-moin	1.6×10^{6}
Bambara Soup	4.0×10^{4}
Bambara and rice	3.9×10^{6}

TNTC - Too numerous to count
Cfu/g -Colony forming units/gram

REFERENCES

Alabi, M.O. (2007). Processing and Utilization of selected food crops in Nigeria. Peace House publications, Gboko, Nigeria.

Aliyu, S.M.R. and Mohammed, R. (2000). Nutrient Composition of food stuffs and Dishes/Foods of Indigenous Population of Jos Plateau, Nigeria. *West African Journal of Food and Nutrition*, Vol. 2. No. 3, pp. 203-208.

AOAC (2005). Official method of analysis. Association of Official Analytical Chemists, Washington D.C.

Barnet, J.A., Payne, R.W. and Yarrow, D. (1990). Yeast Characteristics and Identification. Second edition, Cambridge University Press, U.K.

Echendu, C.A, Obizoba, I.C, Anyika, J.U. and Ojumelukwe, P.C. (2009). Changes in Chemical composition of Treated and Untreated Hungary Rice "Acha" (Digitaria exiles) *Pakistan Journal of Nutrition*, Vol. 8, pp. 1779-1785.

F.A.O. (1982). Legumes in Human Nutrition. FAO Food and Nutrition paper No. 20, FAO, Rome.

FAO/WHO (1998). Preparation and use of food-based dietary guidelines. Report of a joint FAO/WHO Consultation, WHO Technical Report series 880, Geneva.

F.A.O. (1995). International Conference on Nutrition. Food and Agricultural

Organization World Declaration and Plan of action, Rome.

Fejiokwu, L.C. (1997). Political Leadership Handbook and Who's Who. Polcom Nigeria Limited, Enugu, pp. 666-673.

Folorunso, A.A. (2015). Standardization, nutrients and nutrients-inhibitors composition of acha (*Digitaria Exilis*) and bambara nut (*Vigna Substerranea*) based dishes commonly consumed in Niger state, Nigeria. Unpublished Ph.D. thesis, Department of Nutrition and Dietetics, Federal University of Agriculture, Abeokuta, Nigeria.

Harris, D.C. (1997). Exploring Chemical Analysis. Second edition, Reinhold Publication Co., New York.

International Organization for Standardization (2004). Microbiology Methods. Available at: http:/iso.org

Kunyanga, C.N., Imungi, J.K. and Vellingiri, V. (2013). Nutritional evaluation of indigenous foods with potential food-based solution to alleviate hunger and malnutrition in Kenya. *Journal of Applied Biosciences*, Vol. 67, pp. 5277 – 5288.

Mojekwu, C.C. and Anyafulu, A.M. (2014). Analysis of nutritional composition and acceptability of selected fast foods and standardized indigenous dishes in Nigeria. *Research Journal in Organizational Psychology and Educational Studies*, Vol. 3 No. 6, pp. 415-418.

Mwaura, F. (2004). Networking Event on: 'Indigenous foods and local security. COASAD Council.

National Bureau of Statistics (2012). Consumption Pattern in Nigeria. Publication of National Bureau of Statistics, Abuja, Nigeria.

Obizoba, C.I, and Atil, V.J. (1994). Evaluation of effect of processing techniques on nutrients and antinutrients of pearl millet (*Pennisetum glaucum*) seeds. *Plant food for Human Nutrition*, Vol. 45, pp. 23-34.

Oguntona. C.R.B, Odunmbaku, J.A. and Otun, B.O. (1999). Proximate composition of ten standardized Nigerian dishes. *Journal of Nutrition and Food Science*, Vol.6, pp. 295-302.

Okhiria, A. A. (2010). Nutritional evaluation and standardization of indigenous-dishes in the South-West of Nigeria. Unpublished Ph.D. Thesis, University of Agriculture, Abeokuta, Nigeria. Pp.67-76.

Oluwafemi, F. and Ibeh, I.N. (2011). Microbial contamination of Seven Major Weaning Foods in Nigeria. *Journal of Health, Population and Nutrition*, Vol. 29, No. 4, pp. 415-419.

Otemuyiwa, I.O. and Adewusi, S.R. A. (2014). Nutrient composition of some foods from a Nigerian eatery. *Journal of Food Chemistry and Nutrition*, Vol. 2, No. 1, pp. 11-18.

United States Department of Agriculture (1995). A tool kit for healthy school needs: Recipes and Training materials. USDA report, pp. 37.