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Motto: Eat Organic, Stay Alive and Healthy

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The Association of Organic Agriculture Practitioners of Nigeria (NOAN) was founded in 2009 in Nigeria and registered with Cooperate Affairs Commission (CAC) in 2012.

The Association is responsible for the publication of Journal of Organic Agriculture and Innovation as well as creating awareness on Organic Agriculture and advocating for Organic Agriculture Principles and Practice in Nigeria. Membership to the association is open to all persons (ordinary/individual) and cooperate bodies including NGOs, Cooperative Societies, farmers' groups and students interested in organic Agriculture. The application forms and subscription for membership can be obtained from the administrative officer, Ms Rebecca Okunola (08035796856), C/o Room 25, Department of Agronomy, University of Ibadan. Manuscripts should be sent to the editor-in-chief via editornoanjournal@gmail.com.

FROM THE EDITORIAL DESK

I want to start by appreciating NOAN Governing Board on behalf of the Editorial Board for finding us worthy to handle this assignment. My appreciation goes to the contributors/manuscript authors who confided in our ability to deliver and thereafter submitted their manuscripts to our journal. To the members of NOAN who gave us the needed massive support to carry out this assignment seamlessly, I say a very big thank you. On behalf of the editorial team, I appreciate our reviewers for their dedication and commitment especially in the timely review work done.

This is actually the maiden issue of the Journal of Organic Agriculture, Research and Innovation (JOARI). It comprises original research work on Organic Agriculture in different areas of specialization viz: Agricultural Economics and Extension, Animal Science, Crop Science, Soil Science, Food Science and Technology, Agric. Engineering, Product Development etc.

I wish to recommend this Journal to researchers, scientists, students and organic agriculture advocates who wish to expand their scope/knowledge in organic agriculture. Read, Learn and be blessed.

Onunwa, Akudo O. PhD.

Editor-in-Chief

Guide to Contributors

Interested contributors in Organic Agriculture are invited from all parts of the world whose work covers original scientific researches, theories, and innovations on organic agriculture which have not been published, accepted or submitted for publication in any other journal.

The electronic manuscript should be written in English, carefully laid out in a simple and concise two-column format, composed in Microsoft Word version 6.0 or higher. Manuscript should be on A4 paper with 1" margin. The body of the manuscript should be Times New Roman font 12.

Major manuscript headings should be **Abstract, Introduction, Materials and Methods, Results, Discussion or Results and Discussion, Conclusion Recommendation/Suggestions, acknowledgments (if any) and References.** Abstract should not be more than **250 words in single lines spacing**.

Major and minor headings should be concise, with Major headings in **capital letters** and the Minor headings in sentence case**, both bolded, and typed against the left-hand margin**.

The manuscript Title Page should contain the following information: Author(s)' name(s), and affiliations, E-mail Address, phone number and correspondents contact. Tables should be numbered in Arabic numerals with titles in small letters. There should be Minimum Horizontal lines and vertical lines should be avoided. Diagrams, tables and figures must be of good quality, and appropriately placed within the text with System International (SI) unit. Photographs should be included as imbedded JPEG images with names corresponding to the figure number (i.e. fig1)

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Journal of Organic Agriculture Research and Innovation (JOARI)

EFFECTS OF RUBBER EFFLUENT AND POULTRY MANURE ON SOIL BACTERIAL CHANGES AND GROWTH OF *AMARANTHUS* (*Celosia spp.*) IN AN ULTISOL IN THE LOWLAND FOREST ZONE OF NIGERIA

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Abstract

This study examined the impact of rubber effluent and poultry manure on the growth of amaranth and changes to soil properties. Four rates (0, 5, 15 and 30 milliliters) of effluent application were applied to plots measuring 3m by 2m each. *Amarathus* was thereafter transplanted to the plots at two weeks after the application of the effluent. The field was laid out in a Randomized Complete Block Design (RCBD). Plant parameters (plant height, number of leaves and leaf area) were measured at two weeks' interval while soil (physical, chemical, and microbial) properties were determined before and after experiment using standard procedures. Results showed that the effluent-treated plots had increased soil pH (4.84 – 5.09), N (0.36 gkg^{-1} – 0.41 gkg^{-1}), P (22.24 $mgkg^{-1}$ – 41.88 $mgkg^{-1}$) Mg (0.65 – 2.36 $cmolkg^{-1}$), and TOC (3.63 – 4.15 $cmolkg^{-1}$), while Mn content was higher in the control (38.58 $cmolkg^{-1}$). The growth of amaranth plants was significantly *($P<0.05$)* and positively impacted by the rubber effluent treatments compared to the control. Microbial populations in the test soil increased relative to the control and new microorganisms were introduced in response to the effluent. Bacteria isolates identified in the control sample were; *Pseudomonas* spp., *Klebisella sp.*, and *Bacillus* spp. Meanwhile, *Proteus sp.*, *Staphylococcus* spp., and *Micrococcus* spp. were found in the rubber effluent-treated plots. Overall, the study demonstrated that the application of rubber effluent and poultry manure can enhance soil properties and plant growth, but that, it can also introduce new microorganisms into the environment. These findings have important implications for sustainable agricultural practices in the region, as the use of these materials may provide a cost-effective and environmentally friendly way to improve soil fertility, health and crop productivity.

Keywords: Amaranth, Microorganisms, Poultry manure, Rubber effluent

INTRODUCTION

Soil is a major part of the natural environment, along air and water which are vital to the existence of life on planet earth. Soil is the main stay of agriculture and horticulture, forming the medium on which growth and ultimately the yield of food producing crops occurs. Soil is increasingly being recognized as playing a fundamental role in the quality and distribution of our water supply. The discharge of industrial effluents especially without treatment may have profound influence on the physical, chemical and biological properties of soil in relations to soil fertility (Aishwarya *et al.*, 2014).

Natural rubber processing sector is an industry which produces raw materials used for the manufacture of rubber products. However, effluents generated from this sector could become big issues in terms of disposal. Natural rubber processing sector consumes large volumes of water and energy and uses large amount of chemicals as well as other utilities (Leong *et al.*, 2003). Waste water is an unavoidable by-product of rubber processing: whatever the processing procedures used for preparing products from latex, there will always be an aqueous liquid as a by-product (Rungruang and Babel, 2008). The major chemical component groups of natural rubber waste 'serum' shows that it consists mainly of nitrogenous compounds. In the waste water (effluent), the bulk of the nitrogen component consists mainly of ammoniacal nitrogen as a result of the use of ammonia in the preservation of the latex. The high level of ammonium ion (NH_4^+) and other plant nutrients makes it a good medium for algal growth, thus resulting in the eutrophication of water bodies (Chislock *et al.*, 2013). Consequently, there is increasing global concern on the environment over the proper management of waste in order to minimize and possibly eliminate their potential harm to public health and the environment.

The low fertility status of Utisols necessitates the need for external fertilizer input hence, the use of fertilizer (organic or inorganic) supplements to

enrich the soil with nutrients, especially in nitrogen for the growth of succulent leafy vegetables (Emede *et al.*, 2012, Orhue and Osaigbovo, 2013). The use of synthetic fertilizer to sustain crop production has been reported by several researchers to increase yield only for few years but not on long-term sustainable basis (Ojeniyi, 2000). In highly weathered soils (e.g., Utisols), the use of synthetic fertilizer has not been sustainable due to its ability to induced soil acidity, nutrient imbalance and physical degradation leading to increase in soil erosion coupled with the fact that synthetic fertilizers are usually not available and are always expensive for the resource-poor farmers (Ojeniyi, 2000). These facts stress the need and had also prompted many researchers to experiment with organic fertilizers (waste from farm animals and plants) to improve the physical, chemical and biological properties of soils (Linger and Critchley, 2007). Researches have shown that organic fertilizers are currently being preferred to synthetic fertilizer as they are capable of improving the nutrient contents of soils on a sustainable basis. They have also been reported to be the best means for recycling nutrients contained in a material, thus; activating the microbial biomass and improving soil tilth (Emede *et al.*, 2012). Incorporating organic fertilizer into the soil as a cultural practice for crop production is expected to play a direct role in plant growth by supplying all necessary macro and micronutrients in available forms during mineralization, thereby improving the physical, chemical and the biological properties of soils.

The numerous importance of organic fertilizers had over time aroused the interest of scientist to experiment with more natural materials that could be used as organic fertilizer that will not only supply the needed nutrients for plant growth but will also enhance the soil health and nutritional values of crops produced. Most research on the use of effluent as soil amendments had only considered the effects on the physical and chemical properties of soils without emphases on the biological properties. This investigation is aimed at determining the growth response of *Amaranth* and the changes in soil bacteria composition due to the application of rubber effluent and poultry manure (organic materials) in a ultisol.

MATERIALS AND METHODS

Study Area

This study was carried out at the University of Benin Teaching Research and Integrated Project (UBTRIP) Farm Site, Ugbowo Campus, Benin City. The site lies between latitude 06.39589ºN and longitude 005.63235ºE. The area is characterized by a tropical climate with an annual rainfall amount of 1900mm and mean annual temperature ranging from 23 ºC to 37 ºC. The site is situated at the Rainforest belt of the humid tropics and southern ecological zone of Nigeria, with distinct dry and wet seasons. The dry season begins early November and ends by March, while the rainy season is usually from April to October. The rainfall pattern is bimodal with peaks in July and August; however, there is a short spell called "August-break" in mid-August, accompanied by few thunderstorms. The soils are derived from coastal plain sands (unconsolidated sands and sandy clay) and alluvial deposits.

Source of Materials

The rubber effluent (liquid waste) was obtained from Odia Farm at Ikpoba-hill, Benin City, Edo State, Nigeria. The poultry manure from battery cage (cured state) was obtained from the University of Benin Animal Farm Project while the *Amaranth* seeds were obtained from the Crop Science Department of the University of Benin. Benin City.

Field Layout/Operations

The field was laid out in a Randomized Complete Block Design (RCBD) with four rates of application; 0, 5, 15 and 30 milliliters of rubber effluent was added to two liters of water and thereafter used in irrigating the various plots in a single application. These treatments were designated as: T_0, T_1, T_2, T_3 and T_4 respectively (these rates are equivalent to 0, 10, 30 and 60 litres ha^{-1} respectively). The treatments were replicated three times to give a total of 12 plots measuring 3m by 2m each used for the experiment. The poultry manure was applied as a basal amendment at the rate of 0.16 kg per plot which is an equivalent of 0.27 t/ha. Two weeks after the application of poultry manure, *Amaranth* seedlings (2weeks old) were transplanted to the field at the rate of 60 plant stands per plot at a spacing of 30 cm x 30 cm. Plant parameters measured were: plant height, number of leaf and leaf area.

Soil/Plant Analysis

Soil sampling from the field were made at 0 – 15 cm depth before and after planting and were thereafter analyzed for their physical, chemical and microbial properties. These soils were first air dried and sieved to 2 mm particle size. Twenty grams (20g) of soil sample from each treatment was weighed into different 100 ml beaker, 20 ml distilled water was added to each. The mixture was stirred intermittently for 30 minutes while the glass electrode pH meter was standardized with buffer 7.0 and 4.01. At the end of the 30 minutes, the suspension was measured and recorded as pH (1:1) H_2O. The particle size distributions of the soils were determined by the hydrometer method (Gee and Or, 2002). Soil organic carbon (SOC) was determined by Walkley and Black digestion method (Olsen and Sommers, 1982). Total Nitrogen was determined by

micro-Kjeldahl digestion method (Bremner and Mulvaney, 1982) while the available phosphorus was determined by Bray 1 Method (Olsen and Sommers, 1982). Exchangeable cations were extracted with neural 1 N NH_4OAc (Helmke and Sparks, 1996). The concentration of exchangeable sodium (Na), and potassium (K) were read using flame photometer while calcium (ca) and magnesium (Mg) were determined using the atomic absorption spectrophotometer.

Microbial Analysis

The serial dilution method was used to prepare the soil for determination of microbial properties coupled with series of biochemical tests (Coliform test, Methyl red test, Catalase test, Citrate utilization test, Coagulase slide test, Indole production test, Oxidase test, Urease test, the Vogues-proskauer test, Sugar fermentation test, Motility test, Spore stain) Duarte *et al*., 2016, Pascoal *et al*., (2018). were used to identify the bacteria composition in the soil (Cowan and Steel 1970).

Statistical Analysis

Data generated from the experiment were subjected to ANOVA using a Genstat package and treatment means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Some Chemical and Physical Properties of Rubber Effluent/Soil Prior to Amendment

The results presented in Table 1, showed the properties of rubber effluent used in this experiment. The pH value of the effluent was found to be 5.23, which is classified as moderately acidic. This indicates that the effluent is not alkaline and may not cause adverse effects on soil and plant growth when used as a fertilizer or soil amendment. The effluent contained a total nitrogen concentration of 2.30 mg/l, which is relatively low compared to other commonly used fertilizers.

Table 1: Chemical Properties of the Rubber Effluent

Effluent Property	Mean Value
pH (1:1)	5.23
Total Nitrogen mg/l	2.30
Phosphorus mg/l	5.26
Organic carbon %	0.18
Potassium mg/l	11.30
Calcium mg/l	8.50
Sodium mg/l	1.22
Magnesium mg/l	2.86

Nitrogen is a crucial nutrient required for plant growth, and low nitrogen concentration in the effluent suggests that it may not be an effective sole source of nitrogen for plant growth and development. Phosphorus, another essential nutrient for plant growth had a concentration of 5.26 mg/l. This amount of P in the effluent shows that it can provide significant amount of phosphorus (P) for plants uptake. The organic carbon content of the effluent was determined to be 0.18%. The low organic carbon content in the effluent suggests that it may not be an effective soil amendment for enhancing organic carbon content in the soil. The effluent also contained potassium, calcium, sodium, and magnesium at concentrations of 11.30 mg/l, 8.50 mg/l, 1.22 mg/l, and 2.86 mg/l, respectively indicating that the effluent contains vital nutrients which are necessary for plant growth. As a result, it is believed to be a valuable resource for increasing the nutrient levels in soils and enhancing plant growth. This finding however agrees with the reports of Orhue and Osaigbovo, (2013) who also demonstrated that rubber effluent contain substantial amount of N, P, OC, K, Mg, Na and Ca.

The results in Table 2 showed the physical and chemical properties of the soil before amendment and planting. The pH value of 4.24 indicates that the soil is strongly acidic. This pH is capable of limiting soil nutrient availability, growth and yield of crops (Ojeniyi, (2000); Orhue and Osaigbovo, (2013). The H^+ and Al values were low, which is desirable for plant growth as high values can lead to soil acidity and nutrient deficiencies (Asemwota *et al*., 2005).

Table 2: The physical and chemical properties of the soil before amendment and planting

Parameters	Value
pH (1:1)	4.24
H^+(cmol/kg)	0.20
Al (cmol/kg)	0.10
PO_4 (mg/kg)	22.83
N (g/kg)	0.18
TOC (g/kg)	19.50
SO_4 (mg/kg)	11.53
Mn (mg/kg)	22.64
Ca (cmol/kg)	2.28
Mg(cmol/kg)	0.99
Na(cmol/kg)	0.44
K(cmol/kg)	0.48
CEC(cmol/kg)	44.9
Sand (g/kg)	791.10
Silt(g/kg)	20.70
Clay (g/kg)	188.20
Textural Class	Sandy Loam

The soil had a relatively low (22.83 mg/kg) content of available phosphorus which could also limit plant growth. This low status of P in the soil could have

resulted from the high fixation due to the strongly acidic status of the soil (Brady and Weils 2012).

The low (0.18 g/kg) nitrogen content of the soil necessitates the addition of nitrogen amendment during crop production to guarantee optimal production (Agbede 2009). Apart from Mg (0.99 $cmolkg^{-1}$) and P (22.83 $cmolkg^{-1}$), which were relatively high in the soil, the N (0.18 gkg^{-1}) was below the critical values of 1.5 - 2.0 g/kg in N, (Sobulo and Osiname, 1985), while K (0.48 $cmolkg^{-1}$) and Ca (2.28 $cmolkg^{-1}$) were above the critical values; 0.16 - 0.25 cmol/kg K (Akinrinde and Obigbesan, 2000) and 2.0 - 2.50 cmol/kg in Ca (Akinrinde and Obigbesan, 2000) respectively. The total organic carbon (TOC) value was high at 19.50 g/kg, indicating that the soil has a good potential to support microbial activities and nutrient cycling. The CEC value (44.9 cmol/kg) of the soil was observed to be high (Chude *et al*., 2011), which is desirable for nutrient retention in the soil. The texture of the soil is sandy loam, which may require the addition of organic matter to improve its water-holding capacity and nutrient retention. The properties of this soil used indicated that the soil has a low native fertility, which is typical of an Ultisol as reported earlier by Ogunkunle (1993).

Physical and Chemical Properties of Soil after Field Experiment

The post-trial properties of the soil are shown in Table 3. The soil N (0.36 - 41gkg^{-1}), P (22.24 – 41.88 $mgkg^{-1}$), K (0.24 – 0.38 $cmolkg^{-1}$), Na (0.41 – 1.21 $cmolkg^{-1}$), Ca (4.45 – 6.38 $cmolkg^{-1}$), Mg (0.65 -2.36 $cmolkg^{-1}$) and CEC (5.75 – 9.73 $cmolkg^{-1}$) increased slightly with increasing levels of rubber effluent between T_2 and T_3 but the amount were not significantly different at 5% level of probability from their contents in other treatments. While the soil pH values (4.98 – 5.09) were also observed to be higher in the treated soils than the control (4.84), organic carbon, also showed an increase following the application of rubber effluent but not in a steady order with increasing rates of the treatments but were slightly higher (4.01 – 4.15 gkg^{-1}) in the rubber effluent amended soils compared with the control (3.63 gkg^{-1}). The increase in the chemical properties of the treated over the control can be attributed to the 'serum' properties of the effluent as earlier reported by Orhue and Osaigbovo (2013). This increase in soil nutrient contents especially in PO_4, N, Ca and Mg further confirms that applying this effluent is not problematic especially when the rate of application is calculated to supply nutrients at a level corresponding to those in inorganic fertilizers normally applied to promote satisfactory crop performance. This report is similar to the findings of Okorie *et al.,* (2017) who also investigated the on cotton seed oil-mill effluent as inexpensive biofertilizers.

Microbial Properties of Soil before and after the experiment

Table 4, showed that the initial bacterial count was 1.1 x 10^6 in the soil sample. However, the population increased to 1.2 x 10^6 under the control plots. This population growth in *Bacillus sp* could be due to rhizosphere effects (Lopez *et al.,* 2023). The autochthonous (indigenous) bacteria in the soil sample were *Pseudomonas sp. Klebisella sp* and *Bacillus sp*. whereas, at the end of the experiment, only three organisms were isolated from the control plot. The soil with basal treatment of poultry manure had; *Pseudomonas spp.*, and *Bacillus spp* with mean population of 1.2×10^6, and 1.2 x 10^6 cfu/g, respectively. Of the three autochthonous (indigenous) soil organisms associated with the soil prior to amendment, it was observed that the poultry manure amended soil (control plot) supported the growth of two of these autochthonous (*Pseudomonas spp.,* and *Bacillus spp*) while *Staphylococcus aureus, Proteus sp.*and *Micrococcus spp* were isolated from the rubber effluent treated soil. More so, the microbial population increased with higher amount of effluent application hence, the 30 mls treated plots had the highest microbial isolates and population of most of the organisms identified. These results further suggest that the application of the rubber effluent had brought about a significant change in the microbial species that became dominant in terms of their population in the soil. This finding agrees with the reports of Ingham (2000) whose investigation revealed that, different and specific soil organisms occur where they can find suitable pH, appropriate food supply, space, nutrient, and moisture.

Table 3: Physical and chemical properties of soil after field experiment

		cmol/kg			g/kg					cmol/kg						
Treatment (ml)	pH (H_2O)	H^+	Al^{3+}	PO_4 (mg/kg)	N	TOC	Clay	Silt	Sand	SO_4	Mn	Ca	Mg	Na	K	CEC
0	4.84a	0.63a	0.30a	22.24b	0.36a	3.63a	132.10a	10.60a	857.50a	13.69a	38.58a	4.45a	0.65a	0.41a	0.24a	5.75a
5	5.09a	0.47a	0.20a	34.02ab	0.38a	4.01a	128.80a	11.60a	859.60a	14.63a	15.94a	5.13a	1.98a	0.42a	0.26a	7.79a
15	5.09a	0.47a	0.21a	41.88a	0.41a	4.15a	90.30a	09.80a	866.50a	18.07a	30.09a	5.81a	2.36a	1.21a	0.35a	9.73a
30	4.98a	0.47a	0.27a	38.84a	0.39a	4.01a	158.60a	15.40a	826.00b	12.54a	28.52a	6.32a	1.19a	0.99a	0.38a	8.88a
Mean	5.00	0.51	0.25	34.25	0.39	3.95	127.50	11.90	852.40	14.73	28.28	5.43	1.55	0.76	0.31	8.04

Table 4: Population of Soil Bacterial colony forming units (CFU) according to the concentrations of rubber effluent (ml)

		Mean Population in Cfu/g of soil			
Isolates	Initial	0	5	15	30
Pseudomonas sp	1.2×10^6	1.2×10^6	-	-	-
Klebisella sp.	1.1×10^6	-	-	-	-
Bacillus Sp.	1.1×10^6	1.2×10^6	-	-	-
Proteus sp.		-	-	-	1.1×10^6
Micrococcus spp.,		-	-	2.6×10^6	2.8×10^6
Staphylococcus aureus.		-	1.6×10^6	1.6×10^6	1.1×10^6

(-) = No visible culture

Influence of Rubber Effluent on Height, Number of Leaves and Leaf Area of *Amaranth*

Table 5 presents the effect of rubber effluent on the plant height of amaranth at different weeks after planting (WAP). The rates of effluent application were; 0ml, 5ml, 15ml, and 30ml of rubber effluent per plot. The results showed that plant heights (40 – 52 cm at week 10) increased with increasing concentration of rubber effluent. The plants in the control treatment had the lowest plant height (3.03 cm in week 2 – 40.00 cm at week 8) at all weeks after planting. At the 3rd and 4th WAP, plants grown on effluent treated soils were all significantly ($P < 0.05$) taller than plants on the control soils. While at the 6th WAP, only T_3 (15ml) and T_4 (30ml) plants had plant heights (37 cm and 40 cm respectively) that were significantly different ($P < 0.05$) form the control (30 cm) and at the 8th WAP, the treated plants were significantly taller than the plants in the control. These results suggest that the application of rubber effluent had a positive effect on the plant height of amaranth, with the highest concentration (30ml) resulting in the tallest plants. These findings indicate the potential use of rubber effluent as an organic fertilizer for enhancing the growth of amaranth. This increase in growth parameters as a result of the treatment applied is similar to the reports of Lim *et al.,* (1983) on oil palm and Orhue *et al.,* (2005) who observed an increase in the growth of their experimental plants due to effluent application.

Table 6, showed the effects of rubber effluent on the number of leaves of the plants. The results suggest that the treatments had varied effects on the number of leaves at different weeks after planting (WAP). At 2WAP, there was no significant difference ($P<0.05$) in the number of leaves among the treatments. The number ranged from 2.5 at the 2nd week – 29.5 at the 8th WAP. However, at the 8th WAP, T_2, T_3 and T_4 had a significantly higher number of leaves than the control treatment. This may be due to the nutrients provided by the effluent which had improved the nutrient status of the treated soil over the control soils thereby resulting in higher growth of the plants (Orhue *et al.,* 2005).

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Table 5: Effects of Rubber Effluent on Plant Height

	Plant Height (cm)						
Treatments	**2WAP**	**3WAP**	**4WAP**	**5WAP**	**6WAP**	**7WAP**	**8WAP**
T_1(Control)	3.03^b	4.49^b	10.00^b	21.50^{bc}	30.00^{bc}	36.00^{bc}	40.00^b
T_2 (5ml)	3.02^b	5.13^a	11.40^a	22.00^{bc}	35.00^{ab}	40.00^{ab}	48.00^a
T_3 (15ml)	3.03^b	5.20^a	11.40^a	24.00^a	37.00^a	42.00^{ab}	50.00^a
T_4 (30ml)	3.10^a	5.30^a	11.41^a	23.00^b	40.00^a	47.00^a	52.00^a
Mean	3.05	5.03	8.84	22.63	35.50	41.25	38.00
SEM	0.06	0.20	0.40	0.49	3.40	4.20	5.10

Plant height values in a column with the same letter are not significantly different from one another; WAP = Weeks after Planting; SEM = Standard error of means

Table 6: Effects of Rubber Effluent on Number of Leaves

	Number of Leaves						
Treatments	**2WAP**	**3WAP**	**4WAP**	**5WAP**	**6WAP**	**7WAP**	**8WAP**
T_1(Control)	2.30[a]	6.50[a]	13.00[a]	19.00[d]	24.00[bc]	26.00[b]	27.00[b]
T_2 (5ml)	2.30[a]	6.00[a]	18.00[a]	20.00[c]	24.00[bc]	27.00[a]	30.00[a]
T_3 (15ml)	3.00[b]	7.00[a]	15.00[b]	22.00[b]	25.00[b]	28.00[a]	31.00[a]
T_4 (30ml)	2.50[a]	7.00[a]	16.00[a]	23.00[a]	26.00[a]	29.00[a]	30.00[a]
Mean	2.53	6.63	15.50	84.00	24.75	27.50	29.50
SEM	0.29	2.20	0.21	1.00	0.73	2.30	1.76

Mean values in a column with the same letter are not significantly different from one another; WAP = Weeks after Planting; SEM = Standard error of means

Table 7: Effects of Rubber Effluent on Leaf Area

	Leaf Area (cm^2)						
Treatments (ml)	**2WAP**	**3WAP**	**4WAP**	**5WAP**	**6WAP**	**7WAP**	**8WAP**
T_1(Control)	2.30[a]	6.50[a]	13.00[a]	18.60[bc]	24.00[b]	25.50[b]	26.50[b]
T_2 (5ml)	2.30[a]	6.00[a]	18.00[a]	19.50[bc]	24.25[b]	27.00[a]	29.50[a]
T_3 (15ml)	2.50[a]	7.00[a]	15.10[a]	22.05[a]	25.00[a]	28.25[a]	30.55[a]
T_4 (30ml)	2.45[a]	6.50[a]	16.08[a]	23.10[a]	26.27[a]	29.25[a]	30.00[a]
Mean	2.39	6.50	15.55	20.81	24.88	27.50	29.14
SEM	0.29	2.20	0.21	1.00	0.73	2.30	1.76

Mean values in a column with the same letter are not significantly different from one another; WAP = Weeks after Planting; SEM = Standard error of means

The effects of rubber effluent on leaf area are presented in Table 7. The leaf area is an important characteristic of plants as it is responsible for photosynthesis, which is essential for plant growth and development. The mean leaf area increased from 2.53 cm^2 at 2WAP to 29.50 cm^3 at 8WAP. Regardless of the amount of rubber effluent applied, it had no significant effect on leaf area during the first four weeks of measurements but at the 8th WAP, the treated (T_2, T_3 and T_4) plants recorded larger leaf area (29.50, 30.55 and 30.00 cm^2 respectively) compared with the control (26.50cm^2).

Conclusion

This experiment revealed that the controlled application of rubber effluent has a positive effect on the growth of *Amaranth* (*Celosia* spp.) plant with increased plant height, higher number of leaves and leaf area than the control. Although the results did not show a steady increase in soil chemical properties with increasing levels of rubber effluent; the basic soil nutrients were relatively higher in the effluent treated soil than the control. Therefore, it could be concluded that rubber effluent has a potential value for consideration as organic fertilizer for the growth of Amaranth. While on the other hand, the rubber effluent treated soils though it had the highest microbial population, had a negative effect on the soil autochthonous (indigenous) organisms. The experiment revealed that the application of rubber effluent completely led to the displacement of the indigenous organisms which are usually considered more relevant in the long term biochemical reactions that occurs in the soil as supported by many researchers. However, it is important to note that while the results of this study are promising, further research is needed to investigate the long-term effects of rubber effluent application on soil health, plant growth, and environmental sustainability.

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ESTIMATION OF NUTRIENTCONTENT OF ENSILED SUPPLLEMENTED BAMBOO LEAVES (*Bambusa vulgaris*) AS DRY SEASON FEED FOR RUMINANTS IN THE TROPICS

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Abstract

This experiment was designed to assess the nutrient content of ensiled Bambusa vulgaris leaf. Bambusa vulgaris leaf was harvested and ensiled with wheat offal (BLWHO), Bambusa vulgaris leaf was harvested and ensiled with groundnut cake(BLGNC) and Bambusa vulgaris leaf was ensiled alone (BLNAD). The silage was left to ferment for 21 days after which it was opened to determine the silage quality characteristics with nutrient composition of each silage. Results revealed that the PH, temperature, colour, aroma and texture of all silage where within recommended range for proper silage. The result of nutrient composition, revealed significant differences ($P<0.05$) in all parameters measured. The BLNAD recorded the highest dry matter value (95.72%) while the BLGNC recorded the least dry matter value (95.01%). The CP of ensiled Bambusa vulgaris leaf obtained in the study was the highest (18.00%) for BLGNC while the lowest (17.21%) was obtained in BLNAD. The highest (25.89%) crude fibre was recorded for BLNAD, while lowest (23.92%) was recorded for BLGNC. The ether extract content was highest in BLNAD (1.43%), followed by BLWHO (1.40%) while BLGNC recorded the lowest ether extract (1.36%).The ash content of BLNAD was the highest (11.56%) while BLGNC recorded the least (11.33%). All the parameters measured for the fibre fractions differed significantly ($p<0.05$).They ranged from 66.30% - 68.17%, 43.05% - 44.67% and 15.17% - 15.76% in NDF, ADF and ADL respectively, with BLNAD recording the highest values, while the least values were obtained in BLGNC. No significant variation occurred among the means for all anti-nutrients investigated. The value of Tannin, saponin, oxalate and phytate obtained in this study ranged from 0.48-0.62, 2.68-3.35, 0.07-0.12 and 0.61-0.93 respectively. They are all within the normal range for optimal metabolic activities. lt can then be concluded that ensiling Bambusa vulgaris leaf with different feed supplements enhanced the chemical composition and therefore could be a potential off season feed for ruminants.

Keywords: Bamboo leaf, silage and nutrient

INTRODUCTION

It is estimated, that the global area of bamboo forest is up to 31.5 M ha, accounting for approximately 1% of the total forest area (Antia *et. al.*, 2006). Over the last 30 years, the global forest area declines continuously, while the bamboo forest area shows an average annual growth rate of 3% (FAO, 2010). In terms of the bamboo forest area, India and China are the first two countries with the largest total areas of 9.57 M ha and 6.01 M ha, respectively. *Bambusa vulgaris* is regarded as the fastest-growing plant on the planet. The fastest growing and quick maturation, as well as the short production cycle, high biomass productivity and wide adaptability make bamboo valuable in rapid forest establishment, sustainable construction, environment-friendly furniture making and ecological foodstuff producing (Allen *et al.,* 2011). Notably, it has been proved that moderate harvesting could benefit the productivity of bamboo. Thus, bamboo is regarded as one of the most culturally, ecologically populations in Asia, Latin America and Africa. In gross, approximately 2.5 billion people worldwide utilize various bamboo-related products. The annually bamboo economic sector worth in China was estimated up to USD 11.8 billion (Felsiberto *et. al.*, 2017). Besides its wide use as animal fodders, the leaves of bamboo have been used up to thousands of years as wrapping materials for Chinese rice-pudding and Japanese sushi (Felisberto *et al*., 2019). In China, the bamboo leaves were also made into a tea form for drink. In contrast to bamboo leaves, the bamboo shoot physiologically refers to the aerial bud or meristematic tissue of bamboo plants. It is often known as the young, juvenile, tender, immature or expanding culms/stalks emerging from the nodes of the pseudo rhizomes of bamboo plants (Ebanyenle *et al.,* 2015).

Feed accounts for about 70% of the total cost of ruminant production (Amoo *et al*., 2018).

This high cost attributed to competition among man, industry and livestock for conventional foodstuffs (Chaney, 2006). There is therefore the need to source for alternative livestock feedstuffs that are cheap, readily available and not competed by man and industry.

According to Antia *et al.* (2006), the use of non-food parts from agricultural products as animal feed will not only enhance food security but also contribute to alleviations of environmental problems associated with their disposal. The attempt to source for locally available low cost but nutritionally adequate feed stuffs for ruminants has brought to lime light Bamboo leaves. Processing of bamboo leaves are by-products which are discarded because they are not suitable for human consumption. Although, not suitable for human consumption, processed bamboo leaves may find some use in animal feeding. Buckingham *et. al.*, (2011) revealed that bamboo leaves contain sufficient number of amino acids, vitamins and ascorbic acid that would aid the growth of animals when fed.

The potential value of non-food in animal feeding depends on their nutritive characteristics and energy value with palatability also being an important feature (Burns *et. al.*, 2015). The significance of nutritive content of feed resources in the health and productivity management of livestock on an ecologically sustainable basis cannot be over-emphasized (Chauhan *et. al.*, 2016). This study is therefore designed to determine the characteristics, nutrient value of *Bambusa* leaves as dry season feed for ruminant animals

MATERIALS AND METHODS

Experimental Site and Location

The experiment was carried out within the environment of Tai Solarin University of Education, Ijebu Ode. The University is located on latitude 7º 10´N, longitude 3o2´E (Google Earth, 2016).

Sample collection

Reasonable amount of *B. Vulgaris* was marked randomly for collection of samples (3-5kg)
The *B. Vulgaris* leaves were harvested from 3 marked bamboo plant in the environment.

Experimental procedure

Silage Making: These leaves were chopped and ensiled with different supplements namely: Groundnut Cake (GNC), Wheat Offal and No supplement. The bamboo leaves and supplement were mixed together at ratio 4:1 (4 parts of leaves and 1 part of supplement). These were placed in a bucket that contain cellophane bag as silo, compaction of materials was thoroughly to eliminate any air pockets to ensure proper fermentation. Thereafter, a large weight was placed on the content to ensure proper fermentation and prevention of rodent attack. The silage was left to ferment for 21 days after which it was opened to determine the silage characteristics (pH, temperature, aroma, texture and colour) 2gm of the sample measured into a baker of 15ml of distilled water was added, then it was placed under bursen burner and allowed to boil for 5 minutes, the liquid content was decanted and allowed to cool. The pH meter was standardized using buffer solution after which it was dipped into the decanted liquid to determine the pH.

Temperature: Immediately the silage was opened, thermometer was dipped into the silage to measure the temperature.

Aroma: The smell of the silage was observed as either pleasant or unpleasant

Texture: Some samples were taken by hand to feel the texture either from wet or watery

Proximate composition of ensiled Bamboo leaves (*B. Vulgaris*)

Crude protein, crude fibres, ether extract and total ash of samples were analyzed in triplicate using standard procedure of A.O.A.C (2005). The crude protein was determined with the micro Kjeldahl distillation apparatus, while chemical component of acids detergent fibre, and acid detergent lignin were determined by Van Soest method (1994).

Plate 1: Photo of Bamboo leaf

Statistical Analysis

Data obtained were analyzed and subjected to analysis of variance procedure (ANOVA) of SAS (2012). Significant treatment means were separated by Duncan's multiple range test of the same package.

RESULTS AND DISCUSSION

Quality characteristics of ensiled *Bambusa vulgaris* leaf

The quality characteristics of ensiled *Bambusa vulgaris* leaf is presented in Table 1. lt was observed that *Bambusa vulgaris* ensiled with no supplement and with supplement recorded the same temperature (29.0 ^{0}C). This value is consistent with the value reported by Dang *et al*., (2016) and De Souza *et. al.*, (2014). This indicated a well preserved silage as temperature is one of the factors that could affect silage colour. High temperature above 30°C could lead to caramelization of sugar in the forage. Temperature above 55°C could lead to reduced protein digestibility and give a black brown colour (Christian *et al*., 2015). The pH values ranged from 4.0 – 5.0 in BLGNC and BLNAD which may be regarded as a good silage as Callewaert and Michael (2013) has classified a good silage to be below 5.5 pH. The pH obtained from this study was better than that obtained by Chongtham *et al*., (2011) who reported pH range of 4.45 - 5.40 for water hyacinth ensiled with different supplement. The aroma for all silage was pleasant. Silages ensiled with supplement changed colour from green to brownish green, while the silage with no supplement it remained greenish. A well fermented silage should exhibit color similar to the actual forage ensiled (Bhatt and Singh, 2005). Bambusa vulgaris in its natural state is known to be greenish in colour. The texture for silages ensiled with supplement was firm, while that ensiled without supplement was wet. All silages properly fermented should come out with pleasant aroma confirming the fact that all the supplement might have contributed positively to making a good silage. This agrees with the findings of (Barciela and Bermejo-Barrera, 2015).

Table 1: Quality characteristics of ensiled Bamboo leaves

Parameters	BLGNC	BLWHO	BLNAD
Temp (^{0}C)	29.0	29.0	29.0
pH	4.0	4.44	5.0
Aroma	Pleasant	Pleasant	Pleasant
Texture	firm	firm	Wet
Colour	Brownish green	Brownish green	Greenish

Bamboo leaf ensiled with groundnut cake= BLGNC; BLWHO= bamboo leaf ensiled with wheat offal; BLNAD= bamboo leaf ensiled without additives

The proximate composition of ensiled *Bambusa vulgaris* leaf

The proximate composition of ensiled *Bambusa vulgaris* leaf is shown in Table 2. The result showed significant differences ($p<0.05$) in all parameters measured. The Bamboo leaves ensiled without supplements (BLNAD) recorded the highest dry matter content (95.72%) while the Bamboo leaf ensiled with groundnut cake (BLGNC) recorded the least dry matter content (95.01%). These results are comparable to the report of Amoo *et al.* (2018) in the study of potential values of some non-legume on browse plants as a dry season feed for ruminant animals. The CP content of ensiled Bamboo (*Bambusa vulgaris*) leaf ranged from 17.21% - 18.00% in BLNAD and BLGNC. These values are lower than the value range of 21.57% - 21.68% obtained my Burns *et al.* (2009) in cassava leaf silage fermented with rice bran and palm kenel cake, but in agreement with the values obtained by Allen *et al*. (2011) for some shed leaves of three trees. The value obtained in this study was above the recommended value 7% for small ruminant to enhance microbial activities (NRC 2001). It therefore confirmed that the silage were good enough for small ruminant without the problem of protein supplementation, because the CP obtained here is within the recommended value that will enhance dry matter intake (Chaney, 2013).

The highest CF was recorded for BLNAD (24.89%) while the lowest was recorded for BLGNC (23%) These variation could explain on the basis of different supplements used in ensiling of the leaf. The ether extract content was highest in BLNAD (1.43%) while BLGNC recorded the lowest ether extract (1.36%). BLNAD recorded the highest (11.56%) ash content, followed by BLWHO (11.50%) while BLGNC recorded the least at (11.33%). These results are higher than the (9.71 - 10.12% ash and (16.31 - 17.21%) crude fibre reported by Christian *et. al*., (2015) in cassava leaves silage fermented with rice bran and PKC. According to Ebanyenle *et al*. (2015).Ash is the measure of the total mineral content in a sample. The highest (45.39%) NFE was recorded for BLGNC, while the least (44.73%) was obtained in BLWHO. These result is at variance with the values reported for ensiled water hyacinth (Choudhury *et al.*, 2012).

Table 2: Proximate Composition (%) of ensiled Bambusa vulgaris

Parameters	BLGNC	BLWHO	BLNAD	SEM
Dry matter	95.01^c	95. 63^b	95.72^a	0.04
Crude protein	18.00^a	17.64^b	17. 21^c	0.02
Crude fibre	23.92^c	24.73^b	24.89^a	0.03
Ether extract	1. 36^c	1. 40^b	1.43a	0.01
Ash	11.33^c	11.50^b	11.56^a	0.02
Nitrogen free extract	45.39^a	44.73^b	44.91^c	0.08

a, b, c= means on the same column with different superscript differed significantly ($p<0.05$). Bamboo leaf ensiled with groundnut cake= BLGNC; BLWHO= bamboo leaf ensiled with wheat offal; BLNAD= bamboo leaf ensiled without supplements.

Fibre fraction of ensiled *Bambusa vulgaris* leaf

The fibre fractions of ensiled *Bambusa vulgaris* leaf is presented in Table 3. It was observed that all the parameters measured differed significantly ($p<0.05$).They ranged from 66.30 -68.17%; 43.05% - 44.67% and 15.17% - 15.76%) in NDF, ADF and ADL respectively. Values of ADF were lower than values 47.18% - 50.31% obtained for shed leaves study by Buckingham *et al*., (2011). Bhatt and Singh (2005) opined that fibre is very essential in livestock feed as it provides roughages which aids digestion, while NDF content of diet controls the voluntary feed intake of animals, the ADF content is negatively related to digestibility (Bhatt and Singh 2005). Therefore the value of NDF, ADF and ADL obtained in this study were pointers that Bamboo (*Bambusa vulgaris*) leaves are suitable for ruminant rather than monogastrics.

It is an established fact that NDF controls voluntary feed intake of animals, while the ADF controls the digestibility. Both NDF and ADF have an inverse relationship with voluntary feed intake that is the higher the NDF, the lower the ADF, and the lower the voluntary feed intake Amoo *et al.,* (2018).

Table 3:Fibre fraction (%) ensiled with Bamboo *(Bambusa vulgaris)* leaf

Parameters	BLGNC	BLWHO	BLNAD	SEM
Neutral detergent fibre	66.30	67.44	68.17	0.03
Acid detergent fibre	43.05	44.00	44.67	0. 25
Acid detergent lignin	15. 17	15.23	15.76	0.15

Conclusion

This experiment indicated that *Bambusa vulgaris* (Bamboo) leaf is fortified with adequate nutritional value required for adequate growth maintenance and establishment of ruminants. The quality and characteristics, proximate composition and fibre fractions of ensiled *Bambusa vulgaris* (Bamboo) leaves were found to be at optimum level. This study therefore concludes that ensiled *Bambusa vulgaris* (Bamboo) leaf has great potential in livestock nutrition in the tropics.

Recommendation

Based on this research findings, it is therefore recommended that ensiled *Bambusa vulgaris* (Bamboo) leaf be fed to ruminants. Therefore awareness should be made to educate and enlighten rural farmers on the benefits of using ensiled *Bambusa vulgaris* (Bamboo) leaf as livestock feed.

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REPRODUCTIVE PERFORMANCE OF DOES FED ON GRADED LEVELS OF DRIED OKRA LEAVES

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Abstract

The need to seek for alternative feed materials with nutritional and medicinal values to support livestock growth necessitated this study. The reproductive performances of 20 does were examined. Each treatment consisted of 4 does and replicated twice with each replicate consisting of 2 does. The experiment was arranged in a Completely Randomized Design while data collected were subjected to one way analysis of variance. Results indicated that daily feed intake was significantly ($P<0.05$) largest in rabbits fed 5.00% inclusion level of dried okra leaves (84.57g) and least in rabbits fed 0% level of inclusion of dried okra leaves (72.12g). Live weight, carcass weight, dressing percentage, loin, hind limb, fore limb, tail, liver and kidney were not significantly influenced by the diets. Rabbits fed on 2.50 % dried okra leaves (DOL) recorded the largest value of 24 litter size at birth and also recorded the best value of 24 litter size at weaning. The breeding efficiency, number of kindled does and gestation length followed the same trend. This study concluded that inclusion of dried okra leaves at 2.50 % in growing rabbits diet significantly improved weight gain, feed efficiency and reproductive performance.

Keywords: Does, Dried Okra leaves, litter size

INTRODUCTION

Rabbits are mini livestock that are easy to manage, highly prolific and have a short gestation interval of thirty days (Corpet, 2011). Also, they are fast becoming substitute for red meat which is believed to have a slower rate of digestion and hence under investigation for the cause of colon cancer (Corpet, 2011). Rabbit is becoming a popular farm animal, which is receiving considerable research attention due to its genetic flexibility, variability and adaptability to produce in a wide range of production systems (Lebas *et. al*., 1986). Okra has important sources of ingredients for use as functional food (Amaravadhi *et. al*., 2012). Okra leaves are commonly used both as food and for curative purposes showing low calories, a good source of edible fibre, and contains important bioactive compounds such as carotene, folic acid, thiamine, riboflavin, niacin, vitamin C, oxalic acid and amino acids (Roy *et al*., 2014). Okra leaves have essential B vitamins for creating and maintaining new cells and foliate, a vital substance for optimum pregnancy. Vitamin C aids in preventing birth defects and enables the foetus to develop completely (Habtamu *et. al*., 2014).). Okra leaves are highly perishable because of its high moisture content and respiratory activities, leading to increased post-harvest losses due to poor storage facilities or preservation methods. Processing and storage foods have become integral parts of modern day food chain, and seasonal produce are processed and preserved during the peak harvest to reduce post-harvest loss therefore making the products available all year round (Habtamu *et al*., 2014). Ndubuisi *et al*. (2013) reported a marked improvement in the number of eggs laid and the percentage of fertile eggs at candling was observed to be higher in hens treated with okra seed extract indicating possible improvement in the reproductive rate of the birds. Extracts of okra seed function as antioxidants and contain high amounts of minerals like calcium, iron, zinc, magnesium and phosphorus that have the ability to stimulate sperm cells and enhance fertility in birds (Corpet, 2011). It was observed in Igboora, Oyo state that okra leaves are widely cultivated by several local farmers. The general belief in this locality is that when women consume okra leaves, they are likely to give birth to twins. Hence this research is aimed at determining the pre-gestation growth performance of rabbits fed diets containing varying levels of dried okra leaves.

MATERIALS AND METHODS

Experimental Site and Location

The experiment was carried out at the rabbitary unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture (FUNAAB), Alabata Road, Abeokuta, Ogun State, Nigeria. The University is located on latitude 7^{o} 10´N, longitude 3o2´E (Google Earth, 2016).

Experimental Design

Twenty (20) Rabbit Does of twenty-four weeks old with live-weight ranging from 1580.33g –1900.10g were used in the experiment. Six rabbits were allotted to each treatment using a Completely Randomized Design. Each of the treatment was replicated three times with two Rabbits housed together serving as a replicate in each cage. The Rabbits were fed for a period of 8 weeks to enable them to reach the peak condition in body size and to fully mature for reproduction prior to the start of the experiment. The experiment started at the day of mating. The Rabbits were maintained on forage and concentrate diets. Daily routine management procedure was adhered to.

Experimental procedure

The mating ratio was 1 male to 2 females. They were mated early morning and late in the afternoon, each doe was carried to the buck cage for mating. After successful mating, it was observed that the buck fell aside and utters a characteristic cry. The Doe was carried back to her cage after a successful mating.

Pregnancy test was carried out on each Doe by palpating at the 14th day after mating. Clean and well disinfected kindling boxes were provided for the does (28th day of gestation) to make nest of fur in preparation for birth.

Data Collection

Daily feed intake: A known weight (100g) of experimental diets for each replicate was given and recorded daily. Feed left over was recorded the next day before morning feeding. Feed intake for each day was obtained from the differences between the feed given per day and the left over (NRC, 1994).

Total feed Intake (g) = Total feed given (g) – Total feed left over (g)

Average daily feed intake (g) =

$$\frac{\text{Total feed intake (g)}}{\text{Total number of days of the experiment}}$$

Feed efficiency: This was calculated as the ratio of the daily weight gain to that of the daily feed intake (NRC, 1994)

$$\text{Feed efficiency ratio} = \frac{\text{Daily weight gain (g)}}{\text{Daily feed intake (g)}}$$

Mortality: This was calculated as percentage of number of dead rabbits to the total number of rabbits (NRC, 1994)

$$\textbf{\% Mortality} = \frac{\text{Number of dead rabbits}}{\text{Total number of rabbits}} \times \frac{100}{1}$$

Doe weight at kindling: After each doe has kindled, the doe was weighed.

Doe weight at weaning: Each doe was weighed at weaning

Gestation length: The number of days the doe carries the kittens in her womb usually 30 days.

Breeding efficiency: This was calculated as number of mated does per number of kindled does multiplied by 100 (NRC, 1994)

$$\frac{\text{No of kindled Does}}{\text{No of Does mated}} \times \frac{100}{1}$$

Pre-weaning loss: This is the amount of kittens dead (NRC, 1994)

$$\frac{\text{No of dead kittens}}{\text{Total No of kittens}} \times \frac{100}{1}$$

Litter size at birth: This was taken immediately after kindling by counting the number of kits per doe

Litter weight at birth per Doe: This is the total live weight of kittens at birth per doe.

Average live weight of kittens at birth: The average live weight of kittens at birth was calculated by dividing the total live weight of kits per doe by the number of kittens per Doe using this expression (NRC, 1994)

Average live weight =

$$\frac{\text{Total live weight of kittens per Doe}}{\text{Number of kittens}}$$

Litter size at weaning: This is the total number of kits per Doe alive at weaning age

Litter weight at weaning: This is the live weight of litters per Doe at the time of weaning

Average weight at weaning per kit: This was calculated as expressed below as:

$$\frac{\text{Litter weight at weaning per Doe}}{\text{Number of kittens}}$$

Pre-weaning weight gain per kit: This was calculated as expressed below as Average weight at weaning per kit – Average weight at birth per kitten.

Statistical analysis

Data collected were subjected to one-way analysis of variance in a Completely Randomized Design (CRD). Data were analysed using SAS. Package. Significant means were separated and compared using Duncan Multiple Range Test of the SAS package at 95% level of probability.

RESULTS

Reproductive performance of Does fed diets containing graded levels of dried okra leaves

Figure 1 below shows the effect of the diets on the litter size at birth (LSAB), litter size at weaning (LSAW) and pre-weaning loss (PWL). 2.50 % of dried okra leaves had the largest value of 24 kittens litter size at birth while 0.00 % of dried okra leaves had the least value of 13 kittens at litter size at birth. 2.50 % of dried okra leaves had the largest value of 24 kittens at litter size at weaning and 10.00 % of okra dried leaves had the least value of 12 kittens at litter size at weaning. Mortality had a value of 2 kittens in 5.00 % of dried okra leaves while 10.00 % of dried okra leaves had a value of mortality of 2 kittens. 0.00 %, 2.50 % and 7.50 % of dried okra leaves recorded zero pre-weaning loss.

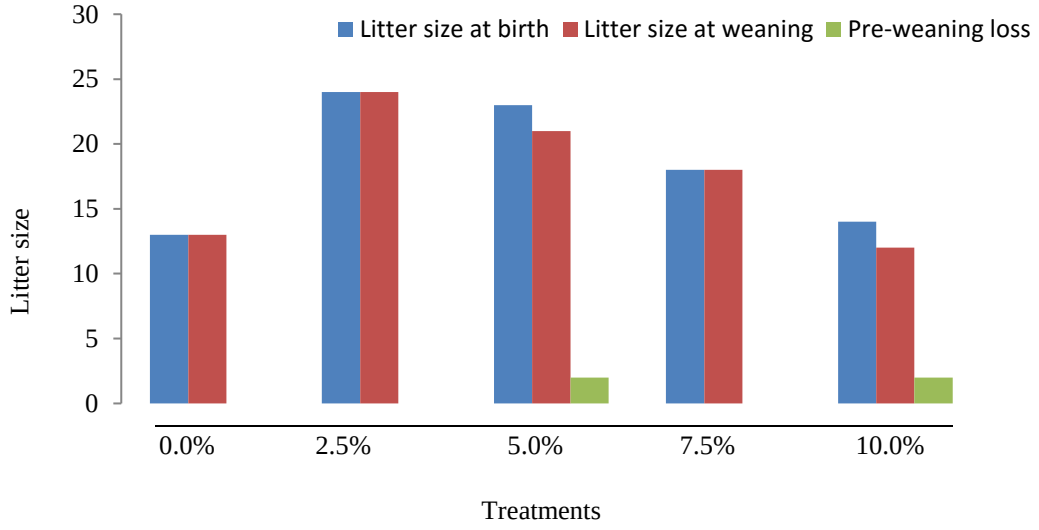

Figure 1: Effect of graded levels of dried okra leaves (*Abelmoschus esculentus)* on Doe Litter size at birth (LSAB), Litter size at weaning (LSAW) and Pre-weaning loss (PWL)

Kindled Does, breeding efficiency and gestation length of Does fed diets containing graded levels of dried okra leaves (*Abelmoschus esculentus*)

Figure 2 shows the effect of graded levels of dried okra leaves on number of Does that kindled after mating, gestation length and breeding efficiency is shown in Figure 2. The inclusion of 0.00 %, 2.50 % 5.00 %, 7.50 % and 10.00% dried okra leaves had the same value of four kindled Does. Breeding efficiency had the same trend value of 50 % in all the treatments. All the dietary groups had the same gestation period of thirty days.

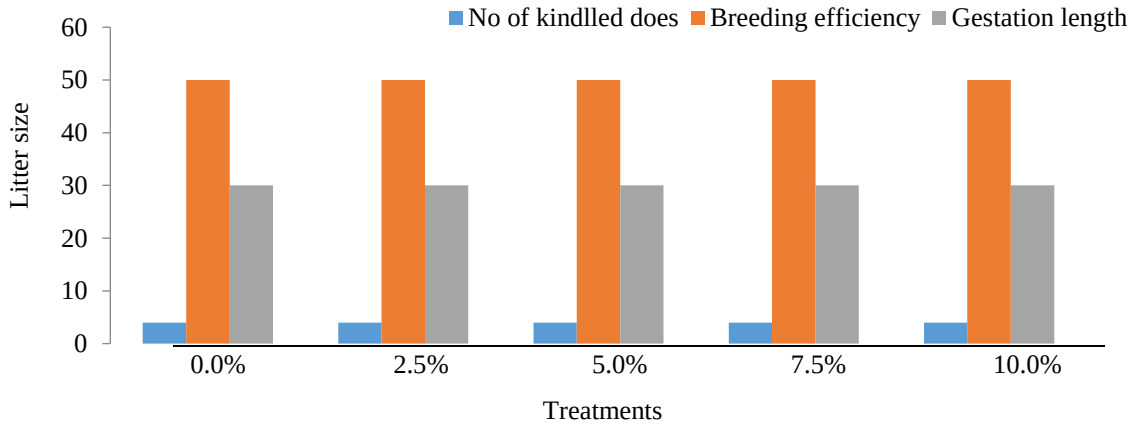

Figure 2: Effect of graded levels of dried okra leaves on Doe kindling, breeding efficiency and gestation length

DISCUSSION

Litter size is one of the most important factors affecting productivity of rabbit Does. The more kits the doe kindles and weans, the greater the profitability of the enterprise Afifi and Emera, (1987). Nutrition is an important factor affecting litter size of does. Higher energy intake has been reported to increase ovulation when given for a short period (Anderson and Melampey, 1971). 2.50% of dried okra leaves had the largest litter size (24) at birth. Ren *et al.*, (2004) reported that the litter size and birth weight vary depending on the breed and size of the dam. Factors that increase litter size include the age at which the does are served and the optimum weight at service which is an index of the breed (Hafez and Hafez 2000). 2.50 % inclusion of dried okra leaves had the largest value of litter size at weaning. These values obtained in this study are in agreement with the report of Ren *et al*., (2004). Likewise, the values obtained for litter size at birth (LSAB) and litter size at weaning (LSAW) for this study showed that 2.50 % inclusion of dried okra leaves performed better than the control diet. The performance could be attributed to factors of good mothering ability, maternal environment and effect of dietary fibre inclusion (Iyeghe-Erakpotobor *et al.* (2008). The pre-weaning loss in the inclusion of 5.00 % and 10 % dried okra leaves recorded the highest values. The loss could be attributed to environmental factors (Schloanut, 1980). The values obtained for average weight at birth recorded in this study is in agreement with the report by Mai (2005) and average weight at weaning value obtained in this study are in agreement with the findings by Odeyinka *et al*. (2008) who fed *Moringa oleifera* as a replacement for *Centrosema pubescens* during reproductive study conducted on New Zealand White and chinchilla breeds of rabbits. The breeding efficiency values obtained in this study is slightly lower than the values reported by Adelli–Larbi *et al*., (2014) in New zealand white breed of rabbits and the study of Odeyinka *et al*. (2008) who fed *Moringa* leaf in replacement of *Centrosema pubescens:* Gestation length in different breeds of rabbits ranged between 28- 36 days, Morimoto, (2009). However, rabbits normally kindle between 30 - 33 days after mating or artificial insemination Rashwan *et al*., (2003). From this study, gestation length duration is in line with recommended gestation length duration between (29-30 days) for rabbits. This is in agreement with the findings of Nguyen *et al*., (2006) and Odeyinka *et al*. (2008). It showed that dried okra leaves do not have negative effect on the gestation length of the rabbits. In pre-gestation period, mortality of two bucks was observed in 2.50 % and 10 % inclusion of dried okra leaves. The loss was due to mis-management.

Conclusion

Reproductive performance of does fed 2.50 % dried okra leaves improved and had the highest litter size at birth (LSAB) and litter size at weaning (LSAW). Reproductive performance of Does fed 2.50 % dried okra leaves had the largest value of kittens average at birth and weaning.

Recommendation

It is recommended that up to 2.50% inclusion level of dried okra leaves could be tolerated by the rabbits to obtain the highest value of live body weight, enhance feed intake, and improved feed conversion ratio without any detrimental effects on the reproductive performance.

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EFFECTS OF MILLED AND UN-MILLED COCOA BEANS WASTES ON GROWTH AND YIELD OF AMARANTH IN OBUBRA DERIVED SAVANNA OF NIGERIA

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Abstract

A two season field experiment was conducted at the Teaching and Research Farm of the Department of Agronomy, University of Cross River State during the 2023 cropping season to determine the effects of milled and un-milled cocoa beans store wastes on the growth and yield of Amaranthus. The design was randomized complete block (RCBD) with three replications. The six treatments consisted of control (no manure), Un-milled cocoa beans wastes (5 t/ha), Un-milled cocoa beans wastes (10 t/ha), Milled Cocoa beans wastes (5 t/ha) Milled cocoa beans wastes (10 t/ha) and inorganic control (NPK 20.10.10. at 250 kg/ha) Results obtained indicated that, the milled Cocoa beans wastes at 10 t/ha significantly ($p < 0.05$) produced the tallest plants at 3 and 4 weeks after planting (33.7cm and 52.3cm) and (34.2 cm and 58.3 cm) respectively for the early and late seasons. Also, the milled Cocoa beans wastes at 10 t/ha 3 and 4 weeks after planting significantly produced the plants with the highest mean number of leaves (23.1 and 51.4) (24.2 and 52.6) respectively for the early and late seasons. Stem girth was not significantly different between fertilized plants and the least girth was in the control. Milled cocoa beans wastes at 10 t/ha significantly produced the highest yield per plant, highest yield per plot and highest yield in tons/ha (176.1g, 3.5kg and 23.0 t/ha) and (178.2g, 3.7kg and 23.8t/ha) respectively for the first and second seasons. Milled Cocoa beans wastes at 10 t/ha is therefore most suitable for optimum growth and yield of amaranthus.

Keywords: Cocoa beans, milled, organic, Amaranthus, yield, derived savanna

INTRODUCTION

Amaranthus is a nutrient-rich crop that is cultivated for its grain, leaves, and flowers. The growth and yield of amaranth can be affected by nutrient availability in the soil, which makes the use of fertilizers an important part of amaranth cultivation (Márquez *et al.*, 2018). Apart from its uses as a vegetable, it has also been used as an effective alternative to drug therapy in people with hypertension and cardiovascular diseases (CVD) (Martiorosyan and Miroshnichen, 2007). Amaranth is rich in protein, essential amino acids, dietary fiber, and minerals such as iron, calcium, and magnesium. The vegetable is also a good source of antioxidants and phytochemicals, which may have beneficial health effects.

It is known for its adaptability to various environmental conditions. However, the yield and quality of amaranth can be significantly influenced by soil physical and chemical properties and the nutrient availability in the soil (Sarker and Oba, 2018).

Recycling of agricultural waste is a great resource for sustainable crop yields in Nigeria. This is so because soils in the humid tropics are poor in organic matter and available nutrients, hence their productivity and sustainability decline over time when subjected to continuous cultivation (Zingore *et al.*, 2003).

The maintenance of soil organic matter is the basis of sustainable crop production in Nigeria and the tropics in general (Oladipo *et al.* 2005). Organic based fertilizers have been reported to increase crop yield as well as soil quality (Babalola and Olowokere, 2005). Cocoa is one of the major agricultural commodities globally, and its cultivation produces a significant amount of wastes. This waste is rich in nutrients and can serve as an organic fertilizer to improve soil fertility and crop yield (Aikpokpodion, 2018).

The addition of organic materials such as crop residues, animal manures and green manures to soils have a direct effect on soil organic matter content, can improve soil fertility, soil physical characteristics, augment microbial activities and can ameliorate metal toxicity (Escobar and Hue 2008). Application of organic manure increases organic elements availability in the soil, thereby improving the nutrient use efficiency (NUE) of crops and alleviating the harmful impact of climate change on crop production (Liang *et al.* 2018). Recent research has shown that cocoa waste can have a positive

components of cocoa waste are the pod husk and the pod shell. Cocoa waste is a rich source of nutrients, including nitrogen, phosphorus, and potassium (NPK). It also contains organic matter, which can improve soil structure and fertility. Research has shown that applying cocoa waste to crops can increase plant height, stem diameter, leaf number, and leaf area. It can also increase fruit yield and quality. In addition, the nutrients in cocoa waste can help to reduce soil acidity and improve the water-holding capacity of the soil. Cocoa waste compost on different types of vegetables, has been shown to be a beneficial organic fertilizer (Chris Fidelis and Rajashekhar Rao, 2017). It has also been reported by Kekong (2023) that composted cocoa pod husk amended with poultry droppings and Moringa leaf improved soil properties and significantly increased the yield and yield components of maize.

The poverty amongst small scale holder farmers who dominate the Nigeria agricultural land space vis-à-vis the cost and scarcity of inorganic fertilizer and the deleterious effect on soils is a serious challenge to food security in Nigeria. It is on this premise that this study was carried out to evaluate milled and un-milled cocoa store beans wastes on the growth and yield of Amaranthus, a cherished vegetable in Nigeria.

MATERIALS AND METHODS

Location of the Experiment

The study was carried out at the Teaching and Research Farm of the Department of Agronomy, University of Cross River State (UNICROSS), Obubra campus located between latitude 60.18°N and longitude 80.181°E in the tropical rainforest Agro-ecology of Nigeria. The rainfall pattern is bimodal with peaks occurring in July and September (NIMET, 2021)

Experimental materials

The Amaranthus seeds used for the experiment was *Amaranthus hybridus* procured at Nigeria Institute of Horticultural Research (NIHORT) Benin. The cocoa beans wastes were obtained at cocoa grading stores at Ikom Local Government Area, Cross River State.

Experimental design and treatments

The design used for this experiment was the randomized complete block design (RCBD) which was replicated three times. There were six treatments which consisted of T1 - control (no manure), T2 - unmilled cocoa beans wastes 5 t/ha, T3 - unmilled cocoa beans wastes 10 t/ha, T4 - milled Cocoa beans wastes 5 t/ha, T5 - milled cacoa beans wastes 10 t/ha and T6 – Compound NPK 20.10.10 at 250kg/ha (inorganic control) as recommended by Alonge *et al.*(2007).

Nursery bed Preparation

A nursery bed was raised with an addition of poultry droppings to the soil. The Amaranthus seeds were then broadcasted on the 17th April 2023 for the early season and 11th of August 2023 for the late season planting.

Land preparation

Conventional land preparation of clearing, stumping and packing of the cleared thrash was carried out manually. The experimental layout was then done using a measuring tape. The seed beds were raised at a plot size of 1.5 X 2.0m ($3m^2$) with an inter row of 1m and intra row of 0.5m respectively.

Manure Preparation and Application

The cocoa beans wastes were collected and milled with a Hammer Mill for the milled wastes. Both wastes were incorporated in the field on April 18th and August 14th 2023 respectively, for the two planting (two weeks before transplanting was done) through broadcasting method. This was done to ensure the decomposition and curing of the cocoa beans wastes before planting of the seedlings.

Field planting

The seedlings were transplanted from the nursery to the experimental site after two weeks in the nursery. The planting was done at a spacing of 25m X 25cm with each treatment containing forty two (42) seedlings per plot.

Data collection and analysis

Plant

Data collection commenced at two weeks after transplanting from the nursery. The growth parameters observed were plant height, number of leaves and stem girth. Number of leaves was determined by direct counting of fully opened leaves. Plant height was determined using meter rule which was placed at the stem base and run into the top of the plant. The stem girth was determined by a Veneer calliper.

All data collected were analyzed following the procedure of analysis of variance (ANOVA) and significant means were separated using LSD at 5% probability level.

Soil Sampling and Analysis: Soil samples were collected randomly from five points within the experimental plot which were bulked, and thoroughly mixed to form a composite.

Particle size distribution (PSD): this was determined by the Bouyoucos (Hydrometer) method procedure by Udo *et al*. (2009). This involves the suspension of soil samples with sodium hexametaphophate (calgon). The reading on the hydrometer was taken at 40 seconds. Second reading was taken three hours later. The particle size was then calculated using the following formulae:

Sand = 100- (H1 + 0.2 (T1 – 68)-2.0) 2.,
Clay = (H2 + 0.2 (T2 (T2-68) -2.0)2
Silt= 100 – (% sand + % clay)
Where:
H1 = Hydrometer first reading at 40 seconds
T1 = temperature first reading at 40 seconds
H2 = Hydrometer second reading after 3 hours
T2 = Temperature second reading after 3 hours

Soil pH: This was determined in both water and 0.1 N KCL in a ratio of 1:1 soil: water and 1:2.5 soil: KCl respectively. After stirring the soil suspension for 30 minutes, the pH values were read using the glass electrode pH meter (Mclean, 1982).

Organic Matter: This was determined by the walkley-Black method as outlined by Page *et al*. (1982) which involves the oxidation with dichromate and tetraoxosulphate vi acid (H_2 SO_4). The excess was titrated against Ferrous Sulphate. The organic carbon was then calculated using the relationship:

% org.C = N(Vi – V2) 0.3f
Where:
N = Normality of FerousSulphate solution
V1 = Ml Ferrous Ammonium Sulphate for the black
V2 = ml Ferrous Ammonium Sulphate for the sample
W = mass of sample = farm
F = correction factor = 1.33
% organic matter in soil = % org.C x 1.729

Nitrogen in Soil and Cocoa Seed Waste: Total nitrogen in soil was determined by the Macro Kjeldahl and in cocoa beans wastes by Micro kjeldahl methods as described by Udo *et al*. (2009). The soil samples were digested with Tetraoxosulphate (VI) acid (H_2SO_4) after addition of excess caustic soda. This was distilled into a 2% Boric acid (H_3BO_4) and then titrated with 0.01 HCl. And the nitrogen was obtained from the relationship:

%N = T x Mx14 x100
N
Where:
T = Titre value
M = Molarity of HCl
W = Weight of soil used
N = Normality of H_2SO_4

Available phosphorus: Available P was determined by Bray 1 method as outlined by Page *et al*. (1982). This involved mechanical shaking of the sample in an extracting solution then centrifuging the suspension at 2000 rotations per minutes for 10 minutes. Using Ascobic acid method, the percentage transmittance on the spectrophotometer at 660 nm wave length was measured. The optical density (OD) of the standard solution was then plotted against the phosphorus ppm and the extractable P of the soil was then calculated.

Cation Exchange capacity (CEC) and Exchangeable acidity (EA): This was determined by the kjeldahl distillation and titration method as outlined by IITA (1979) using ammonium acetate solution the soil samples were leached then the soil washed with methyl alcohol and allowed to dry. The soil was then distilled in kjeldahl operation in to a 4% Boric acid solution. The distillate was then titrated with standard solution of 0.1 N HCl.

Exchangeable cations: This was determined by ammonium acetate extraction method as described by IITA (1979). The soil samples were shaken for 2 hours then centrifuged at 2000 rpm for 5-10 minutes after decanting into a volumetric flask, ammonium acetate (30 ml) was added again and shaken for 30 minutes, centrifuged and the supernatant transferred into same volumetric flask. Atomic Absorption spectrophotometer (AAS) was used to read the cations.

RESULTS AND DISCUSSION

Results of the physical and chemical properties of the experimental site before treatments application (Table 1) indicated that, texturally, the soil is Sandy-loam, with sand particle content of 570.0 g/kg, silt content of 280.0 g/kg and Clay particle of 15.0 g/kg. The soil is moderately acidic with pH of 5.70 in H_2O and 5.30 in $CaCl_2$. The organic matter content was moderately low 13.6 g/kg and total Nitrogen was low with values of 7.9 g/kg. The available Phosphorus was low with value of 6.53 mg/kg. The exchangeable cations of Ca was moderately high (5.75 cmol/kg), Mg, and K were low in status with values of 0.56 cmol/kg and 0.09 cmol/kg. The value obtained for Na^+ was 0.56 cmol/kg, which was moderate. The CEC was 10.4 which was high.

The values of total nitrogen, available phosphorus, and potassium of the experimental soil were below the critical values of the soil of southern States of Nigeria; this may be due to low soil organic matter. The low soil contents for the major nutrients signify the need for improvement of the soil for *Amaranthus hybridus* performance. The low N, P, OM, pH and other nutrients are the characteristics of soils in

Cross River State as described by Chude (1998) and Ojeniyi (2002).

Table 1: Pre Cropping Soil Physical and Chemical Properties of the Experimental Site

Parameter	Season 1	Season 2
Sand (g/kg)	570	580
Silt (g/kg)	280	270
Clay (g/kg)	150	150
Texture class	S/L	S/L
pH (water)	5.70	5.70
pH (CaCl)	5.30	5.30
Organic matter (%)	2.4	2.3
Total nitrogen (g/kg)	0.8	0.8
Available P (mg/kg)	6.53	6.33
Exch. Ca (cmol/kg)	5.75	4.95
Exchange. K (cmol/kg)	0.09	0.08
Exchange. Mg (cmol/kg)	0.59	0.60
Exchange Na (cmol/kg)	0.56	0.58
Exchange. Acidity	0.60	0.62
CEC (cmol/kg)	10.04	11.01

Nutrient composition of the Cocoa Beans Store Wastes

The nutrients composition of the cocoa beans store wastes is presented in Table 2. The laboratory analysis of the cocoa beans store waste materials indicated that the cocoa beans wastes contained 11.57% Organic carbon, 1.68% nitrogen, 1.43% Available phosphorus, 0.43% Potassium, 744.25 mg/kg Calcium, 2622.5 mg/kg Magnesium and 5450 mg/kg Sodium. The low organic carbon content of cocoa beans wastes with a C/N ratio of 6.8 will not immobilize the soil native nutrients. This is so because the thresh hold level for mineralization as stated by Fairhurst (2012) is < 16 and this justifies the use of this wastes as soil amendment for the production of vegetables, especially Amaranthus. This is an indication that the nutrients in this amendment can be easily mineralized for plants use.

Table 2. Nutrient Composition of compost materials and composts

Material	Org C%	N%	P%	K%
Cocoa beans wastes	11.57	1.68	1.43	0.43

Plant Height of Amaranthus as Influenced by Milled and Un-milled Cocoa Beans Store Wastes

Result of plant height of Amaranthus as influenced by application of milled and unmilled cocoa beans store wastes is presented in Table 3.

The result indicated that application of cocoa beans store wastes significantly ($P<0.05$) increased the plant height of Amaranthus plants. At 3 weeks after planting (WAP), milled cocoa beans store wastes at the rate of 5 t/ha, 10 t/ha, unmilled cocoa beans wastes at 10 t/ha and NPK 20.10.10 significantly produced taller plants of 33.7, 30.5, 30.3 and 30.4 cm respectively than plants that were applied with 5 t/ha of unmilled cocoa beans wastes and the control which heights were 24.4 and 15.9 cm respectively in the first cropping season. In the second cropping season, the growth of Amarants showed the same trend.

At 4 WAP, the result showed that application of milled cocoa store wastes at the rate of 10 t/ha produced significantly, tallest plants of 52.3 cm. This was followed by plants that were applied with 5 t/ha milled cocoa store wastes (46.6) cm, NPK 20.10.10 at 250 kg/ha 46.4 cm and 10 t/ha unmilled cocoa store wastes with plant height of 47.7 cm, then followed by plants in plots that were applied with 5 t/ha unmilled cocoa beans store wastes (40.2 cm) and the least plant height was obtained from control (plots without manure). In the second season planting, 10 t/ha milled cocoa beans store wastes produced tallest plants (61.2 cm). This was followed by 5 t/ha milled cocoa store beans wastes, 10 t/ha un-milled beans wastes and NPK 250 kg/ha with plant heights of 50.1 cm, 51.4 cm and 52.0 cm, respectively. The least plant height was obtained from the absolute control without any amendment.

The significant increase in plant height of Amaranthus indicated that cocoa beans wastes in cocoa stores is a good source of plant nutrients if incorporated into the soil, especially when milled. This highest plant height of Amaranthus obtained from milled cocoa beans wastes may probably be due to favourable nutrients mineralization of this waste due to reduction in particle size and increase in its surface area. This result is in agreement with the findings of Agbenin *et al.* (2012) who reported that cocoa wastes can be used as a fertilizer for vegetables regardless of whether it is grinded or unground and that this waste increased vegetable plant height.

Number of leaves and stem girth of Amaranthus as affected by application of milled and un-milled cocoa bean store wastes.

Result of number of leaves and stem girth of Amaranthus as affected by application of milled and un-milled cocoa beans store wastes is presented in Table 4.

The result indicated that application of cocoa beans store wastes significantly ($p < 0.05$) increased the number of leaves of Amaranthus plants. At 3 and 4 WAP, with same trend. At 4 WAP, application of milled Cocoa store beans wastes at the rate of 10 t/ha produced significantly plants with the highest number of leaves of 51.4 in the first season and 52.3 in the second season. This was followed by plants that were applied with 10 t/ha of un-milled cocoa store wastes 42.8 in the first season and 46.2 in the second season, NPK with 41.7 and 45.2, respectively for the first and second seasons and 5 t/ha of milled cocoa beans wastes with number of leaves 40.9 and 42.6 respectively for the first and second seasons. Then followed by plants in the plots that were applied with 5 t/ha of un-milled cocoa beans store wastes (34.6) and the plant with the least number of leaves was obtained from control (i.e. plot without manure).

The result of stem girth was not statistically significant with all treatments including the inorganic fertilizer and the control, though some treatments showed larger stems.

The significant increase in the number of leaves of Amaranthus therefore indicates that Cocoa beans wastes in cocoa stores is a good source of plant nutrients if incorporated into the soil especially when milled.

Table 3: Plant height of Amaranthus as influenced by milled and unmilled cocoa beans store wastes

	Season 1		Season 2	
Treatment	**3 WAP**	**4 WAP**	**3 WAP**	**4 WAP**
No manure	15.9	24.3	15.9	26.1
5 t/ha un-milled	24.4	40.2	24.4	39.8
10 t/ha un-milled	30.3	47.7	31.1	51.4
5 t/ha milled	30.5	46.6	30.9	50.1
10 t/ha milled	33.7	52.3	34.6	61.2
250 kg/ha NPK	29.8	46.2	30.1	49.6
$LSD_{0.05}$	5.0	3.3	3.1	3.3

Table 4. Number of leaves and stem girth of Amaranthus as affected by application of milled and unmilled cocoa beans store wastes

Treatment	**Season 1**			**Season 2**		
	Number of leaves per plant			**Number of leaves per plant**		
	3 WAP	**4 WAP**	**Stem girth (cm)**	**3 WAP**	**4 WAP**	**Stem girth (cm)**
No manure	11.2	15.6	0.12	11.2	15.6	0.12
5 t/ha un-milled	16.5	34.6	0.44	16.5	34.6	0.44
10 t/ha un-milled	23.3	42.8	0.82	23.3	42.8	0.82
5 t/ha milled	21.8	40.9	0.67	21.8	40.9	0.67
10 t/ha milled	23.1	51.4	1.34	23.1	51.4	1.34
250 kg/ha NPK	22.4	41.1	0.68	19.8	40.3	0.73
$LSD_{0.05}$	4.7	2.8	ns	4.7	2.8	ns

Shoot Yield of Amaranthus as influenced by application of milled and un-milled cocoa beans store wastes

Result of shoot yield of Amaranthus as influenced by application of milled and un-milled cocoa store wastes is presented in Table 5. The result indicated that application of Cocoa beans store wastes significantly ($p < 0.05$) influenced the yield of Amaranthus per plant (g), per plot (kg) and in tons per hectare. Milled cocoa beans store wastes at the rate of 10 t/ha produced significantly the highest vegetable yield per plant of 176.1g and 178.0g This was followed by plants that were applied with 5 t/ha

of unmilled cocoa store wastes (130.1g) and then followed by plants in plots that were applied with 5 t/ha unmilled cocoa beans store wastes (80.3g) and the least yield per plant was obtained from control.
On the yield per unit area, Milled cocoa beans wastes at 10 t/ha produced highest vegetable yield of 23.0 t/ha and 24.1 t/ha for the first and second seasons cropping. This was followed by yields in plots that were applied with 10 t/ha un-milled and 5 t/ha milled cocoa beans wastes and 250 kg/ha NPK 20.10.10 whose yield in the first season were 17.4, 15.7 and 15.5 t/ha respectively, while the yield in the second season were 18.1, 16.0 and 15.9 t/ha respectively.

The significant increase in yield per plant (g), yield per plot (kg) and yield in t/ha shows that the cocoa beans wastes in cocoa stores is a good source of plant nutrient if incorporated into the soil. The yield response of Amaranthus to cocoa beans wastes is a reaffirmation of the efficacy of organic sources of nutrients in plants nutrition and soil productivity. The higher yield of the crop with application of the organic wastes over the inorganic fertilizer could be due to the gradual and continuous release of nutrients from organic sources which provided sustainable availability of nutrients for the vegetable throughout the growing season.

The result of this study is in tandem with the findings of other investigators on organic wastes including Adegunloye and Olotu (2018) who reported tallest plants of maize in response to Cocoa pod composted with poultry droppings over control and NPK inorganic fertilizer treatments; Akanni and Ojeniyi (2007) who reported that cocoa pod husk ash increased growth and nutrient uptake of Kola seedlings and ChrisFidelis and Rajashekhar Rao (2017) who reported increased growth rate of cocoa seedlings due to application of composted poultry droppings with inorganic Phosphorus. Furthermore, on combination of organic wastes, Kekong (2020) reported increased growth and yield of water melon using combined rice mill wastes and poultry droppings; Moyin Jesu (2015) reported increased growth and head yield of cabbage from manures supplemented with poultry droppings; Kekong *et al*. (2016) on Moringa leaf and rice husk that increased garden egg yield.

Table 5: Shoot Yield of Amaranthus as influenced by application of milled and unmilled cocoa beans store wastes

	Season 1			Season 2		
Treatment	**Yield per plant (g)**	**Yield per plot (kg)**	**Yield in tons/ha**	**Yield per plant (g)**	**Yield per plot (kg)**	**Yield in tons/ha**
No manure	32.9	0.7	4.1	33.4	0.8	4.4
5 t/ha un-milled	80.3	1.6	10.7	81.4	1.7	11.1
10 t/ha un-milled	130.1	2.6	17.4	131.6	2.9	18.1
5 t/ha milled	117.8	2.4	15.7	117.8	2.4	16.0
10 t/ha milled	176.1	3.5	23.0	178.0	3.9	24.1
250 kg/ha NPK	119.4	2.5	15.5	120.2	2.5	15.9
$LSD_{0.05}$	58.0	0.35	7.6	57.1	0.36	6.8

Conclusion

The result obtained from the experiment showed that Cocoa beans wastes can be recycled into a soil organic amendment. This store waste, especially, the milled cocoa beans wastes is suitable for optimum growth and shoot yield of Amaranthus vegetable in the study area. The application of milled cocoa beans wastes can serve as a short term soil nutrient enrichment for vegetable production.

Recommendation

For optimum growth and shoot yield of *Amaranthus hybridus* in Obubra derived savanna, application of milled cocoa beans store wastes at the rate of 10 t/ha should be adopted.

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MICRONUTRIENT DISTRIBUTION IN ARABLE SOILS ALONG RIVER KADUNA WATERSHED, NORTH-WESTERN NIGERIA

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Abstract

This research was carried out on arable soils along the river Kaduna watershed within Kaduna in North Western Nigeria and aimed at studying the micronutrients distributions and its relationship with some selected soil physical and chemical properties. A total of six profile pits were dug where samples were collected to study selected micronutrients such as; Copper (Cu), Iron (Fe), Zinc (Zn) and Manganese (Mn) among some other soil physical (bulk density, sand, silt, clay, silt/clay ratio) and chemical properties (soil pH, OM, Total N, Available P, Exchangeable cations; Ca, Mg, K and Na, and Efective cation exchange capacity ECEC). Copper (Cu) generally decreased down the profiles in all studied locations (Loc. A – F), except in Loc. C where it increased down the profile. Cu has the highest mean concentration in Loc. A (3.84 mg/kg) while the lowest mean was recorded in Loc. F (2.39 mg/kg). Means Zn was highest in Loc. D (18.79 mg/kg) while lowest in Loc. C with a mean of (10.63 mg/kg). The distribution pattern of Iron (Fe) was not very clear in the studied soils, although it increased in the first 2 to 3 horizons of Locations A – E while it constantly decreased in Loc. F. Zinc (Zn) was the most irregularly distributed of the investigated micronutrients as though it ultimately indicated an increase in one or two of the horizons of Locations A – E and consistent decrease in Location F. Means Zn was highest in Loc. D (18.79 mg/kg) while lowest in Loc. C with a mean of (10.63 mg/kg). Mean Mn was highest in Loc. A (71.82 mg/kg) and lowest in Loc. C recording 55.34 mg/kg. Manganese (Mn) showed a consistent decrease down the profiles in almost all studied location except in Loc. E where it only increased in the second horizon. The study reveals that none of the studied micronutrients were available at toxic level as they were all barely within the critical limits except Mn which was below. Low organic matter may be responsible for the low micronutrients resulting from continous grazing and cropping as micronutrients have high positive correlation with organic matter in the studied soils of River Kaduna watershed.

Keywords: Micronutirents, soil properties, critical limits, River Kaduna watershed

INTRODUCTION

The intricate relationship between soil health and agricultural productivity has long been a focal point for researchers seeking to optimize crop yields and ensure food security (Kopittke *et al.*, 2019). In the context of Northern Nigeria, the River Kaduna Watershed stands as a vital lifeline, influencing the agricultural landscape and shaping the region's socio-economic fabric. One crucial aspect of soil quality lies in the distribution of micronutrients – essential elements that play a pivotal role in plant growth and human nutrition (Soares *et al.*, 2019). This study delves into the intricate tapestry of micronutrient distribution within the soils along the River Kaduna Watershed, unraveling the dynamics that govern the availability and variability of these essential elements. Micronutrient deficiencies can have profound implications for both crop production and human health, making an in-depth understanding of their spatial distribution crucial for sustainable agricultural practices (Balaska *et al.*, 2023). Obasi *et al.*, (2022) noted that against the backdrop of climate variability, land use changes, and population growth, exploring the micronutrient landscape in this region of River Kaduna watershed becomes imperative.

By shedding light on the micronutrient profiles of soils along the River Kaduna Watershed, we aim to contribute valuable insights that can inform targeted interventions, agricultural policies, and land management strategies. Obasi *et al.*, (2022) further emphasized the need for more research on micronutrients, which is critical given the wide variation in soil physicochemical characteristics and the factors that have impacted its availability in various ways. Certain soil types naturally lack micronutrients as a result of the observable effects of micronutrient dynamics. Micronutrient deficiencies are the result of widespread erosion and ongoing crop removal from the soil, which has destroyed soil organic matter (Vijayakumar 2011).

Numerous factors, such as the soil's organic matter content, the interactions between plants, microorganisms, and the soil, pH, and plant genotype, influence the dynamics of micronutrients in soils, which in turn determine their total concentrations (Shukla *et al.*, 2015; Rengel, 2005; Agrawal *et al.*, 2016).

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Depletion of micronutrients has created serious obstacles to soil productivity and sustainability (Bell and Dell, 2008). Recently, there is widespread worry over the variability of micronutrient availability in soil (Monreal *et al.*, 2016). It has been observed that a number of agronomic soils throughout the world have shortages in certain micronutrients, and that attempts to fertilize these shortfalls have not produced the desired results.

Kaduna River, main tributary of the Niger River, in central Nigeria. It rises on the Jos Plateau 18 miles (29 km) southwest of Jos town near Vom and flows in a northwesterly direction to a bend 22 miles (35 km) northeast of Kaduna town. River Kaduna and its tributaries are very essential to the north central and north western Nigeria as they supply irrigation water for dry season farming and their floodplains makes farming possible all year round. Most soils within the river Kaduna watershed are used for irrigation farming due to their proximity to the source of irrigation water. Most part of northern Nigeria receive less than 1000 mm rainfall in a normal year which is not sufficient for adequate rain-fed crop production in a region that have over a quarter of the country's population. River Kaduna watershed constitutes, of numerous uplands and ridges as well as floodplains where agricultural activities take place. Many cereal crops, legumes and vegetables are farmed on these regions as these crops may easily be irrigated from the river. The study of soil physico-chemical properties of River Kaduna watershed is necessitated by the fact that the country is struggling to feed its fast-growing population. There is also much pressure on the farmers, agricultural researchers and extension agents by the government and stakeholders to save the nation and world population by stepping up food production and farming generally.

This research not only bridges the gap in our understanding of soil health in Northern Nigeria but also offers a foundation for fostering resilient and productive agricultural systems. As we embark on this study, the goal is not only to unravel the current state of micronutrient distribution but also to pave the way for future research, enabling sustainable agricultural practices that align with the unique ecological and agronomic challenges of the River Kaduna Watershed in Northern Nigeria.

MATERIALS AND METHODS

Location

The River Kaduna watershed is situated in Kaduna state, in the northwest of Nigeria, at latitudes 10° 36' and 10° 60' N and longitudes 7° 25' and 7° 40'E, respectively. The research area has been described as having a unimodal rainfall pattern with an annual total of 900–1300 mm (Uyovbisere and Lombin 1991). Along with an undulating plain topography, the region has an average elevation of between 450 and 700 meters. Its very sandy soils, which typically contain very little organic matter, might deteriorate quickly in the event of heavy rains. The area is distinguished by a long dry season (6–9 months), a short wet season, and a high annual average temperature (28–32°C). It is generally assumed that the soil moisture and temperature regimes in the region are, respectively, ustic and isohyperthemic. But from June to September, the mean temperature dips to 25–28 degrees Celsius during the rainy season, and from December to February, it drops to less than 20 degrees Celsius (Gabasawa et al., 2017). Open woodland and light forest have different levels of tree cover, and uncontrolled tree felling for fuel and farming operations have reduced the area to bare land (Carsky et al., 1998). Short grasses (<2 m) are also widely accessible (Sowunmi and Akintola, 2010).

Existing Information on Soil

Generally, soil such as that of dry land of northern Nigeria are named as 'Aridisols' by soil taxonomists (Soil Survey Staff, 1975) and are characterized by less than 1200 mm annual rains which are usually slowly permeable, leading to most of the water being lost to run-off (Fitzpatrick, 1980). Most of the rainfall received by the river Kaduna watershed drains to the river itself and this causes flooding along the watershed at the peak of rainy season around October in most years. The watershed soon experiences aridity as the dry seasons sets in between December and May. These soils are characterized by their sandy texture, which covers a large area of land with a low capacity to hold water and a low content of organic matter, nitrogen, and phosphorus, as well as a neutral or slightly acidic pH and a low capacity for cation exchange. The Kaduna River watershed contains a substantial area of arable land with the ability to produce a wide variety of crops, mostly grain crops like maize, sorghum, millet, rice, and wheat.

Field Work

In the study area, a reconnaissance survey was conducted utilizing the obtained map (Chinwendu *et al.*, 2017). To illustrate some of the main cropping features of the Kaduna River, a section of the watershed was divided into mapping units. Pedons were sunk in each of the defined mapping units based on the detected soil groupings. Six profile pits were excavated, spanning the watershed of the Kaduna River. In compliance with the profiles horizonation, soil samples were gathered. Samples for bulk density were taken using core samplers, and 1 kg of samples were taken from each profile pit's various horizons. The samples were labeled and packed with care before being sent to Ahmadu Bello University Zaria's soil laboratory, where they were examined for micronutrients and other soil properties.

Table 1: GPS Coordinates of Soils around River Kaduna

Location	Latitude	Longitude	Elevation (m)
Pit 1	10º.492267”	7º.431442”	574
Pit 2	10º.492842”	7º.431392”	574
Pit 3	10º.492200”	7º.430547”	577
Pit 4	10º. 493270”	7º.429865”	579
Pit 5	10º.493277”	7º.429058”	577
Pit 6	10º.492886”	7º.477420”	583

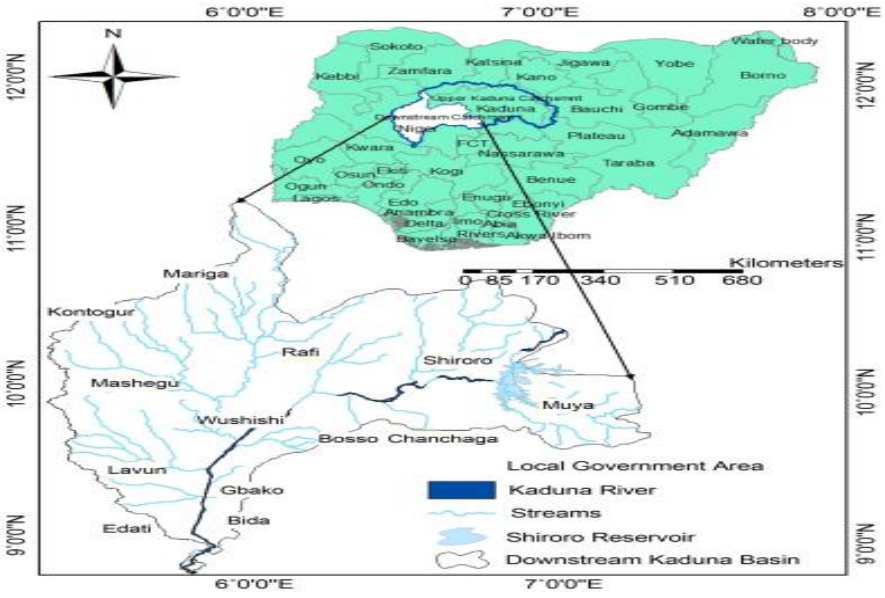

Fig. 1: Map of downstream Kaduna river basin location (Chinwendu *et al.*, 2017)

Laboratory Soil Analysis

The study's parameters included a few of the soil's chemical and physical characteristics. The chemical properties of soil include pH, exchangeable acidity (Al^{3+} and H^{+}), exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}), ECEC, percentage base saturation, total nitrogen, available phosphorus, total carbon, organic matter, and the carbon to nitrogen ratio. The physical properties are mechanical analysis (particle size distribution), porosity, bulk density, moisture content, and atterberg limits. The following are their methods of determination: Using the process of (Gee and Or, 2002), the hydrometer method was used to determine the particle size distribution. Porosity was calculated using bulk density and particle density, and bulk density was determined using the core method (Grossman and Reinsch, 2002). The pH of the soil was measured using 0.1N KCl and water in a 1:2.5 soil liquid ratio (IITA, 1979). Nelson and Sommers (1982) provided the method used to determine the amount of organic carbon. The modified micro-Kjeldahl method (Bremner and Milvaney, 1982) was used to determine total nitrogen, while the Bray II method (Olson and Sommers, 1982) was used to determine total available phosphorus. The Cation exchange capacity (CEC) was measured by repeatedly saturating with 1M NH4OAC, followed by washing, distilling, and titrating (Soil Survey Staff, 1996). Micronutrients, including Mn, Fe, Cd, and Zn, were extracted using the acid method with 0.1M HCl.

Statistical analysis

Coefficient of Variation (CV) was used to estimate the degree of variability existing among soil properties in the study site. Coefficient of variation (C.V.) ranked as follows; Low variation ≤15%, Moderate variation >15≤35%, High variation >35% was used as outlined (Wilding, 1985).

RESULTS AND DISCUSSION

Micronutrients

Micronutrient distributions of the studied soils are as shown in Table 2. Copper (Cu) generally decreased Zinc (Zn) was the most irregularly distributed of the investigated micronutrients as though it ultimately indicated an increase in one or two of the horizons of Locations A – E and consistent decrease in Location F. Means Zn was highest in Loc. D (18.79 mg/kg) while lowest in Loc. C with a mean of (10.63 mg/kg). Manganese (Mn) showed a consistent decrease down the profiles in almost all studied location except in Loc. E where it only increased in the second horizon before it decreased again.

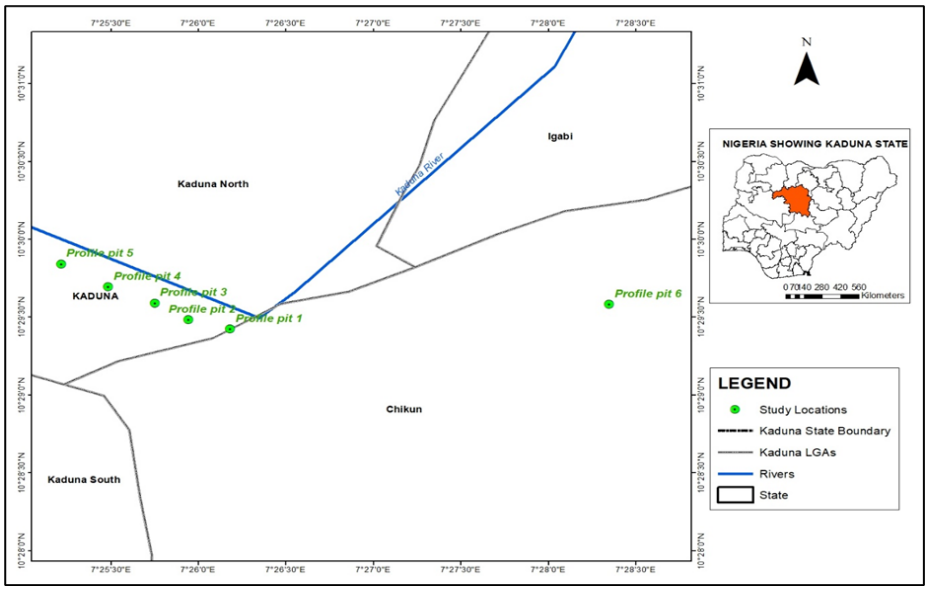

Fig. 2: Map of study area showing sampling points

Mean Mn was highest in Loc. A (71.82 mg/kg) and lowest in Loc. C recording 55.34 mg/kg. Generally, micronutrient trends indicated that Locations A and D consistently exhibited higher micronutrient concentrations compared to other locations. Loc. F consistently shows lower micronutrient concentrations, especially in Fe and Zn while mean values give an overview of the central tendency of micronutrient concentrations across all locations.

The micronutrients content of the investigated soils were all within the critical limits; (Cu: 2- 100 mg/kg, Fe: 100 – 400 mg/kg, Zn: 10 – 150 mg/kg) except Mn which was below the allowable or critical limits (80 – 140 mg/kg) according to Dhaliwal *et al.*, (2019); Hamza, (2008); Obasi (2015). It is worthy to note that micronutrient toxicity would be far-fetched as all recorded values never indicated toxicity. Obasi *et al.*, (2022) observed a similar pattern of micronutrients distribution in soils of Rigachikun within the same agroecology and attributed the widely low micronutrients to low organic matter. Green manuring and organic matter availability can lead to an upsurge the Mn content in soils. Organic matter, can produce a number of organic acids as it decomposes, brings down the soil pH and heighten the rate of reduction in soils. This process leads to more availability of Mn in soils especially when accompanied with green manure application. Submerged conditions leads to a more valent forms of Mn like MnO2, Mn2O3 and Mn3O4 to get reduced to Mn2+ form which is easily taken up by crops. Drought and overgrazing have grossly depleted the organic matter content of soils under study. Rainfall duration in northern Guinea Savanna Nigeria is very short, about four months (May – August).

Coefficient of Variation (CV) CV values indicate the degree of variability in the data. For Cu, Zn, and Mn, there is moderate variability, while Fe shows low variability. Variability in micronutrient concentrations across locations may influence crop growth and nutrient uptake. Therefore, understanding micronutrient distribution is crucial for assessing soil health and potential impacts on agricultural productivity.

Particle Size Distribution

Table 3 shows the soil particle size distribution, often known as soil texture, for the River Kaduna Watershed. Sand, clay, and silt concentrations were 4, 40.5, and 55.2% in pit 1; 10, 27.8, and 62.2% in pit 2; 3.5, 36.25, and 60.25% in pit 3; 38.6, 19.2, and 43.2% in pit 4; 3.8, 31, and 65.25% in pit 5; and 12.8, 22 and 65.25% in pit 6, respectively. The studied soils were dominated by the silt clay loam soil texture class. Almost all of the soils studied (pits 1, 2, 3, 5, and 6) exhibited a texture ranging from silt clay loam at the top horizons to silty loam or silt clay below the horizons. The lone exception was Pit 4, which was dominated by sand with its lower horizon as sandy loam. The increasing clay content seen in the majority of the profile Pits (Pits 1–5) shows that illuviation (clay moving down the profile) is occurring. These findings strongly demonstrate that pits 1, 2, 3, 5, and 6 were located in the Backswamp depositional area of the watershed. These places have very low sandy content (4, 10, 3.5, 12.8, and 4%, respectively). Profile pit 4, which had a considerably greater sand content (38.6%), was located in the watershed's terrace area. There was evidence of extensive clay and silt deposition in these Backswamp soils.

Table 2: Micronutrients Content of soils (mg/kg)

Loc. A	**Cu**	**Fe**	**Zn**	**Mn**	**Loc. D**	**Cu**	**Fe**	**Zn**	**Mn**
0 – 11	5.73	192.39	16.54	78.51	0 – 10	4.33	204.22	23.66	78.16
11 – 28	3.75	194.84	11.43	79.10	10 – 25	3.93	208.33	25.27	65.34
28 – 56	4.36	198.97	19.38	70.82	25 – 42	3.87	198.86	18.95	44.53
56 – 82	2.83	192.44	17.86	70.63	42 – 75	2.35	195.02	14.15	48.56
82 – 112	2.55	190.36	8.86	60.05	75 – 108	1.73	193.02	11.93	52.80
Mean	3.84	193.80	14.81	71.82	Mean	3.24	199.89	18.79	57.88
CV	33.25	1.701	30.19	10.76	CV	34.94	3.183	30.84	23.78
Loc. B					Loc. E				
0 – 8	4.12	184.42	15.34	75.15	0 – 6	3.15	192.41	14.92	72.86
8 – 22	3.22	189.64	11.76	72.42	6 – 18	3.59	197.34	18.55	75.74
22 – 46	3.13	193.32	16.45	69.34	18 – 44	2.98	185.65	14.34	68.45
46 – 73	2.35	182.11	17.54	56.99	44 – 98	2.45	179.34	12.56	60.20
73 – 102	1.85	176.45	15.55	45.77	Mean	3.04	188.69	15.09	69.13
Mean	2.93	185.19	15.33	63.93	CV	15.49	4.166	16.66	9.77
CV	29.73	3.545	14.19	19.24					
Loc. C					Loc. F				
0 – 14	2.54	178.24	10.68	73.42	0 – 15	2.87	155.87	14.40	70.87
14 – 33	3.28	188.76	13.28	68.84	15 – 35	2.34	143.55	12.66	64.22
33 – 79	3.18	190.65	11.45	43.54	35 – 74	1.96	105.84	12.33	62.95
79 – 105	2.47	185.66	7.10	35.55	74 – 104	2.38	162.85	10.32	52.08
Mean	2.87	185.83	10.63	55.34	Mean	2.39	142.03	12.43	62.53
CV	14.7	2.939	24.39	33.65	CV	15.63	17.89	13.46	12.45

Table 3: Physical and Chemical Properties of studied soil

Loc. A	BD (g/cm^3)	Sand ($g.kg^{-1}$)	Clay ($g.kg^{-1}$)	Silt ($g.kg^{-1}$)	Silt/ clay	pH ($CaCl_2$)	O.M. ($g.kg^{-1}$)	Avail.P ($mg.kg^{-1}$)	Ca	Mg	K	Na	ECEC ($cmol.kg^{-1}$)
0 – 11	0.96	60	260	680	2.62	5.80	5.07	15.26	9.40	2.54	0.61	0.90	13.35
11 – 28	1.14	40	420	540	1.29	6.00	4.39	6.69	4.60	1.24	0.19	0.22	6.45
28 – 56	1.14	60	420	520	1.24	5.90	13.18	8.75	10.0	2.70	0.21	0.10	13.55
56 – 82	1.31	20	440	540	1.22	4.10	2.37	4.97	2.80	0.76	0.21	0.10	3.96
82 – 112	1.22	20	500	480	0.96	5.70	4.39	5.12	5.20	1.40	0.15	0.10	7.25
Mean	1.154	40	400	550	1.36	5.50	5.88	8.16	6.40	1.73	0.27	0.28	8.91
CV (%)	11.19	50	21.81	13.70	44.86	14.37	71.5	52.1	49.16	49.2	69.1	122	48.44
Loc. B													
0 – 8	0.89	110	270	620	2.29	7.70	4.06	32.93	6.00	1.44	0.29	0.11	7.84
8 – 22	1.00	60	320	620	1.94	5.60	5.74	4.63	6.00	1.80	0.17	0.21	8.78
22 – 46	1.49	90	280	630	2.25	4.80	7.77	4.80	4.20	1.13	0.12	0.10	6.75
46 – 73	1.31	40	300	660	2.20	5.00	3.87	3.09	6.20	1.86	0.13	0.39	9.78
73 – 102	1.32	200	220	580	2.64	5.60	6.76	4.12	3.20	0.86	0.16	0.11	5.13
Mean	1.20	100	270	620	2.24	5.74	5.64	9.91	5.12	1.42	0.17	0.18	7.66
CV (%)	20.66	62.05	13.55	4.60	11.07	20.08	36.0	130.0	26.29	30.3	39.1	67.2	23.56
Loc. C													
0 – 14	0.97	20	320	660	2.06	6.10	4.95	4.97	9.20	2.76	0.12	0.09	12.27
14 – 33	1.22	40	380	580	1.53	6.10	2.70	18.01	5.00	1.35	0.26	0.16	6.87
33 – 79	1.24	40	350	610	1.74	5.80	1.69	3.26	12.40	3.35	0.11	0.18	16.14
79 – 105	1.14	40	400	560	1.40	5.50	2.03	2.92	4.00	1.08	0.07	0.16	5.51
Mean	1.14	35	362	602	1.66	5.88	2.84	7.27	7.65	2.14	0.14	0.15	10.20
CV (%)	10.75	28.57	9.66	7.29	17.12	4.89	51.6	98.8	50.8	51.3	59.2	26	48.26
Loc. D													
0 – 10	1.33	180	150	670	4.47	4.80	1.67	2.40	4.40	1.13	0.20	0.43	6.58
10 – 25	1.10	280	220	500	2.27	5.60	9.12	8.75	4.00	1.08	0.11	0.16	5.75
25 – 42	1.05	280	260	460	1.77	4.10	5.31	5.48	6.80	1.84	0.16	0.10	10.10
42 – 75	1.07	520	210	270	1.29	4.70	1.01	2.74	3.20	0.86	0.10	0.16	5.52
75 – 108	1.39	670	120	260	2.17	5.40	1.35	2.57	5.40	1.46	0.09	0.28	7.63
Mean	1.19	386	192	432	2.25	4.92	3.69	4.39	4.76	1.27	0.13	0.23	7.12
CV (%)	13.42	52.38	29.32	39.74	51.09	12.14	94.7	62.6	29.17	30.0	35.3	58.2	26.17
Loc. E													
0 – 6	1.23	40	240	720	3.00	4.90	3.72	3.09	5.20	1.38	0.08	0.19	8.05
6 – 18	1.29	20	300	680	2.27	5.30	1.67	2.40	6.60	1.78	0.18	0.40	9.36
18 – 44	1.10	50	340	610	1.79	5.40	7.77	7.89	5.40	1.46	0.17	0.17	7.60
44 – 98	1.20	40	360	600	1.67	5.00	1.64	4.63	4.80	1.30	0.09	0.02	7.61
Mean	1.21	38	310	652	2.10	5.15	3.70	4.50	5.50	1.48	0.13	0.20	8.16
CV (%)	6.59	33.55	17.07	8.79	40.76	4.62	77.9	54.3	14.08	14.2	40.2	80.2	10.18
Loc. F													
0 – 15	1.44	40	300	660	2.20	5.60	0.34	2.92	5.20	1.41	0.18	0.07	7.26
15 – 35	1.59	90	280	630	2.25	5.70	2.03	2.40	6.60	1.79	0.11	0.18	8.88
35 – 74	1.47	220	160	620	3.88	5.80	1.35	2.92	2.20	1.33	0.10	0.16	6.79
74 – 104	1.33	160	140	700	5.00	5.70	1.33	7.03	3.40	0.92	0.12	0.03	4.67
Mean	1.46	128	220	652	2.97	5.70	1.26	3.82	4.35	1.36	0.13	0.11	6.90
CV	7.33	62.25	37.11	5.51	27.65	1.43	55.1	56.5	44.64	26.2	28.2	65.1	25.15

Sand showed substantial variability (CV≥35%) in the examined soils, with the exception of pits 3 and 5, where it was moderate (CV≥15<35%). Clay exhibited mostly moderate variability (CV≥15<35%) except in pit 2 and 3 where it had low variability (CV≤15%) and pit 6 with high variability (CV≥35%). The silt content of the soils all indicated low variability (CV≤15%) except pit 4 where it varied highly (CV≥35%).

Smith *et al*. (1998) found a strong association between specific surface area, soil compatibility, compressibility, and particle size distribution measures, specifically the percentages of silt, clay, and organic matter. All of these factors influence soil productivity. Thus, except in oxide soils, soil fertility within a mineralogical class is proportional to clay content. This finding suggests that the Backswamp will likely have less plant development, particularly for annual crops, due to its high clay content, which was generated by debris deposited by the River Kaduna as a result of the infrequent flooding activities in most years. This is due to clay's interacting effect on soil water and nutrient levels (Scholes et al, 1994; Iheka *et al*., 2015). The availability of these nutrients is determined by the activities of the clay in the soil. Because clay soils can contain and trap certain nutrient components in their colloidal surfaces, they are ideal for heavy tuber crops and perennial crops with naturally nutrient-absorbing roots.

Table 3 shows silt-clay ratios of 1.36, 2.24, 1.66, 2.25, 2.10, and 2.97 for pits 1, 2, 3, 4, 5, and 6, respectively. The ratio trend suggested that most of the profile pits tested, such as pits 1, 3, 4, and 5, were decreasing, whereas Pit 2 showed no special distribution patterns, and Pit 6 rose as the horizons decreased. The silt:clay values indicate that the soils under examination are young and have not weathered significantly. Young soils, such as Entisols or Inceptisols, are freshly produced soils with high silt-to-clay ratios (>1.0) (Obasi *et al.* 2015). Such soils were formed by the regular deposition of clay and silt transportation materials from river flows, particularly during the heavy rainy seasons.

The common soils in the area were formed in part by periodic flooding of the banks of the River Kaduna watershed. Pits 1, 4, and 5 in the profile had significant variability (CV≥35%), Pit 2 had low variability (CV≤15%), and Pits 3 and 6 showed moderate variability (CV≥15<35%). The bulk densities, with means of 1.15, 1.20, 1.14, 1.19, 1.21, and 1.46 gcm-3, are displayed in Table 3. In Pits 1 through 3 of the investigated soils, the bulk density of the soils rose down the profile, however it subsequently dropped in these places. Where Pits 4–6 were located, the bulk density distribution was asymmetrical. According to Massawe et al. (2017), bulk density is a crucial physical property of soils that is used to gauge soil compactness and, in turn, root penetration, soil structure, and soil aeration. According to Hazelton and Murphy (2007), topsoil is considered overly compacted when it surpasses the threshold value of 1.4 g cm-3 for root growth. As a result, the bulk densities of the soils under study were below the critical values, at which the structure, aeration, and penetration of roots are negatively impacted. With the exception of Pit 2, which showed significant variability (CV≥15<35%), all studied soils had low coefficients of variation (CV≤15%).

Soil Reaction

As indicated in Table 3, the pH of the soil was examined in both water and 0.01N CaCl2. Since pH either increased or dropped within the horizon in every profile pit that was examined, the trend of pH distribution across horizons was not specific. The average soil pH in water and $CaCl_2$ for each of the six pits is as follows: Pit 1 has a pH of 6.42, 5.50; Pit 2 has a pH of 6.02, 5.74; Pit 3 has a pH of 6.63, 5.88; Pit 4 has a pH of 5.76, 4.92; Pit 5 has a pH of 6.08, 5.15, and Pit 6 has a pH of 6.35, 5.70. When tested in $CaCl_2$, the pH of the soil in water was primarily mildly acidic (pH≥6.0) and moderately acidic (pH >5.0<6.0). The sole location where this pattern did not hold true was Pit 4, where the pH was 4.92 in $CaCl_2$ and 5.76 in water, respectively. There may be significant weathering occurring here, which would explain the increased pH when compared to other areas. It is important to note that this site has the highest percentage of sand (38.6%), which may promote the leaching of exchangeable cations that caused the soil to become acidic.

Soil Organic Carbon, Organic Matter & Total N

Table 3 displays the organic matter and carbon content of the soil. Pit 1 reported 3.44 and 5.88 g.kg-1 for OC and 1.65, 2.85, 2.14, 3.69, 2.15, 3.70, and 0.73, 1.26 g.kg-1 for OM, respectively. In almost every profile pit under study, the distribution of organic carbon and organic matter showed an uneven pattern, with a concentration in the middle of the horizons. Pits 3, 4, and 6 showed an exception to this pattern, with a steady decline in OC and OM down the profile despite Pits 4 and 6's surface horizons being lower than the horizon that followed them. In a typical soil, organic matter that has decomposed and incorporated into the soil's system produces organic C and OM, which diminish as one moves down the soil's profile. These soils have extremely low and poor levels of Organic C and OM (<5.0; <20 gkg-1). Tabi *et al*. (2012) defined low as OC of less than 5 gkg-1 and OM of less than 20 gkg-1. This might be because there has been a lot of farming done in these areas, which removes organic materials from the soil without providing enough replenishment or renewal. The Kaduna River's ongoing overflow has also had an impact on the soils under study, which is why majority of the soils under study have significant

levels of silt and clay. The inconsistent distribution of soil OC and OM indicates that this condition has changed the physical and chemical characteristics of the soil. In every soil investigated in the River Kaduna basin, there was a significant variation in both organic carbon and organic matter (CV≥35%).

Available Phosphorus

Although P eventually declined in Pits 1–3 and increased in Pits 4–6, the accessible its content of the analyzed soils showed no special trend of distribution down the horizons in the majority of the studied soils at shown in Table 3. A decrease in organic matter concentration with depth may be the cause of the P decrease. Because organic debris can coat iron and aluminum oxides, reducing P sorption, it has a significant impact in P availability (Debicka *et al*., 2015). Table 3 displays the mean available P distribution for Pits 1 through 6, which are 8.16, 9.91, 7.27, 4.39, 4.50, and 3.82 mg.kg-1, respectively. According to Tabi *et al*. (2012), Pits 4, 5, and 6 had low P concentrations (< 5 mgkg-1) but Pits 1, 2, and 3 had high P values (5 -15 mgkg-1). Soil pH is one of the elements that influences P availability. Any of these conditions, where the pH is too high (high alkalinity) or too low (high acidity), can fix the available P. Every soil under study had a pH that indicated it was mildly to somewhat acidic. Pits 4 and 5 exhibited pH values of 4.92 and 5.15, respectively, which was higher than other places, suggesting more acidity. This could be the reason for the low P that was found in these places. The percentage of available P varied greatly (CV≥35%) in all soils examined along the Kaduna River watershed.

Exchangeable Cations

According to Table 3, the principal nutritional cations that were exchangeable bases were Ca, Mg, K, and Na. The following are the means of exchangeable bases distributed: Calcium (Ca) for Pits 1 through 6 is 6.40, 5.12, 7.65, 4.76, 5.5, and 4.35. In Pits 1 through 6, the magnesium (Mg) values are 1.73, 1.42, 2.14, 1.27, 1.48, and 1.36. Potassium (K) for Pits 1 through 6 is 0.27, 0.17, 0.14, 0.13, 0.13, and 0.13. Moreover, the sodium (Na) values for Pits 1 through 5 are 0.28, 0.18, 0.15, 0.23, 0.20, and 0.11, respectively. Exchangeable bases were not systematically distributed among the various profile pits, despite the fact that the majority of profile pits had their highest concentrations in their third and fourth horizons. Nevertheless, when Ca critical limits were taken into account, the Ca distribution was low (<5 cmolkg-1) in Pits 4 and 6 and moderate (5 – 10 cmolkg-1) in Pits 1, 2, 3, and 5. Moreover, Pit 1 exhibited a considerable Mg content (1.5-3.0cmolkg–1), whereas the concentrations of Mg in Pits 2–6 were uniformly low (< 1.5 cmolkg–1). In all research locations, potassium and sodium were found to be low within their respective horizons, with ranges of less than 0.3 cmolkg-1. Excessive leaching in the investigated soils could be the reason for the low exchangeable bases that were found. According to Obasi *et al*. (2015), leaching occurs in the majority of tropical soils. Additionally, the dynamics of moisture in the Kaduna River basin and ongoing agricultural practices may have leached away the exchangeable basic cations, reducing their availability. All examined soils from Pits 1 through 6 had moderate effective cation exchange capacities (ECECs, ranging from 6 to 12 cmolkg-1). Table 3 displays the ECEC distributions, which were 8.91, 7.66, 10.20, 7.12, 8.16, and 6.90 cmolkg-1 in Pits 1 through 6, respectively. Critical ECEC was identified by Landon (1991) as low (<6 cmolkg-1), medium (6 – 12 cmolkg-1), and high (>12 cmolkg-1). All of the locations had high percentage base saturations: pits 1–6 of the investigated soils had 94.45%, 89.01, 89.17, 89.00, 98.37, and 97.34 percent. Pits 1 and 3 had high coefficients of variation (CV≥35%), Pits 2 and 4 had intermediate coefficients of variation (CV≥15<35%), and Pit 5 had low coefficient of variation (CV≤15%). All soils under investigation showed low variability in base saturation (CV≤15%).

Correlation Studies

The correlation between micronutrients and other soil properties were presented in Table 4. Copper had very high positive significant correlation with Iron (Fe) (0.886**), Sodium (Na) (1.000**) and Organic Matter (OM) (0.771). It had significant correlation with Manganese (Mn) (0.543*), Zinc (Zn) ().543*) and a negative significant correlation with silt (-0.64*) and soil reaction (pH) (-0.66*). Effective Cation Exchange Capacity (ECEC) had very high positive significant correlation with only Magnesium (Mg) (0.943**) and very high negative significant correlation with sand and silt-clay ratio at -0.89** and -0.94** correlation coefficients respectively.Iron (Fe) equally had positive significant correlation with OM (0.698*) and very high negative correlation with silt (-0.75*) and pH (-0.71**). Potassium (K) had positive significant correlation with Mg (0.577*) and OM (0.698*) and very highly negative significant correlation with Silt-clay ratio (-0.70**). Magnesium (Mg) positive significant correlation with only pH (0.543*), negative significant correlation with Zn (-0.66*) while it maintained a very high negative significant correlation with Sand (-0.94**) and Silt-clay ratio (-0.89**). Manganese (Mn) had positive significant correlation with Na (0.543*) and high positive significant correlation with OM (0.771**). Sodium (Na) maintained high positive significant correlation with OM (0.771**), positive significant correlation with Zn (0.543*) while it had negative significant correlation with Silt (-0.64*) and pH (-0.66*).

Table 4: Correlation between micronutrients and other soil properties

	Cu	ECEC	Fe	K	Mg	Mn	Na	OM	Sand	Silt	Zn	pH
Cu												
ECEC	0.257											
Fe	0.886**	0.257										
K	0.334	0.577*	0.030									
Mg	0.029	0.943**	-0.03	0.577*								
Mn	0.543*	0.086	0.143	0.395	0.143							
Na	1.000**	0.257	0.429	0.334	0.029	0.543*						
OM	0.771**	0.371	0.698*	0.698*	0.257	0.771**	0.771**					
Sand	0.086	-0.89**	0.086	-0.33	-0.94**	-0.09	0.086	-0.143				
Silt	-0.64*	-0.23	-0.75**	-0.34	0.029	0.203	-0.64*	-0.290	-0.232			
Zn	0.543*	-0.43	0.486	-0.15	-0.66*	0.200	0.543*	0.429	0.600*	-0.319		
pH	-0.66*	0.371	-0.71**	0.455	0.543*	-0.31	-0.66*	-0.200	-0.486	0.261	-0.66*	
Slit/clay	-0.49	-0.94**	-0.37	-0.70**	-0.89**	-0.37	-0.49	-0.600*	0.771**	0.314	0.314	-0.200

Organic matter equally had negative significant correlation with Silt-clay ratio (-0.66*). Sand had positive significant correlation with Zn (0.600*) and high positive significant correlation with Silt-clay ratio (0.771**) while Zn had negative significant relationship with pH (0.66*). It is worthy to note that the correlation coefficient is a quantitative measure of the strength and direction of the relationship between two variables. A positive correlation coefficient indicates a positive relationship, a negative correlation coefficient indicates a negative relationship, and a correlation coefficient close to zero suggests a weak or no linear relationship.

Conclusion

The study aimed to explore the relationship between micronutrients (Copper, Iron, Zinc, and Manganese) and selected soil physical and chemical properties revealed that; none of the studied micronutrients reached toxic levels; all concentrations were barely within critical limits, except for Manganese, which was below. Low organic matter content in the soils may be responsible for the low micronutrient levels. Continuous grazing and cropping practices were identified as potential contributors to the low organic matter content as micronutrients showed a high positive correlation with organic matter in the studied soils. The research therefore underscores the importance of understanding micronutrient distributions in arable soils for sustainable agricultural practices. The findings provide valuable insights into the specific patterns of Copper, Iron, Zinc, and Manganese in relation to other soil properties across different locations, shedding light on potential factors influencing micronutrient availability in the studied soils of the river Kaduna watershed.

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DESIGN AND FABRICATION OF AN ALTERNATIVE DRYING SYSTEM USING ZEOLITE

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Abstract

Zeodration drying process is an alternative to freeze drying and some of the most sophisticated existing (indirect) drying processes. It's a process that uses zeolite properties as an adsorbent and as a molecular sieve for volatile substances recovery (aromas and others) present in the processed products. The technology offers a drying solution down to a residual moisture content of less than 0.5% This paper ascertains the need for an alternative drying system, the effects of zeolite as a dehumidifying agent on some specific raw materials, and a design concept for a zeolite drying system. An online survey was done with questionnaire administration stating the most utilized dryer, mode of operations, raw materials samples, frequency of drying operation, and appropriate suggestions to dry at ambient temperature within a very short time. The effects of zeolite on the organoleptic properties of some selected vegetables were observed and recorded. (750 x 600 x 50) mm with (250 x 150 x50) mm equipment, horizontally aligned to the ground level was designed. Increasing in adsorbent properties of zeolite with an increase in its surface area was a major criterion for the dehydration phase in the dryer. From the data obtained, the most significant items were as follows: 45% of respondents use cabinet dryers, 78% said dryers were made with Iron plates, and 25% with Stainless steel, while its durability ranges from 3 - 4 years. Most of the dryers are powered by an electric motor but about 34% are by Solar panels, 56% of the dryers work for every raw material except for drying done under vacuum, 89% of the respondents desire an alternative dryer with short drying time, low rate of energy consumption at an ambient temperature. Available drying processes are cumbersome, climate dependent, high energy consumption, expensive, and require a long operational time thus making it challenging for adoption by users of such technologies. The proposed drying system is designed to operate at the optimal operating parameters for specified products.

Keywords: Zeolite, Mineral resources, Adsorption, Dryer, Surface Area

INTRODUCTION

In the food industry, low-temperature drying within the range of 10 – 50^{o}C is required to prevent the loss of valuable organic content; limit product deterioration; and retain product quality (Djaeni, 2008). Moisture absorption during manufacturing processes is an integral part of the entire process for quality production (Mohammed, 2015).

The already existing available drying processes are cumbersome, expensive, and require a long operational time thus making it challenging for adoption by users of such technologies (Ajayi, 2009). The food industry is not alone in the search for alternative drying methods. Enzyme conversion to powder has also been a challenge in Nigeria. An alternative method other than freeze drying is required for the enzymes to be made in powdered form (Gessesse, 2018).

Zeolite drying system design gives the users a solution for drying liquid and semi-solid products with a reduced residual moisture content of less than 0.5%. The drying system has the advantage of reduced energy consumption in comparison to other drying methods.

Nigeria depends heavily on the importation of raw materials and equipment for utilization in its growing industrial manufacturing sector. The zeolite drying system seeks to provide a solution to this challenge. The proposed drying system will utilize zeolite, a raw material found in abundance in Northern Nigeria, hence eliminating importation. Also, the dryer design and development are to be done locally, thus providing the equipment at a reduced cost and specifications for the MSMEs (Ajayi, 2009).Locally manufacturing this equipment not only reduces post-harvest losses in the agricultural sector; it also ensures that jobs are created for local fabricators while providing alternatives for other industries that require low-energy drying processes (Adefila, 2008).

MATERIALS AND METHODS

Questionnaire Data Collection: The survey was conducted using an online questionnaire

administration stating the most uutilized dryers, mode of dryer operation and forms and type of raw materials usually dried, frequency of drying operation, and appropriate suggestions to dry at ambient temperature within a very short time. This is to verify that the use of zeolite for drying will be generally accepted in Nigeria, and also to ascertain the respondent's desirability to embrace zeodration process as a form of an equipment as an alternative means for drying.

Laboratory data collection: Data was collected and analysed for mass loss as a result of moisture content absorption with time using zeolite at a constant temperature as shown in Fig 1-4. Zeolite powder was purchased from a Chemical market, Ojota, Lagos, Samples of vegetables were obtained at the same market: Tomatoes, Onions, Garlic, and Cucumber were obtained and subjected to drying with the zeolite powder. Figure 1-4, and significant moisture reduction was observed.

Zeodration dryer design Consideration: The following points were critically considered under zeodration design: The material for construction, design calculation showing the shape and capacity of the equipment, mode of power generation, zeodration thermal activities (heat and material), which included: Drying under vacuum at a temperature close to ambient. Design calculation/drawing: Showing the amount of moisture to be removed from the sample, as shown in Table 2 and the design calculation, that reasonable amount of moisture was absorbed by the zeolite powder and the equivalent quantity/quality of zeolite to be used. Concepts described in an Engineering design and drawing (Figure 13).

Figure 1: Onions on Zeolite

Figure 2: Tomatoes on Zeolite

Figure 3: Onions and Tomatoes with Mass Loss (%)

Figure 4: Samples

3.0 RESULTS AND DISCUSSION

Online Survey Result: Nigeria depends heavily on the importation of raw materials and equipment for utilization in its growing industrial manufacturing sector which is high and unaffordable for Micro, Small, and Medium Enterprises (MSMEs). Figure 6 shows the online survey of dryer usage stating cabinet dryer as the highest percentage of 44.4%. Figure 7 shows that about 78% of cabinet dryer/dryer used are locally made. This served as a motivation to develop an alternative dryer using zeolite. Figure 8 shows that 25% percent of the dryer used are a made with iron plate and also predominantly coupled with stainless steel which should be affordable by for Micro, Small and Medium Enterprises (MSMEs). Figure 9 shows the time of usage by each respondent in other to ascertain the durability of the dryer, 44% of the respondents stated that the durability of the equipment is about 3-4 years. Figure 10 shows the mode of power predominantly used by the dryers, and about 56% uses electric motor while 33% uses solar powered system. Figure 11 shows routine maintenance strategy for a typical dryer, and on the average a monthly maintenance system carries the highest percentage. Figure 12 shows that the

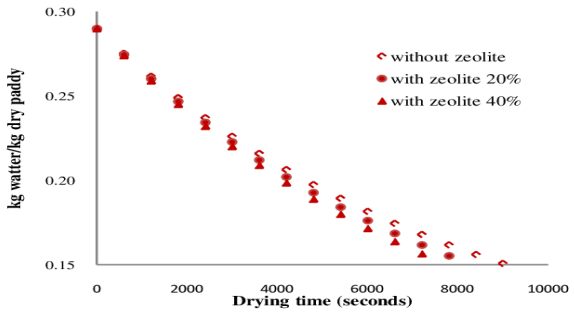

Figure 5: The response of moisture content versus time in grain drying with zeolite 20 and 40%, and without zeolite at operational temperature 50ºC (Nurul *et al.*, 2018)

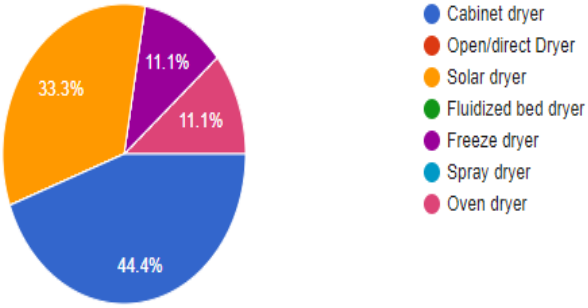

Figure 6: Pie chart showing percentage of different dryer usage

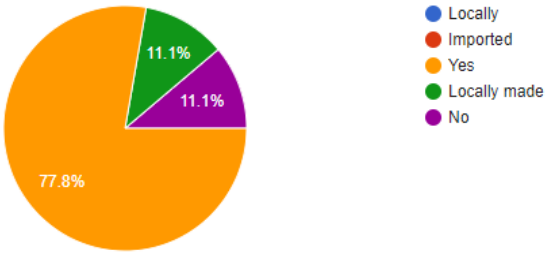

Figure 7: Pie chart showing that our dryers are predominantly made locally

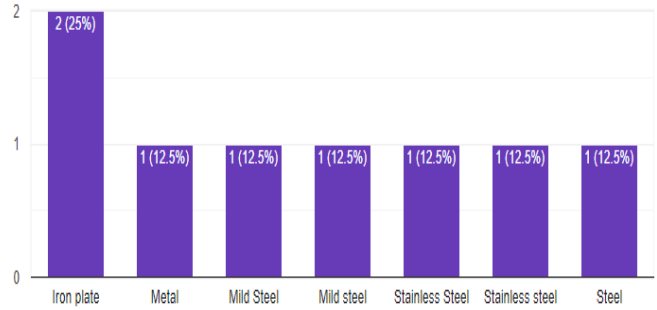

Figure 8: Bar chart showing different metallic material for dyer construction

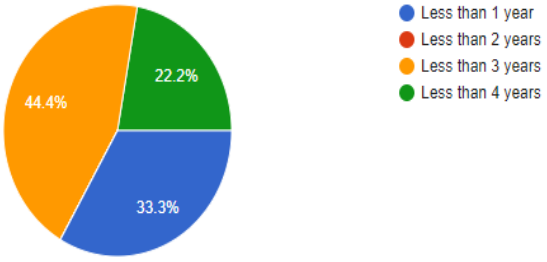

Figure 9: Pie chart showing dryers durability

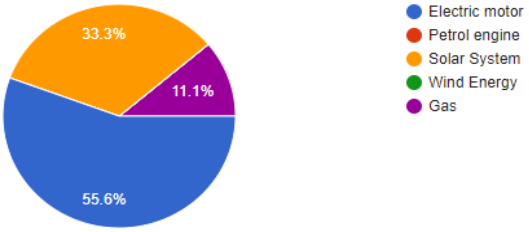

Figure 10: Pie chart showing the mode of power of a typical dryer

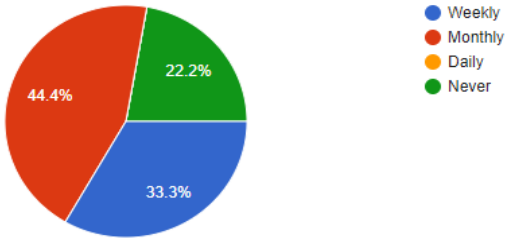

Figure 11: Routine maintenance strategy

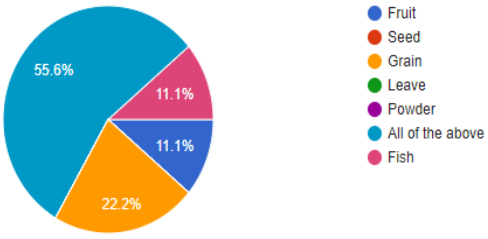

Figure 12: Pie charts showing raw materials for drying

Table 1: Results of the effects of zeolite as a dehumidifying agent on the Organoleptic Properties of some selected samples

Samples	32-34°C , Resident Time = 1440 min				38-40°C , Resident Time = 800 min			
	Colour	Smell	Mass Loss %	Appearance	Colour	Smell	Mass loss %	Appearance
Tomatoes	2	4	66.2	3	4	4	65.3	4
Onions	3	3	45.8	4	4	4	48.2	4
Garlic	4	3	43.5	4	4	4	45.5	4
Cucumber	4	3	50.3	3	4	4	52.1	4
Grain	4	4	33.1	3	4	4	34.3	4

1 = Unacceptable; 2 = Below Satisfactory; 3 = Satisfactory 4 = Above Satisfactory; 5 = Good

Table 2: Design calculated output and Technical specifications

Type	**Zeolite drying system**
Zeolite Cabinet Dimension (mm)	750 x 600 x 50
Zeolite tray dimension (mm)	300 x 350 x 50
Stainless Steel diameter (mm)	10 mm
Rated Voltage	220 V/150 Hz
Weight (Gross/Net)/Tray	26.26 kg
Equipment Capacity	105 kg/B
Equipment Cooling Capacity	< 5°C
Heat exchanger	Yes
Mode of Power (Solar + Electric)	600 W
System Lag	Yes
Heat generation within the system MC (Q_1-Q_2)	± 6125 kJ/m^{2}min°C
Insulation thickness	10 mm
Proposed Overall Efficiency	75%
System Temperature range	35.5°C – 37oC

proposed drying system must be designed to handle all materials that are temperature sensitive. Table 1 revealed that zeolite absorption properties has done no harm to the organoleptic properties of the samples provided but rather caused a reduction in weight and mass of the sample hence the reason why zeodration method of drying is to be adopted, the very sensitive characteristics of samples were retained even after drying which played a very vital role in consumer acceptance and preference for food product (Ajayi 2009).Likewise, the resident time for drying was reduced on temperature increase, which brought about the design consideration for the dryer .

Design Equation

Zeolite Tray: Packed bulk density of Zeolite = 1.12 g/cm^3 = 0.0012 kg/m^3

Density = Mass / Volume
Such that, Mass of Zeolite Tray = Density x Volume

Zeolite tray is Cuboidal in shape with dimension 300 x 350 x 50 mm,
Volume = L x B x H= 0.00525 m^3
Mass of Zeolite for each layer in a tray is 0.00525 x 0.001 = 5.25 kg/m^3

Therefore 5 Layers compacted with 1000 m^3 of binder makes a tray = 5.25 x 5 = 26.26 kg of Zeolite /tray.
For 5 trays = 26.26 x 5 = 131.3 kg of Zeolite surface area of each tray is L x B = 300 x 350 =105,000 m^2
Particle size of raw materials (fruits, vegetable or grain) at this area is about 5000 m^2
Therefore, the quantity of raw material to dry per tray is 105,000/5000 = 21 kg.

Total Capacity/ Volume of the Drying Chamber

Thickness of each Tray 50 mm x 5 = 250 mm
Tray Spacing 50 mm x 6 = 300 mm
= 550 mm
Capacity of the drying Cabinet (cylindrical) Πr^2 h/2 = 22/7 x 0.25 ^{2} x 0.5 = 0.049107 m^3

In Mass = 149 kg.

No of Tray = Total capacity of drying Chamber – Spacing / Capacity per Tray 149 -35/21 ~- = 114/21 = 5.46 Trays. Therefore, 5 trays are required for 105 kg/batch

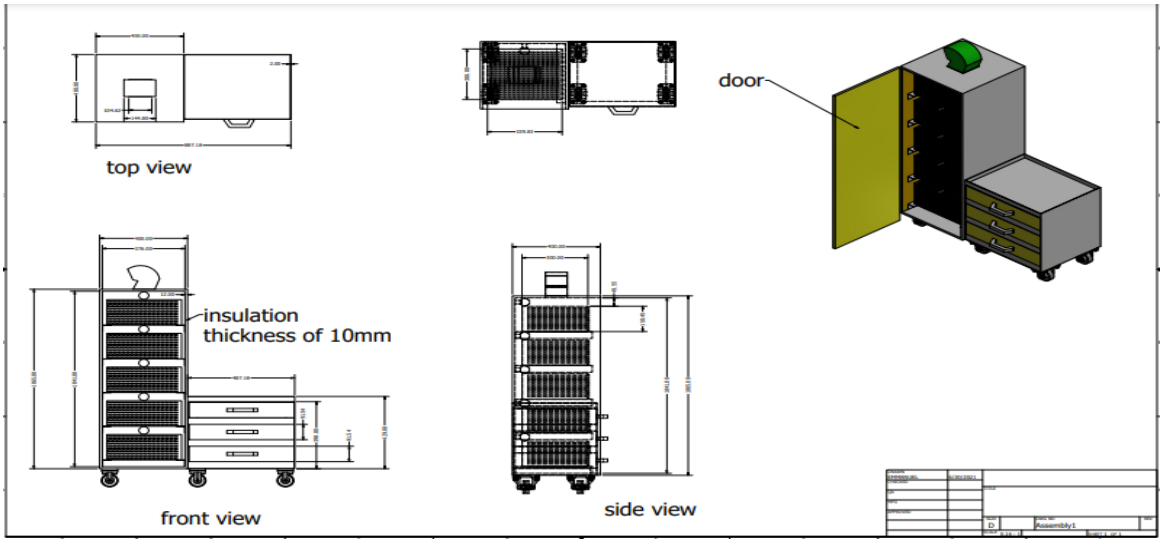

Figure 13: CAD Design

Conclusion and Recommendations

Drying is one of the most important processes often necessary in various industrial operations. Design and Fabrication of an appropriate zeodration dryer will industrialize zeodration process with reduction in drying time, rate of energy consumption during drying, a short operational time, low product contamination, optimum nutrient retainer at a very low operational cost. The equipment is compact in design, with appropriate automation gadgets.

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Journal of Organic Agriculture Research and Innovation (JOARI)

SURVEY OF EDIBLE INSECTS CONSUMPTION IN UNIVERSITY OF LAGOS

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Abstract

Lagos is one of the world's mega cities, with an estimated population of 17.1 million people. The availability of edible insects is limited to the outskirts of Lagos and it is not easily obtainable in major food markets in Lagos state, Itookin in Epe local government and Gate junction in Alimosho local government are two areas where edible insects are sold in Lagos. Analysis of the respondents within the University of Lagos showed Education is strongly correlated (0.001) with acceptance of edible insects as a part of the staple diet. The edible insects; African palm weevil larva, Red palm weevil larva and Pallid emperor moth caterpillar analysed for their nutritional content indicate they are high in protein with 40.55%, 54.57% and 58.54% while the fat content were 22.3%, 18.13% and 10.33%, respectively. Red palm weevil larvae has the highest protein composition (58.54%) and African palm weevil larvae has the least (40.55%) whereas the African palm weevil has the highest fat content of 22.30% while the Red palm weevil larvae has the least fat content of 10.33%. This study shows that these edible insect species though tree pests are highly nutritive and can serve as alternate protein source for the growing population of Lagos State.

Keywords: Edible insects, Lagos state, Availability, Nutritional

INTRODUCTION

Insects have a unique combination of characteristics which gives them an unusual survival advantage. These attributes include an exoskeleton, small body size, a high reproductive potential, complete metamorphosis, and adaptability in an ever changing environment. Insects are the most successful group of animals on earth based on adaptation. Insects are invertebrate animals and are cosmopolitan. They can be found in the house, farms, roads, air, and so on (van Huis, 2003). All insects have three body parts; the head, thorax and abdomen. Insect cause a lot of damage to stored grains leading to huge agricultural loss to farmers and merchants of agricultural produce, that is why insects are considered as pests. However, there are some insects that are beneficial. An example of a beneficial insect is the honey bee, *Apismellifera*. It produces honey as well as pollinates flowers. Many insects such as ants, bugs, beetles and moths pollinate plants and flowers too.

Parasitic insects such as Ichneumon flies, wasp, flies, ladybird beetles, serve as biological control of other insect groups. Maggots and honey from bee are used in medicine to treat and dress wounds (Veldkamp *et. al.*, 2012). Silk, used in textile, is gotten from the silkworm. Insects such as beetles and bugs help to aerate the soil. Black soldier fly, the biological vector of *Onchocerca vulvarus*, known to cause river blindness, is a great decomposer, and breaks both animal and human faeces down to humus (Veldkamp *et. al.*, 2012).

In addition, an important beneficial aspect of insect that is gaining global prominence is entomophagy, which is the consumption of insects. Insects are consumed as food and this is common in cultures in some parts of the world such as North, Central and South America, Africa, Asia, Australia and New Zealand (Jongema 2012). It is estimated that insects form part of the traditional diets of at least 2 billion people. More than 1900 species have reportedly been used as food. (De Foliart 1990, Jongema 2012).

Edible insects inhabit a large variety of habitats, from aquatic ecosystems and farmed land to forests. Until recently, insects were a seemingly inexhaustible resource obtainable by harvesting from nature. However, some edible insect species are now in peril. A number of anthropogenic factors, such as overharvesting, pollution, wildfire and habitat degradation, have contributed to a decline in many edible insect populations (FAO, 2013). The environmental benefits of rearing insects for food and feed are founded on the high feed conversion efficiency of insects. For example, the production of 1 kg of live animal weight of crickets requires as little as 1.7 kg of feed (Collavo *et al.*, 2005).

In addition, insects can be reared on organic matter such as human and animal waste and this can help

reduce environmental contamination. Insects are reported to emit fewer greenhouse gases and less ammonia than intensive cattle or pigs farming, and they require significantly less land and water than cattle rearing (van Huis, 2013). Compared with mammals and birds, insects may also pose less risk of transmitting zoonotic infections to humans, livestock and wildlife. Insects are a highly nutritious and healthy food source with high fat, protein, vitamin, fibre and mineral content (Durst *et al.*, 2010). The nutritional value of edible insects is highly variable because of the wide range of edible insect species. Even within the same group of species, nutritional value may differ depending on the metamorphic stage of the insect, the habitat in which it lives, and its diet (FAO, 2013).

Usually, it is the larva and adult stage of insects that is mostly consumed. With the increasing human population, and Lagos being one of the world's emerging megacities, meeting the protein demand of the populace is a major challenge. Lagos is in the South western part of Nigeria with side of the city leading into the Atlantic Ocean. Its estimated population is about 17.1 million people and by the year 2030, it's expected to be one of the top 10 most populated cities in the world (The Business Aim, 2013). Feeding a growing world population with more demanding consumers will necessarily require an increase in food production. This will inevitably place heavy pressure on already limited resources such as land, oceans, fertilizers, water and energy. If agricultural production remains in its present form, increases in Green House Gases emissions, as well as deforestation and environmental degradation, are set to continue. The culture of eating insects is fast eroding due to urbanization and there is therefore need to promote the consumption of insect-based animal protein.

MATERIALS AND METHODS

Experimental Site: Lagos State with the Atlantic seaboard as the southern boundaries lies between longitudes 2º 42'E and 3 º 22'E of the Greenwich Meridian and latitudes 6 º 22N and 6 º 42'N of the Equator. The metropolitan area comprises of seventeen out of the twenty Local government Councils which make up the state. These include: Lagos Island, Eti-Osa, Lagos Mainland, Surulere, Ikeja, AjeromiIfelodun, Amuwo- Odofin, Alimosho, Apapa, Ojo, Somolu, Kosofe, Mushin, Oshodi- Isolo, Agege and Ikorodu. Littoral climatic variables prevail throughout the year with average daily maximum temperature of about 30ºC and 29 mils bar of vapour pressure in the air at critical sunny dry season days. Metropolitan Lagos is within the Sandy Barrier- Lagoon Complex of Western Nigerian coastline. Morphologically, this bioregion is framed by interconnecting creeks.

The University of Lagos is situated in the western part of Lagos State at approximately 20˚ 50'N and 30˚ 50'E. It is largely surrounded by the scenic view of the Lagos Lagoon on 802 acres of land in Akoka, North Eastern part of Yaba, Lagos. It is bounded on the North by IlajeEse-Odo, South West by Iwaya and South East by the Lagos Lagoon. The total area spans approximately 8194.93m^2 consisting of both wet and dry land out of which a conservative 21.5% is estimated to be wetlands (Nwankwo *et. al*., 2003).

Source of Information: The information was gathered by oral interview of market traders, buyers, motorists, edible insect consumers and traders on where edible insects can be obtained in Lagos metropolis. Information was also gathered by reviewing the work done by other scientists on edible insects. A total of 600 questionnaires were distributed out of which 470 were filled and returned in a sampling technique. The choice of the University of Lagos as a study site for administering of questionnaire was based on the fact that the university is open to large population of people.In order to cut across the entire community, people in the University of Lagos were categorized into 6 groups, which are academic staffs, non-academic staff, post graduate students, undergraduate students, traders and visitors. Some of the information captured from respondents include the following; age group, the categories people belong to in the University of Lagos, the awareness they have of insects being edible, if they have ever eaten insects, the insects encountered here in Lagos, the kind of insects eaten, how often they consume edible insects, whether they know any place or places where insects can be bought, their level of acceptance of edible insect consumption and so on.
The African palm weevil, *Rhynchophorus phoenicis* and the Red palm weevil, *Rhynchophorus ferrugineus* were obtained from Itookin, Epe Local Govt. and Pallid emperor moth caterpillar *Cirinaforda* at Gate bus stop, Ipaja-Ayobo Road, Alimosho Local Government area of Lagos State. These processed insects were then identified based on oral interview from traders, past literatures on local names and host species- Alamu *et al.*, 2012, Banjo *et al.*, 2006.

Questionnaire administered to assess the acceptability of insect consumption at the University of Lagos: A total of 600 questionnaires were distributed out of which 470 were filled and returned in a convenient sampling technique. The choice of the University of Lagos as a study site for the administering of questionnaire was based on the fact that the university is open to large population of people. As at 2010, the student population was about 45,000- www.unilag.edu.ng. While some trod in daily, some are temporary and permanent residents

of the university. In order to cut across the entire community, people in the University of Lagos were categorized into 6 groups, which are academic staffs, non-academic staff, post graduate students, undergraduate students, traders and visitors.

Statistical Analysis: Data was analysed using non parametric test SPSS. Also, descriptive analysis such as frequency counts, percentages and tables were used to summarize the data obtained.

RESULTS AND DISCUSSION

Location of Edible Insects

The edible insects found in Lagos include the African Palm weevil *Rhynchoporu sphoenecis.(Ogongo)*, Red palm weevil, *Rhynchoporus ferruginus (itun)* and the Pallid emperor moth *Cirinaforda (Monimoni)*, Termites, *Macrotermes spp*. Itookin was found to be the main market for edible insect from this study. This is in agreement with the findings of Adeoye *et al.*, (2014) who reported that the African palm weevil *Rhynchophorus phoenicis, (*Fabr) Curcilionidae , is sold alongside the Red palm weevil *Rhynchoporus ferruginus (itun)* in a small town called Itookin as collaborated by Adeoye *et al*, 2014. This is a town along Ikorodu Epe expressway about 15 minutes drive from Agbowa, Ikorodu. The town is a transit town for people travelling to Ijebu Ode and Epe. It is sold by the roadside by young females to mostly motorists and travellers. Upon interviewing the traders, they get their raw or fresh insects from boatmen and claim the boatmen were from Lekki, Ajah axis. Another trader said they get their supplies from Orisha under Epe Local government. The palm grubs are usually processed by boiling and frying and then fixed on bamboo sticks. It is sold with freshly fried pepper. A stick of four palm grubs is sold for 100naira. The palm grubs are also sold alongside fried snails and shrimps.

Questionnaire administered at the University of Lagos

Age of respondents: Table 1 shows the age of respondents. The highest frequency within the age is 20- 39 years while 60 years and above have the least age frequency.

Residential area of Respondents: Most of my respondents reside in Lagos with most of the residential areas represented in the data as shown in Table 2. Being a University community, most of the respondents fall within the age range of 20 – 59 years. The highest percentage is 67.4% of age group 20- 39years, with age group 40- 59years having 16.2%, below 20years 12.3% and above 60years having least percentage of 1.3%.. Most of the respondents had education up to tertiary level with 67.2% , 19.1% has had up to secondary education while 9.6% had primary education. Only 10% of my respondents view edible insects as being very good, while 20% of the respondents view the practice of entomophagy with disgust with the remaining respondents scattered in between. 57% of the respondents do not accept insects should form a staple part of our diet as against 34% that accept insects as a staple part of our diet. Many of the respondents are undecided and fall within the proportion of non-response.

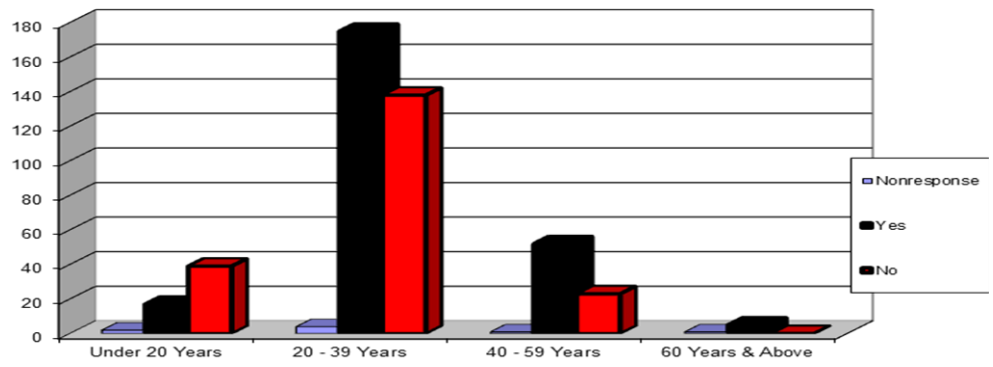
Educational Background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nonresponse	45	9.6	9.6	9.6
	Primary	19	4.0	4.0	13.6
	Secondary	90	19.1	19.1	32.8
	Tertiary	316	67.2	67.2	100.0
	Total	470	100.0	100.0	

Table 2: Residential Area of Respondents

Residential Area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nonresponse	16	3.4	3.4	3.4
	shomolu	56	11.9	11.9	15.3
	ikorodu	31	6.6	6.6	21.9
	island	73	15.5	15.5	37.4
	awodi-ora	1	.2	.2	37.7
	anthony	2	.4	.4	38.1
	ikeja	32	6.8	6.8	44.9
	abule-egba	2	.4	.4	45.3
	akoka	135	28.7	28.7	74.0
	egbeda	6	1.3	1.3	75.3
	mile12	2	.4	.4	75.7
	festac	4	.9	.9	76.6
	gbagada	5	1.1	1.1	77.7
	badagry	11	2.3	2.3	80.0
	ogudu	18	3.8	3.8	83.8
	orile iganmu	2	.4	.4	84.3
	mushin	15	3.2	3.2	87.4
	surulere	19	4.0	4.0	91.5
	oshodi	12	2.6	2.6	94.0
	alimosho	2	.4	.4	94.5
	ibafo	1	.2	.2	94.7
	ketu	2	.4	.4	95.1
	ifo	1	.2	.2	95.3
	isheri	6	1.3	1.3	96.6
	ikosi	9	1.9	1.9	98.5
	isolo	2	.4	.4	98.9
	osogbo	2	.4	.4	99.4
	ejigbo	2	.4	.4	99.8
	ojodu	1	.2	.2	100.0
	Total	470	100.0	100.0	

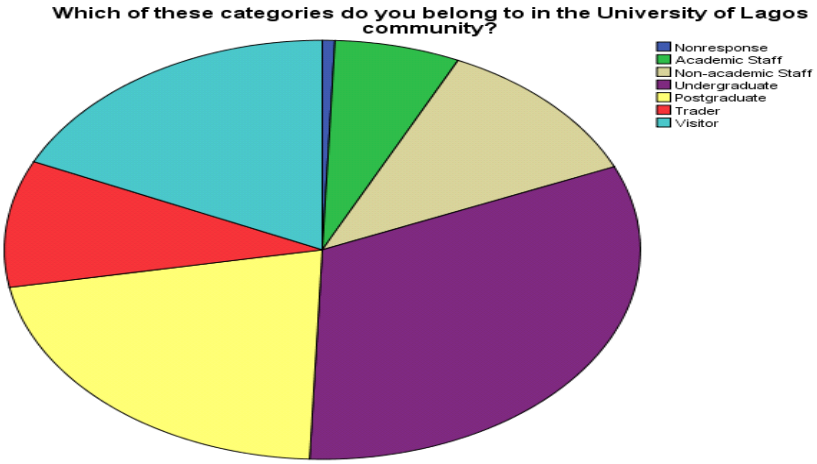


Categories Respondent Belong to in the University of Lagos Community: The six categories of respondents in the University of Lagos are represented in the (Table 3) with the number of post graduate and undergraduate students having the highest frequency of 101 and 151 frequency respectively. 87 % of my respondents are aware that insects are edible while only 54% have actually consumed insects

Table 3: Categories of Respondents in University of Lagos Community

Which of these categories do you belong to in the University of Lagos community?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nonresponse	3	.6	.6	.6
	Academic Staff	30	6.4	6.4	7.0
	Non-academic Staff	54	11.5	11.5	18.5
	Undergraduate	151	32.1	32.1	50.6
	Postgraduate	101	21.5	21.5	72.1
	Trader	46	9.8	9.8	81.9
	Visitor	85	18.1	18.1	100.0
	Total	470	100.0	100.0	



Conclusion

The practice of consuming insects amongst the university community is quite low as most of those who have eaten edible insects before did so a long time ago. Government needs to review insect farming as a means of livelihood or extra income to farmers. Therefore, they need to provide funds and grants so as to develop ways of cultivation of edible insects to make them available all year round. This would in turn bring more commerce in the area of edible insects both within and outside the country

Recommendation

Government needs to view insect farming as a means of livelihood or extra income to farmers. Therefore, they need to provide funds and grants so as to develop ways of cultivation of edible insects to make them available all year round. This would in turn bring more commerce in the area of edible insects both within and outside the country.

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CONSUMPTION OF ORGANIC VEGETABLES AMONG THE HOUSEHOLDS: A MICRO-LEVEL EVIDENCE FROM UMUAHIA MUNICIPAL OF ABIA STATE, NIGERIA

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Abstract

Interest in organic food has expanded globally as people become aware of the impacts of commodities produced with synthetic chemicals. The broad objective of this study was to analyze the consumption of organic vegetables among households in Umuahia Municipal, Abia State. Data were collected from primary sources. A multi-stage purposive sampling technique was adopted for the study and information on 120 consumers were collected using a structured questionnaire. The data collected were analyzed using descriptive statistics such as means, percentages, charts and Mean scores. The results show that the respondents were mostly females (51.7%) and highly educated people (55.8% having the highest educational qualification) with the mean age of 42.7 years. The average earning per month was ₦39,170. More than half (58.4%) of the consumers purchased organic vegetables once a week from the market outlets (44.2%). Only 55% of the consumers agreed that the vegetables contain agro-chemical residues and considered the problem to be moderate (43%). 78.33% were willing to pay a premium of 30% more for organic vegetables. Few of the reasons for preferring organic vegetables were, they taste better (55.8%), protect the environment (56.6%), longer shelf- life (58.3%) and their families like it (55%). Some of the constraints to consumption of the vegetables were, they are not readily available, affordable or popular in the area. The study therefore recommends that, government should formulate a policy which would aid in the successful transition to organic agriculture. Efforts should be geared towards increasing the supply of organic vegetables, since there is a market for them.

Keywords: Consumption, Organic, Vegetables, Preference, Willingness to pay

INTRODUCTION

Consumer concerns about health and environmental damage have increased the demand for organic food items which is a part of sustainable agricultural system (Barkley, 2002; Nguyen et al., 2019; Kumar, 2021). This growing demand for organic vegetables among other products is making farmers the world over to shift their production practices to meet this challenge. Meanwhile, the demand for organic products according to (Belicka and Bleidere, 2005), increased in recent years, with the value of the global organic market reaching 59 billion US$ in 2010, owing primarily to growth in the United States of America and many European countries which account for 96% of global revenues. The high degree of sales concentration underlines the gap between production and consumption, implying that most organic food production in places such as Africa and Latin America is export-oriented. On the other hand, the African organic product market is under-developed and the continent's general absence of big domestic markets appears to pose a high risk to commercial organic agriculture, which is heavily reliant on export markets. Certified organic products are now recognized in only a few local markets, excluding Nigeria (Olaito, 2014).

Nevertheless, organic vegetables such as water leaf and fluted pumpkin are produced without the use of chemical fertilizers and pesticides. And Due to food safety and environmental quality concerns, policy makers worldwide are attaching more importance to the production and consumption of such food products. Food safety is a serious worry, as many vegetable growers inappropriately apply harmful pesticides at pre and post- harvest stages, threatening the health of farmers and consumers while also damaging the environment (Yesufu *et al*., 2018).

Assuredly, consumption of fresh organic food products could enhance the prevention of some of the health hazards associated with the consumption of conventional foods. Indeed, the risk of consuming conventional foods in Africa including Nigeria could be traced to inappropriate use of chemical pesticides and inorganic fertilizers by agricultural producers who may or may not be aware of the associated health hazards of the chemical residues (Coulibaly, 2013; Oluwakemi, 2014; Kumar, 2021). Fresh organic vegetables could contribute significantly to employment generation, wealth creation and poverty alleviation in Nigeria. They constitute important raw materials for the local food industries as well as the fast- growing restaurants and supermarkets in the country. But they are often

assumed to be more expensive than their conventional counterparts, mostly due to the perceived greater quality of the product and higher production, processing and transportation costs (Adeoye, 2005). It has been observed that the production, distribution and marketing of organic food is more costly than conventional food because of the costs of segregation of organic products. Most households in Nigeria traditionally consume more of conventional fruits and vegetables. An important approach to achieve food safety and minimize health hazards associated with fruits and vegetable consumption is the promotion of consumption of organic vegetables in the country (Yesufu *et al*., 2018). This in turn requires reliable information on consumer willingness to pay a premium for organic fruits and vegetables, specifically water leaf and fluted pumpkin in Nigeria.

In spite of the numerous advantages of consumption of organic food products, information on their market demand and prospects in Nigeria appear to be limited (IFOAM and FiBL, 2010). A number of consumer studies have examined the consumption of organic food products in developed countries (Wier *et al*, 2001; Boys *et al*., 2014; Thomson, 2015; Bhattarai, 2019). However, few consumer studies on organic food products exist in Nigeria and other developing economies (Aryal *et al*., 2009; Coulibaly *et al*., 2013; Bhattarai, 2019; Pham, 2020). In particular, issues concerning consumer willingness to pay (WTP) a premium for organic fruits and vegetables in Nigeria have not been rigorously addressed. Also, the future of agriculture will, to a large extent, depend on customer demand of organic and their motive for paying extra price for organically grown food. Hence, a customer-oriented approach to understanding the dynamics of consumption of organic products is important for pursuing better management of organic farming. However, this is a complex process, which is determined by factors such as quality production, certification, infrastructure and environment and policies. The need therefore arose to investigate the consumption of organic vegetables among the households in Abia State. Specifically, the study examined the socio-economic characteristics of the respondents; ascertained the consumers' levels of awareness of organic products; and analyzed the consumers' preference and willingness to pay for organic vegetables among rural household.

MATERIALS AND METHODS

The data used in this study comes from a survey conducted among vegetable (Ugu (*Telfairia occidentalis*) and Water leaf (*Talinum fruticosum*)) consumers in Umuahia municipal city of Abia State. Data were collected from primary sources. A multi-stage random sampling technique was adopted for the study. The first stage involved the purposive selection of Umuahia municipal zone. Next was a purposive selection of Umuahia North local government area. The third stage involved the purposive selection of Umuahia Municipal city from the local government. Finally, a direct face to face interview (using questionnaires) with respondents were undertaken during the research. According to Carson (2002), a more reliable approach in valuation studies is the face-to-face interview. This method offers a direct interaction with the respondents and provides an opportunity to clarify some of the questions to consumers with low literacy level. Consumers were approached during their food shopping in the major market (Orie-Ugba) located in the sampled area. Sample inclusion is based on the consumers awareness of the term 'organic' food. They were asked if they have heard and consumed organically produced food. Only those that said yes were included in the study. In the end, 180 consumers were approached of which only 120 were qualified. The questions asked during the survey cover consumer-specific socio-demographic characteristics, food purchasing habit and constraints limiting organic food consumption. This was analyzed using descriptive statistics such as means, percentages and charts. Data were also collected on consumer's perception of and preference for organic food products and their attributes. The perception of the consumers, benefits and qualities of organic food products were measured on 5-point /4-point Likert indices from averages of coded responses comprising strongly agree (+1), agree (+0.5), neutral (0), disagree (-0.5), strongly disagree (-1); very regularly (4), regularly (3), rarely (2), never (1); high (3), moderate (2) and low (1). In addition to this specific perception dummies indicating 1, if the consumer agrees that organic foods are tastier or expensive and 0, otherwise were captured in the research instrument.

Variables with the mean score of 3.0 (which is the average mean score of the rating level) and above imply that they are positive and is affirmative to the objective being measured while factors with mean score behind 3.0 have no influence on the variable being measured. To determine the mean Likert Scale ($\sum X/N$), mean of each item was computed by multiplying the frequency of each response with its appropriate nominal value and dividing the sum with the number of respondents to the item. This can be given thus;

$$\text{Mean} = \sum^{fn}/N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where mean = Likert Mean Score
$\sum$ = Summation
f = Frequency.
n= number of nominal scale
N = Number of respondents

$= \frac{1+2+3+4+5}{5} = \frac{15}{5} = 3.0$ …...2

Also, for the 4-point Likert scale, Variables with the mean score of 2.5 (which is the average mean score of the rating level) and above imply that they are positive and is affirmative to the objective being measured while factors with mean score behind 2.5 have no influence on the variable being measured. Hence;

$\text{Mean} = \frac{1+2+3+4}{4} = \frac{10}{4} = 2.5$ …..3

The consumers' perception regarding the intensity of the problem caused by chemical residues on the conventional pesticide treated vegetables was measured on a scale of 1 to5 with 1 indicating very high, 3 moderate, 4 low and 5 very low and presented using a bar chart. Furthermore, the data on the amounts of premium consumers are willing to pay for organic vegetables were collected in the double-bounded dichotomous choice framework following, Boys et al., (2014). The consumers were presented with a first bid, after which a second and third higher bids were offered depending on their response to the first bid. The baseline was ₦100/0.2kg (one bundle) and there were three levels/different bids which were 20% higher than the preceding bid price. The first bid was ₦120, followed by a higher second bid of ₦140 while the last bid was ₦160 for the same quantity of vegetable.

RESULTS AND DISCUSSION

The result on the distribution of respondents according to their socio-demographic characteristics is presented in Table 1 below. The respondents were mostly females (51.7%) which is expected, since they are responsible for food purchases in many households. Also, the consumers were highly educated people (55.8% having the highest educational qualification) with the mean age of 42 years and 7 months. This may be due to the inclusion of consumers that exhibited a slight understanding of organic production, belong to younger age groups and have higher educational qualifications conforming to the findings of Fotopoulos and Krystallis (2002) and Vasquez et al. (2009).

Distribution of the consumers based on ethnicity

The result on the distribution of the respondents based on their ethnic region is presented in Figure 1 below. The result shows that majority (83.3%) of the consumers were of Igbo origin, probably because the study was carried out within the ethnic group. Other ethnic groups were also represented sparingly. In the local markets in Abia, there are no labels or signs to distinguish clearly between organic and inorganic produce unlike in the shops where one can find labelled organic products. It was necessary to ascertain that the consumers knew what organic vegetables are and the result is presented on Table 2. While majority (51.7%) claimed that they are aware of organic produce, had glimpse (63.33%), less than 50 percentage could say categorically which year they saw organic vegetables (33.33%) and when they consumed it (34.17%). The result in Table 2 indicates that most of the respondents have an idea of what organic means, though their understanding was somewhat limited but can be considered correct. This conforms with the findings of some studies (Dipeolu *et al*., 2006; Philip and Dipeolu, 2010).

In terms of the criteria considered during the purchase of organic vegetable, agreement percentage for most of the variables used in the questionnaire, presented on Table 3, are higher than 50%. More than half (58.4%) of the consumers sampled purchased organic vegetables at least once a week which indicates an average purchasing frequency, perhaps due to its unavailability when needed. More than half (58.4%) of the consumers sampled purchased organic vegetables at least once a week which indicates an average purchasing frequency, perhaps due to its unavailability when needed. Also, regarding the sources/point of purchase for organic vegetables patronized by the respondents, greater numbers (44.2% and 32.5%) of the consumers prefer outlets such as market place and shops. In the same vein, most (44.2%) of them indicated quality as the main reason for buying the product in those outlets, followed by the freshness (28.3%) of organic vegetable.

Willingness to pay for organic vegetables

The perception of the respondents concerning vegetable grown with agro-chemicals is presented in Tables 4. Majority (65%) of the consumers stated that vegetables grown conventionally don't contain chemical residues while 55% of them agreed that such vegetables contain agro-chemical residues. A follow up question was asked to the respondents who said that vegetables grown conventionally contain chemical residue. The question was on their perception of the intensity of the problems caused by the chemical residue and measured on a scale of 1 to 5 from very high to very low. The result showed that 24% of the consumers considered the problem to be very high, 28% perceived the problem to be high while 43%, 18% and 7% of them considered chemical residue as moderate, low and very low problems respectively. Also, only about 78.33% of the respondents who stated that there is a problem of chemical residue are willing to pay more (premium prices) for organic vegetables. This indicates that there is market for organic vegetables in Abia State and corroborates the findings of the study carried out by Bhattarai (2019). However, as mentioned, a greater number of respondents (65%), said there

Table 1: Socio-demographic characteristics of the respondents

Variable	Frequency	Percentage	
Sex			
Male	58	48.3	
Female	61	51.7	
Age			
25-34	31	25.8	
35-44	28	23.3	
45-54	41	34.2	Mean=42.7
55-64	20	16.7	
Marital Status			
Single	16	13.3	
Married	61	50.8	
Widowed	17	14.2	
Divorced	6	5.0	
Separated	20	16.7	
Level of education			
No formal education	7	5.8	
Primary	18	15.0	
Secondary	28	23.3	
Tertiary	67	55.8	
Type of occupation			
Farming	30	25	
Trading	26	21.7	
Civil servant	33	27.5	
Artisans	31	25.8	
Access to credit			
Yes	22	18.3	
No	98	81.7	
Earning per month			
≤ 10,000	12	10	
11,000-30,000	29	24.17	
31,000-50,000	34	28.33	Mean-39.170
≥ 51,000	45	37.50	

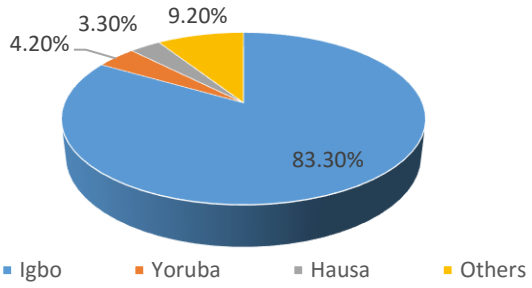

Figure 1: Responses based on ethnic groups.

Table 2: Distribution of the respondents according to awareness and consumption experience

Variables	Frequency	Percentage
Prior knowledge		
Yes	62	51.7
No	58	48.3
Glimpse organic vegetable before		
Yes	76	63.33
No	29	24.17
I don't know	15	12.50
Year seen		
Before 2010	18	24.17
2010-2021	32	42.50
I don't know	26	33.33
Consumed organic vegetable before		
Yes	40	33.33
No	80	66.70
Year consumed		
Before 2010	10	25.83
2010-2021	16	40.00
I don't know	14	34.17

Source: Field Survey Data, 2022. N = 120

Table 3: distribution of the respondents based on their purchasing attitude

Variables	Frequency	Percentage
Purchased organic vegetable before		
Yes	62	51.67
No	58	48.33
When purchased		
Before 2010	30	35.0
2010-2021	49	40.8
I don't know	41	34.2
Monthly purchases		
Once	4	3.3
Twice	16	13.3
3 times	30	25
4 times	26	21.7
5 times	44	36.7
Point of purchase		
Trusted organic farmer	16	13.3
Market place	53	44.2
Hawkers	12	10.0
Shops	39	32.5
Purchase point factor		
Price	17	14.2
Quality	53	44.2
Closeness	16	13.3
Freshness	34	28.3

Source: Field survey data, 2022. N = 120

no chemical residues on vegetables produced conventionally. This could be because the farmers use little or no chemicals or they are not aware of the effects of these chemical residues and it affected how they perceived the intensity of the problem. Hence, they need more enlightenment and education on the consequences of consuming food that contain chemical residues. Much work is needed in the area in the aspect of awareness creation on the effects of consuming such foods. Table 5 summarized the consumer responses for organically and conventionally produced vegetables. The mean distribution of respondents reported willingness to pay baseline is ₦100/0.2kg.

Table 4: Distribution of the consumers based on their perception about agro-chemical residue on conventionally grown vegetables

Variables	Frequency	Percentage
Agro-chemical residue		
Yes	55	45.8
No	65	54.2
Intensity of problem		
Very high	24	20.0
High	28	23.3
Moderate	43	35.8
Low	18	15.0
Very low	7	5.8

Source: Field survey data, 2022

Majority (78.33%) of the respondents indicated that they are willing to pay a premium bid for organic vegetables when compared to the conventional ones. The mean consumer willingness to pay is ₦130/0.2kg (30% more) for organic vegetable and ₦115/0.2kg (15% more) for non-organic vegetable relative to the baseline price. The WTP for organic vegetable is the average valuation of the attributes across consumers who buy the product. The fact that we didn't explore the complementarity of the organic attributes is a constraint. Consequently, whether the WTP value for organic vegetable is dependent on the product growing location and vice versa is not known. This suggests that total WTP for organic vegetable is unlikely to be the direct sum of the reported WTP value for the organic attributes. The results of Boys *et al*., (2014) and Yiridoe *et al*., (2005) corroborates with this finding.

Table 5: Mean distribution of Respondents' Willingness to Pay (WTP) for Organic Vegetables produced using organic and inorganic resources.

Variables	*Frequency	Percentage	Mean
Organic vegetables	94	78.33	130
Inorganic vegetables	86	71.67	115

Source: Field survey data, 2022. Multiple responses, Baseline price is ₦100/0.2kg. N =120

Constraints militating Against the Consumption of Vegetables produced Using Organic Resources

Table 6 showed the constraints militating against the consumption of vegetable produced using organic resources. The study showed that majority (83.3%) of the respondent agreed that organic vegetables are not readily available, and do not budget for them. This is followed by, it is not popular (71%), not affordable to many household (70.8%), and poor shelf life (70%).

Consumer preference for organic vegetables

The results on consumer preferences for organic vegetable in the study area is presented below. As expected, Table 7 shows that consumers' opinion about organic vegetables are positive, and in terms of important criteria that influenced their preference when buying vegetables, their reasons percentage for the selected variables were slightly higher than 50%. Specifically, 55.8% of them agreed that vegetables produced using organic resourced tastes better than those grown conventionally while 55% go for organic food because their families like it. Other reasons for organic vegetable selection are, their high nutrition/superior quality (54.2%), protection of the environment (56.6%), longer shelf life (58.3%), personal choice (55.9%) and modern and trendy (55.8%) in comparison with the conventional foods. Gohorbani, (1999) and Pham (2020) observed that vegetables grown with organic resources are mostly preferred than vegetables produced with inorganic resources, although most people do not care how the vegetable is produced, as far as it is ready for consumption. The result supports the assertions by some authors (Nguyen et al, 2019; Pham, 2020; Kumar, 2021).

Table 6: constraints militating against the consumption of vegetables produced using organic resources

Variable	Yes (%)*	No (%)*
They are expensive	70 (58.3)	50 (41.7)
They are not readily available	100 (83.3)	20 (16.7)
Not affordable to many household	85 (70.8)	35 (29.2)
It is not popular	86 (71.7)	34 (28.3)
Poor shelf life	86 (70)	34 (30)
I don't budget for them	84 (83.3)	36 (16.7)

The result in Figure 2 shows that a little over half (51.7%) of the consumers in the study area preferred to consume organic vegetable. This may be because most of them were educated (as stated above) and have access to information on the risks of using agro-chemicals in food production; both to human life and the environment.

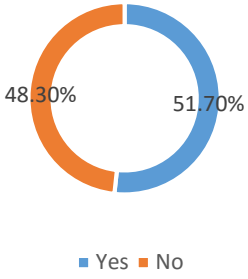

Figure 2: Preferences for organic vegetables

Table 7: Level of agreement regarding the consumers' preference for organic vegetables

Statements	SA (Freq/%)	A (Freq/%)	U (Freq/%)	SD (Freq/%)	D (Freq/%)	Mean
Vegetables produced using organic resources taste b6tter than those grown conventionally	43/35.8	24/20.0	28/23.3	18/15	7/5.8.0	3.650
My immediate family likes me to buy organic vegetables	41/34.2	25/20.8	28/23.3	18/15	8/6.70	3.608
I would rather purchase organically produced vegetables than those grown conventionally	44/36.7	23/19.2	24/20.0	25/20.8	4/3.30	3.650
It is not possible to check if vegetables are organically produced	43/35.8	24/20.0	28/23.3	18/15.0	7/5,80	3.650
Organic vegetables have higher nutritional value and superior in quality	42/35.0	23/19.2	27/22.5	19/15.8	9/7.50	3.583
Growing organic vegetables contributes in the protection of the environment	43/35.8	25/20.8	28/23.3	14/11.7	10/8.30	3.642
Vegetables produced using organic resources have longer shelf life than vegetables produced conventionally	42/35.0	28/23.3	28/23.3	12/10.0	10/8.30	3.667
Organic vegetables are modern and trendy	43/35.8	24/20.0	30/25.0	16/13.3	7/5.80	3.667
Organic labels are necessary to guarantee the organic origin of vegetables	41/34.2	25/20.8	28/23.3	16/13.3	10/8.30	3.592

Source: Field survey data. SA = Strongly Agree, A = Agree. U = Undecided. SD = Strongly Disagree, D = Disagree, Freq = frequency; % = Percentage

Conclusion and Recommendations

The findings from the research showed that consumers in the study area are aware that vegetable can be cultivated using organic inputs. They agreed that organic vegetables are of superior quality, nutritious, tastier and environmentally friendly than the ones produced conventionally and are willing to pay a premium for organic products. The result reflects the fact that there is a potential ready market in the state, if organic vegetables were to be cultivated on a large scale. The study therefore recommends that, government should formulate a policy which would aid in the successful transition to organic agriculture despite the numerous challenges expected. This will increase the standard of living and offer a positive welfare improvement for the populace. Efforts should be geared towards increasing the supply of organic vegetables, since there is a market for them. Also, organic certification and labeling of vegetables may help to increase consumers' confidence in organic products.

Conflict of Interest

The authors can confirm that, this paper is an original, whose copyright is not owned by a third party and it has not been published in another source, either physical or electronic.

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CARCASS QUALITY AND BLOOD PROFILE OF BROILER CHICKENS FED DIETS CONTAINING COOKED IPOMOEA ASARIFOLIA LEAF MEAL

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Abstract

The study was conducted to evaluate the effect of diets containing cooked Ipomoea asarifolia leaf meal (IALM) supplementation on carcass characteristics and blood profile of broiler chicken. There were four dietary treatments containing 0, 2.5, 5 and 7.5% IALM in diets of T1, T2, T3 and T4 respectively. One hundred and twenty day-old Abor acre broiler chicks were distributed into four treatment groups having three replications of ten birds per replicate on a completely randomized design (CRD). The carcass characteristics of the meat cuts were measured while the blood profile were analysed. Statistical analysis shows that there were significant differences ($P<0.05$) in all the blood profile analysis and also in carcass characteristics except head weight. The carcass characteristics and blood profile parameters were negatively affected except cholesterol which slightly reduced as the inclusion level of cooked IALM increased. This implies that cooked IALM can be included in broiler diets in smaller percentages to reduce the concentration of cholesterol in broiler meat.

Keywords: Blood profile, broiler, carcass quality, meat, *Ipomoea asarifolia*

INTRODUCTION

Poultry farming is the process of raising domesticated birds such as chickens, ducks, turkeys and geese for the purpose of producing meat or eggs for food (Wikipedia contributors). Broiler chicken are prolific breeders, they breed and grow fast unlike any other livestock animal. Broiler production represents one of the fastest ways of increasing animal protein since broilers grow at a faster rate. Food and Agricultural organization (FAO, 2010) estimated that average Nigerian consumes 51g of protein per day which is less than the recommended 86g per day. The animal protein shortage in the diets of Nigerians and people of most developing countries is now a matter of urgent concern and measures to save people from imminent protein malnutrition are imperative. It therefore becomes essential to increase animal production in order to meet the recommended daily protein intake.

The importance of poultry to national economy cannot be over emphasized as it has become popular for the small-holders that have contributed to the economy of the country. In Nigeria, poultry contributes about 15 percent of the total annual protein intake with approximately 1.3kg of poultry products consumed per head per annum (Ologbon and Ambali, 2012). The poultry industry has assumed greater importance in improving employment opportunities and animal food production in Nigeria. An earlier report by Mbanasor (2002) showed that about 10 percent of the Nigerian population is engaged in poultry production, mostly subsistence and small or medium sized farms. Broiler production is carried out in all parts of the country, with no known religious, social or cultural inhibitions associated with their consumption. Specifically, investment in broiler enterprises is attractive because the production cost per unit is low relative to other types of livestock. Poultry meat is very tender and commonly used in ceremonies compared to other birds and broiler enterprises have short production circle. Owing to these obvious advantages of broiler enterprises, large number of farmers, men and women go into their production, many of whom do so for income generation purposes (Nwajiuba and Nwoke, 2000), besides meeting the protein needs of the household. The evidence of this is the preponderance of producers–hawkers of broiler products in the urban and rural markets particularly during festive periods, when their demands are highest and selling prices favourable. Animal scientists have been looking at the prospects of using non-conventional agricultural materials as veritable sources of feedstuff for livestock production. This is important because the main problem facing the development of a viable animal production industry seems to be the lack of an adequate local animal feed industry. Nwakpu *et al*. (1999), stated that feed stuffs for poultry such as soybean and maize are costly due to cost of production while their demand is critical in starter feed. Esonu *et al.* (2003) advocated the use of cheap and indigenous sources of protein and energy preferably those not competed for between man and his livestock and therefore suggested the leaves of tropical legumes and browse

plants. This trial seeks to assess the effects of varying dietary inclusion levels of *Ipomoea asarifolia* leaf meal (IALM) in the carcass characteristics and blood profile of broiler birds. Ekenyem (2002) had stated that *Ipomoea asarifolia* (morning glory) belongs to the family Convulvulaceae. It is a herbaceous plant found largely in South Eastern Nigeria having stems growing to the height of 1 metre which arise from stolons. They have purple flowers which develop three seeds for sexual propagation although asexual propagation can also be achieved by stolons. In Nigeria, the leaf of *Ipomoea asarifolia* has no known food value and thus popularly used as compost material, mulch, as well as constituting weed in farms. Thus with a crude protein level of 32%, metabolizable energy of 2760kcal/kg and good mineral profile, *Ipomoea asarifolia* leaf has the potential as a cheap feed ingredient for broiler birds and therefore has the capacity to resolve the animal protein deficit in human diets. However, this great potential which could transform our broiler production industry has hardly been utilized. There seems to be lack of information regarding its usage and possible effects on broiler production. There is therefore a high and urgent need to carry out a comprehensive study on this regard. This study would enlighten poultry farmers most especially on the aspect of broiler production on the potentials of adding *Ipomoea asarifolia* leaf meal in the feeding systems of broilers in Nigeria, and ascertain possible levels of inclusion that will not adversely affect their blood profiles and improve their carcass quality.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Poultry unit of Teaching and Research Farm of the Department of Animal Science and Technology, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. The location lies between latitude 6.24^0N & 6.28^0N and longitude 7.00^0E and 7.08^0E on the South Eastern part of Nigeria. The climate is the tropical wet and dry type with a clear season. The mean daily maximum temperature is usually 27^0C all over the year although could reach 34^0C in March and lowest during the harmattan months of December and January. The mean annual rainfall according to the local Metrological Station which has maintained records since 1978 reveals a mean rainfall of about 1600mm with a relative humidity of 80% at dawn.

Preparation of Brooding House

The brooding house and its environment was thoroughly cleaned, washed with detergent and disinfected two weeks before the arrival of the birds. Black polythene was used to cover the brooding house for the first four weeks to facilitate a warm environment for the birds. Kerosene lamps and charcoal pots were used to supply light and heat respectively.

Experimental Birds

A total of one hundred and twenty (120) abor acre breed of day old chicks were used for the experiment. At the brooding stage, the birds were fed with the experimental diet starting from day one to the end of the research. Four experimental broiler starter and finisher diets were formulated. The feeds were iso-caloric and iso-nitrogenous.

Source and Preparation of Test Ingredient

Fresh and blooming *Ipomoea asarifolia* was harvested fresh green from the bush within Nnamdi Azikwe University. The leaves were washed, chopped and boiled at 100 degree centigrade for two minutes and immediately sun dried by spreading under the sun. The leaves were then milled, sieved and used for ration formulation.

Sanitation and hygiene

The wood shavings were changed every week from week 2 to week 8 of the experiment. This was done to prevent the accumulation of manure which can be a source of disease infection to the birds. The drinkers and feeders were washed thoroughly everyday with clean water. Foot bath were provided at the entrance of each pen to prevent infectious diseases to spread from one pen to the other. For the purpose of convenience, the chicks were fed with shallow feeders and drinkers in their first four weeks.

Experimental Design

The study was carried out using Complete Randomized Deign (CRD), with four treatments and three replicates per treatment. The treatments were T1 as control, T2, T3 and T4. Each treatment had three replicates of ten birds each.

Experimental Model

The data collected was subjected to Analysis of variance (ANOVA) using SPSS analytical package and differences between means were separated using Duncan multiple range test (Duncan, 1955) at 5% probability level.

Ingredient Composition of the broiler treatment diets

Table 1 and 2 show the ingredient composition of the broiler starter and finisher diets respectively

Table 1**:** The ingredient compositions of the broiler starter diet

Ingredients	T1	T2	T3	T4
Maize	44	44	44	44
Wheat offal	9.3	8.3	6.5	5.3
Soyabean meal	21.2	20	19	19
Brewers dried grain	5.0	5.0	5.0	5.0
Fish meal	4.0	4.0	4.0	4.0
Bone meal	3.0	3.0	3.0	3.0
Ground nut cake	11.5	11.2	11.0	10.2
Salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
IALM	0.0	2.5	5.5	7.5
Mycotoxin binder	1.0	1.0	1.0	1.0
Total	100	100	100	100
Calculated Energy(kcal/kg)	2944.23	2870.76	2869.70	2820.42
Calculated Protein(%)	23.86	23.43	23.42	23.41

Table 2*:* Ingredients composition of the broiler finisher diets

Feed ingredients (kg)	T1	T2	T3	T4
Maize	50	49	48	47
Full fat soya	5.0	5.0	5.0	5.0
Soya bean meal	16	15	14	13
Brewers dry grain	10	9.5	9.0	8.5
Groundnut cake	7.0	7.0	7.0	7.0
Bone meal	3.0	3.0	3.0	3.0
Fish meal	3.0	3.0	3.0	3.0
Limestone	3.0	3.0	3.0	3.0
Lysine	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Toxin binder	1.0	1.0	1.0	1.0
IALM	0.0	2.5	5.0	7.5
Total	100	100	100	100
Crude protein (%)	19.93	19.80	19.67	19.54
Calculated Energy(kcal/kg)	3328.10	3287.16	3284.72	3282.73

RESULTS AND DISCUSSION

Phytochemical analysis of *Ipomoea asarifolia* leaf meal

The phytochemical analysis of *Ipomoea asarifolia* leaf meal is presented in Table 3.

Table 3: *Phytochemical analysis of Ipomoea asarifolia Leaf Meal*

Phytochemical	Concentration (%)
Flavonoid	4.70
Alkaloid	4.50
Phytate	5.0
Tanin	0.89
Saponin	1.60

Effects of cooked IALM on the haematology of broiler birds at starter and finisher phases

The haematological assessment of broilers fed diets containing cooked IALM at starter and finisher phases are presented in Tables 4 and 5 respectively.

At the starter phase, all the haematological values of the experimental broiler birds indicated no significant difference ($P>0.05$) between treatments means except lymphocytes, platelet and neutrophil. Lymphocyte had varying values within normal reference range for broiler birds (Osita et al, 2019). The concentration of lymphocytes was lowest in treatment four with the highest level of IALM. This may not be unconnected with the high level of

flavonoids, alkaloids and phytate in IALM which reduced lymphocyte and white blood cell concentration in the blood of broiler. This implies that including IALM above 5% reduced lymphocyte concentration and subsequently reduced white blood cell concentration in broiler. It was also noticed that eosinophil showed no significant differences ($p>0.05$) in accordance to Ekenyem and Madubuike (2006) who fed uncooked IALM to broiler birds.

Table 4: Effects of including cooked IALM on the haematological parameters of broiler at starter phase

Parameter	T1	T2	T3	T4	SEM	P. value
WBC(*10^{9l})	3300.00	2933.33	4400.00	5600.00	4661.26	0.164
Lymphocytes (%)	41.000^{ab}	38.6667^{ab}	61.3333^{b}	14.3333^{a}	6.45125	0.049
Haemoglobin concentration (%)	8.3333	89.4333	9.6667	9.60000	0.54626	0.782
RBC(l)	3.5333	2.1333	3.5667	2.7667	0.38059	0.548
MCV (fl)	71.866	131.233	93.0333	132.9667	14.0216	0.369
MCH (pg)	23.933	43.6667	31.0333	44.2333	4.65671	0.369
McHc (g/dl)	33.3067	33.2867	33.3500	33.12000	0.04814	0.391
Platelet (*10^{9l})	1633.33^{a}	1800.00^{b}	1910.00^{c}	2303.33^{d}	7895.58	0.000
PCV (%)	25.000	25.333	29.0000	29.0000	1.65355	0.775
Neutrophil (%)	59.000^{ab}	61.333^{ab}	38.3333^{a}	85.0000^{b}	6.39301	0.048
Monocytes (%)	0.0000	0.0000	0.3333	0.6667	0.17944	0.561
Eosinophil (%)	0.0000	0.0000	0.0000	0.0000	-	-
Basophils (%)	0.0000	0.0000	0.0000	0.0000	-	-

Means on the same row with different superscripts are significantly different ($p<0.05$); HGB = haemoglobin, PCV = packed cell volume, RBC = red blood cell count, WBC = white blood cell count, PC = platelet count, MCV=Mean corpuscular volume, McHc=mean corpuscles haemoglobin concentration, MCH=mean corpuscular haemoglobin.

Table 5: Effects of including cooked IALM on the haematological parameters of broiler finisher

Parameter	T1	T2	T3	T4	SEM	P. value
WBC(*10^{9l})	3566.6	3233.3	3400.0	3333.3	27629.0	0.985
Lymphocyte (%)	33.000^{ab}	46.000^{ab}	59.666^{b}	19.000^{a}	5.84971	0.049
Haemoglobin (%)	10.066	9.9667	9.6333	10.300	0.24775	0.860
RBC (l)	2.7333	2.4000	2.3667	3.9000	0.27428	0.148
MCV(fl)	111.26	143.10	129.066	85.4333	10.6639	0.270
MCH(mg)	36.900	47.500	42.8667	28.3667	3.52698	0.266
McHc (g/dl)	33.190	33.220	33.2233	33.2300	0.02366	0.954
Platelet (*10^{9l})	1303.3^{ab}	13200.0^{ab}	10500.0^{a}	2336.7^{b}	20261.9	0.088
PCV (%)	30.333	30.0000	29.0000	31.000	0.75336	0.864
Neutrophil (%)	67.000^{ab}	54.000^{ab}	36.6667^{a}	80.6667^{c}	5.7555	0.018
Monocytes (%)	0.0000	0.0000	0.3333	0.3333	0.11237	0.596
Eosphill (%)	0.0000	0.0000	0.0000	0.0000	-	-
Basophil (%)	0.0000	0.0000	0.0000	0.0000	-	-

Means on the same row with different superscripts are significantly different ($p<0.05$).

At finisher phase, haematological values of the experimental broiler birds indicated significant differences (P<0.05) between treatments means in lymphocytes, platelet and nuetrophil but did not show significant difference (P>0.05) in haemoglobin concentration, white blood cell count, red blood cell count, mean corpuscular volume, mean corpuscular haemoglobin, packed cell volume, platelet and monocyte. This shows that the results of the haematological indices of the birds at the starter phase followed the same pattern with that of the finisher phase. This implies that the inclusion of cooked IALM influenced the lymphocyte, platelet and neutrophil values of the broilers fed the treatment diets. Lymphocyte and platelet concentration were minimium at 7.5% IALM inclussion but the concentration of neutrophil was highest at 7.5% inclusion of IALM. It is assumed that the phytates, flavonoids, alkaloids, tannin and saponin in IALM were responsible for the significant concentrations among treatment means of lymphocyte, platelet and neutrophil concentration in broiler.

Table 6: Effects of Including Varying Levels of IALM on The Serum Biochemistry of Broiler Starter chicks

Parameter	T1	T2	T3	T4	SEM	P value
Urea	8.33^{d}	7.83^{c}	6.90^{b}	6.17^{a}	0.31	0.000
AST	112.00^{b}	134.00^{d}	108.00^{a}	126.00^{c}	3.17	0.000
ALT	71.00^{d}	46.33^{c}	32.00^{a}	39.00^{b}	4.44	0.000
ALP	190.00^{b}	215.00^{c}	169.33^{a}	247.00^{d}	8.81	0.000
GLB	22.66^{c}	17.67^{b}	17.67^{b}	14.67^{a}	0.87	0.000
Cholesterol	103.67^{d}	74.00^{a}	91.67^{b}	98.00^{c}	3.37	0.000
Glucose	75.33^{b}	88.67^{d}	79.00^{c}	65.00^{a}	2.56	0.000
Total Protein	44.00^{a}	51.00^{b}	64.67^{c}	88.67^{d}	5.15	0.000

Means with different superscripts in the same row are significantly (P<0.05) different; SEM= standard error of mean; AST= aspartate transaminase (mg/dl), ALT= alanine transaminase (u/l), ALP= alkaline phosphate (u/l), TP= total protein (g/l), ALB= albumin, GLB= globulin (g/l), GLU= glucose, CL= cholesterol

Table 7: Effects of Including Varying Levels of IALM on The Serum Biochemistry of Broiler Finisher

Parameter	T1	T2	T3	T4	SEM	P value
Urea	24.33^{c}	16.67^{b}	14.67^{a}	13.67^{a}	1.269	0.000
AST	157.00^{c}	139.00^{b}	139.00^{a}	163.00^{d}	3.48	0.000
ALT	45.67^{d}	29.67^{a}	33.00	36.33	1.80	0.000
ALP	2043.00^{c}	1967.00^{bc}	1419.00^{ab}	841.00^{a}	164.89	0.000
GLB	39.00^{c}	19.00^{a}	20.00^{a}	24.00^{b}	2.42	0.000
Cholesterol	124.00^{c}	129.00^{c}	19.00^{a}	63.00^{b}	13.77	0.000
Glucose	20.67^{c}	16.67^{b}	16.67^{b}	14.67^{a}	0.67	0.000
Total Protein	61.67^{c}	69.00^{d}	51.00^{b}	37.33^{a}	3.60	0.000

Means with different superscripts in the same row are significantly (P<0.05) different; SEM= standard error of mean; AST= aspartate transaminase (mg/dl), ALT= alanine transaminase (u/l), ALP= alkaline phosphate (u/l), TP= total protein (g/l), ALB= albumin, GLB= globulin (g/l), GLU= glucose, CL= cholesterol

Table 7 shows the effects of including varying levels of IALM on the serum biochemistry of broiler finisher. There were significant differences (P<0.05) between treatment means of the serum biochemistry parameters of the broiler fed diets containing cooked IALM at the starter and finisher phases. Urea, albumen and glucose production decreased progressively as the inclusion levels of IALM increased at both the starter and finisher phases. This also agrees with the findings of Madubuike and Ekenyem (2006). The cholesterol values were also observed to have decreased as the inclusion level of IALM increased. However, total protein increased progressively at the starter phase but decreased progressively at the finisher phase. The reduction of cholesterol as the levels of IALM increased in the diets agrees with the findings of Madubuike and Ekenyem (2006). The variation in the values of AST and ALT also suggest that the liver function was affected according to Ugwuowo et al. (2019). Therefore, liver damage may have occurred in these broilers as indicated in the result obtained from this study. The high concentration of tannin, saponin, flavonoid, alkaloids and phytate in IALM may be responsible for the liver damage.

Table 8 shows the effect of diets containing cooked *Ipomoea asarifolia* leaf meal on the feed and carcass characteristics of broiler birds. All the carcass parameter values were significantly different (P<0.05) between treatments means except head weight which was not significantly different (P>0.05). There were significant differences (P<0.05) between the treatment means of all the carcass characteristics of broilers fed diets containing cooked IALM except the head weight.

Almost all the carcass characteristics decreased progressively as the level of inclusion of cooked IALM increased. This reduction may not be completely out of place since the total protein also reduced as the level of cooked IALM increased in the diets. The result obtained also agrees with Madubuike and Ekenyem (2006) who found that increasing level of grinded *Ipomoea asarifolia* reduced carcass characteristics.

Table 8: Effect of cooked Ipomoea asarifolia leaf meal on the feed and carcass characteristics of broiler

Parameters (g)	T1	T2	T3	T4	SEM	P.value
Live weight	20003.3^{d}	1900.0^{c}	1694.7^{b}	1452.67^{a}	68.813	0.000
Bleed weight	1848.0^{d}	1991.3^{c}	1681.7^{b}	1362.3^{a}	70.615	0.000
De feathered weight	1783.3^{d}	1861.6^{c}	1606.3^{b}	1075.0^{a}	92.495	0.000
Carcass weight	1450.0^{d}	1512.3^{c}	1273.3^{b}	1045.0^{a}	54.715	0.000
Breast weight	354.33^{c}	357.66^{c}	317.33^{b}	225.00^{a}	16.157	0.000
Back weight	321.67^{d}	312.33^{c}	230.00^{b}	218.00^{a}	14.127	0.000
Drumstick weight	190.33^{c}	175.33^{b}	179.00^{b}	151.00^{a}	4.356	0.000
Thigh weight	293.00^{d}	227.00^{c}	165.33^{b}	121.33^{a}	19.526	0.000
Wing weight	144.33^{b}	154.67^{c}	159.00^{d}	116.66^{a}	4.9822	0.000
Neck weight	74.000^{b}	108.00^{d}	92.000^{c}	66.666^{a}	4.8583	0.000
Head weight	205.33	91.000	81.667	52.333	38.306	0.434
Shank weight	90.333^{c}	91.000^{c}	81.667^{b}	52.000^{a}	4.7976	0.000
Average daily feed intake(g)	60.02^{d}	51.12^{c}	40.14^{b}	34.35^{a}	3.00	0.000

Means on the same row with different superscripts are significantly different (P<0.05)

Conclusion

In conclusion, cooked *Ipomoea asarifolia* leaf meal has negatively affected most carcass characteristics and blood profile parameters but reduced cholesterol levels of the broilers. However, the inclusion levels is supposed to be reduced below 2.5% with the target of reducing the cholesterol level of broiler especially when fed with diets containing high cholesterol and low density lipids.

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ASSESSMENT OF LOCAL GOVERNMENT EXTENSION DELIVERY SYSTEM ON COCOYAM FARMING IN YENAGOA LOCAL GOVERNMENT AREA, BAYELSA STATE, NIGERIA

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Abstract

This study assessed Local Government Extension delivery system on Cocoyam farming in Yenagoa Local Government Area, Bayelsa State. Purposive sampling technique was employed in the selection of 40 local government staff. The data for this study were collected using primary and secondary data collection techniques. Data collected were analyzed using simple descriptive statistical tools while multiple regression was employed in testing the hypothesis of the study. Findings from the study revealed that 42.5% of the respondents were within the age bracket of 41-50 years while the average age of the extension staff was 39.98 years. About 85% of the respondents were married and more than half (55%) of the respondents had household size between 1 – 5 persons with average household size of five persons. In addressing the effectiveness of local government extension in conducting extension activities on cocoyam production, result from the study showed that none of methods used by extension agents were effective in disseminating cocoyam production technologies to farmers as the methods employed fell below the bench mark mean score. Results of awareness of cocoyam production technologies dissemination by extension staff showed that ridge planting technique, corn planting technique, time of planting and intercropping had high percentage of awareness by farmers thus resulting to high adoption rate. Extension staff revealed shortage of subject matter specialist, and lack of operation fund with mean scores of 2.80, and 2.75, respectively, as the major factors that affected the effectiveness of conducting extension activities in disseminating cocoyam production technologies to farmers. The null hypothesis of no significant influences of some selected socioeconomic characteristics on effectiveness of local government extension service department staff in conducting extension activities in the study area was not accepted and the alternative hypothesis was upheld. Therefore, it was concluded that Local Government Extension Services delivery system, in disseminating cocoyam production technologies were ineffective. Hence, stakeholders in extension delivery should consider these crucial socioeconomic characteristics of the extension agents in Yenagoa LGA that had influence on their competency level and effectiveness of service delivery level favourable for effective extension outcomes. The income of the income of extension staff should be critically looked into since income is a key component of service delivery.

Keywords: Assessment, local government, extension delivery system, cocoyam and farming

INTRODUCTION

The main channel for disseminating knowledge and new agricultural technologies involves the public extension services of FMAWR, ADPs, and local governments. By the constitution, agricultural development was placed as a share responsibility of the State and Local governments. However, State governments appear to be ultimately responsible for the actual delivery of extension services, and often have to take over the activities and responsibilities of local governments in order to ensure delivery.

The existing agricultural extension delivery service is in a state of confusion, as no definite policy is driving the programmes, strategies and practices (Madukwe, 2008, Abubakar, 2011). In the current practice, the federal government is leading in numerous initiatives and programmes, such as the National Food Security Programme (NFSP), Fadama III, Commercial Agricultural Development Programme (CADP), Root and Tuber Extension Programme (RTEP), among others. The implementation of these programmes usually takes its toll of quality personnel from the few state ADP staff, making it near impossible for the ADPs to undertake the basic functions of grassroots extension delivery.

Moreover, State Agricultural Development Programmes (ADPs) are the only formal institutions for delivering agricultural extension services in the country; they are solely managed by various States, that is, with no institutional arrangement to link with federal or local governments. Visible synergy is only observed on initiatives promoted by the federal government which often reduces both personnel and other resources of these ADPs. This is despite the key constraints of the ADPs, such as shortage of extension agents (EAs) (quality & quantity), inadequate mobility allowances and other key field facilities. To compound the problem, local

government is not in any way connected with any aspects of grassroots extension delivery as most do not have trained EAs, nor are they involved in promoting agricultural innovations. In most cases, the agriculture departments of local government is hardly involved in any real agricultural extension delivery activities. In terms of finance, there seems to be the absence of visible funding mechanism directed at extension delivery from Federal Government and local government (Abubakar, 2011). The State Governments provide finances for ADP's operations and counterpart funding of Federal government initiatives/projects with little impact on grassroots farm families in their states. (Abubakar, 2011).

This has attendant consequences on the productivity of extension workers. Currently, 55 percent of the total budget revenue is allocated to the federal government, 25 percent to the state governments, and 21 percent to the local government areas (Ekpo 2004). This heavy dependence on federal transfers may lead to poor accountability (Akramov, 2010). Finally the document stated clearly that federal, state and "local government should jointly adequately finance agricultural extension and rural infrastructure development". Despite the constitutional acts enactment, cocoyam is facing extinction which implies that local Government Extension service delivery department is not effective. To verify this therefore requires empiricism. Currently, there is no evidence that research has been conducted on the effectiveness of Local Government Extension Services delivery on Cocoyam farming in Sagbama Local Government Area, Bayelsa State, Nigeria. The objective of this study included to: describe the socio-economic characteristics of local government extension staff, ascertain the effectiveness of local government extension service in conducting extension activities; determine awareness level of technologies disseminated by local government extension staff; ascertain factors influencing the local government extension delivery. The study hypothesized that there is no significant influences of selected socio economics characteristic on effectiveness of local government extension service department staff in conducting extension activities in the study area

METHODOLOGY

This study was conducted in Yenagoa Local Government Area (YELGA) of Bayelsa State, Nigeria. This study was conducted in Yenagoa Local Government area of Bayelsa State, Nigeria. The study area lies along Latitudes between 4° 55′ and 36.30 North and Longitudes between 6° 16′and 3.50″ East. Yenagoa Local Government Area had a population of 267,400 by 1996 estimate (National Bureau of Statistics, 2006) with a projected population of 352,285 in 2022 based on growth rate of 0.1 by Nigeria Population Commission NPC (2006). It shares common boundary with Mbiama communities of Rivers State on the north and East, Kolokuma/Opokuma LGA on the North West, Ogbia Local Government area on the south and Southern Ijaw on the West, Ogbia Local Government area on the South East and Southern Ijaw on the South west. A total of 40 local government agricultural extension staff was purposively sampled. Data collected through structured questionnaire were analyzed with descriptive statistic, such as mean, while, ordinary multiple regression was used to test the hypotheses. The questionnaire was a 4-point rating scale of strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD) to which numerical values 4, 3, 2 and 1 were assigned respectively. The scores sum up to 10, and gives a mean of 2.5 when divided by 4. Hence, the cut-off point of 2.55 as the upper limit was used to determine a positive response (i.e., 2.5 + 0.005 = 2.55).

Model specification: The ordinary least square multiple regression model is specified thus:

$Yi = b_0 + b_1X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + ei$

Where;

Yi = Dependent variable (effectiveness of local government extension service department staff)

X_1 = Age, (Number of years)

X_2 = Sex, (Dummy; Male = 1, Female = 0)

X_3 = Marital status, (Dummy; Married = 1, Single = 0)

X_4 = Household size, (Number of persons under the same roof)

X_5 = Educational level, (Number of years in formal schooling)

X_6 = Farming experience, (Number of years into farming)

X_7 = Monthly income, (Amount of Naira earned from farming/month)

X_8 = Social participation, (Number of social organizations belonged to)

e = Error term.

RESULTS AND DISCUSSION

Socio-economic characteristics of Local Government Extension staff

Result in Table 1 shows socio-economic profiles of Local Government extension service Staff. The result in Table 1 showed that moderate proportion 42.5% of the Local Government extension Staff were within the age bracket of 41-50 years with a mean age of 39.98 years. This implies that most of the field extension agents were still in their active and within the active labour force thus, could cope with the tedious activities. This result is in line with the study of Olorunfemi and Oladele (2021) whose

study reported a mean age of 41.5 years of extension workers in south-western Nigeria. The result further showed that majority 85% of the Local Government extension service staff were married with average household size of five persons. The implication here is that married extension workers may have more responsibilities at home and therefore, spend less time at work which could result to ineffectiveness of local government extension service delivery cocoyam farming. The result showed that 32.5% of the respondents had less than five years working experience, 47.5% had between 6-10 years of working experience. This implies that majority of the extension workers had put in many years of service and must have attended extension and manpower development which is crucial to the performance of the duties of an extension workers, as knowledge gained through training keeps the extension workers abreast of new development in their profession. This findings collaborates the finding of Okeowo (2015); Olorunfemi and Oladele (2021); Uzoechi *et al.* (2022) whose studies reported that the average years of extension agent's experience in service in southeast and south western Nigeria are within 5-15 years. Additionally, extension workers in Ghana were reported to have worked for an average of 13 years (Owens *et al.*, 2001) while extension officers in South Africa had a mean of about 14 years working experience (Oladele and Mabe, 2010). This suggests that the working experience in the study area is similar to other countries in Africa where professionalization has taken place. This attribute is expected to positively enhance their exposure and knowledge on professionalization.

Result from Table 4.1 showed that, 57.5% of the respondents earned annual income within the range of ₦10000 - ₦50000 per annum, while the average income per annum of the respondents was ₦68125. The implication of this result is that majority of the extension agents in the study area received less than ₦100,000. This is not encouraging considering the present situation of the Nigerian economy yet incentivizing labour is an important motivator for competence and effective delivery of new innovations in crop production.

Table 1: Percentage distribution of respondents by socio-economic characteristics

Characteristics	Categories	Frequency (N = 40)	Percent (%)
Age (years)	≤ 30	7	17.5
	31 – 40	14	35.0
	41 – 50	17	42.5
	> 50	2	5.0
Mean	39.98±6.85		
Marital status			
	Single	5	12.5
	Married	34	85.0
	Divorced	1	2.5
Educational levels			
	No formal education	0	0.0
	Primary	4	10.0
	Secondary	10	25.0
	Tertiary	26	65.0
Household size			
	1 – 5	22	55.0
	6 – 10	16	40.0
	> 10	2	5.0
Mean	5.73±2.71		
Income (₦)			
	10000 – 50000	23	57.5
	51000 – 100000	10	25.0
	110000 – 150000	3	7.5
	> 150000	4	10.0
Mean	68125.00		
Years of experience			
	≤ 5	13	32.5
	6 – 10	19	47.5
	11 – 15	7	17.5
	> 15	1	2.5
Mean	8.0		

Source: Field survey data (2023)

Effectiveness of local government extension staff in conducting extension activities

In Table 2, the mean response to each item on the effectiveness in conducting extension activities were determined and ranked. The effectiveness of conducting extension activities were determined using a 3-point Likert type rating scale of not effective (1), effective (2), very effective (3). A midpoint of 2.0 was established for the purpose of making decision, any mean response that is less than or equal to 2.0 implies poor response while above 2.0, implies good function. Therefore, from these scores, it showed that none of these methods used by extension agents were effective in disseminating cocoyam production technologies to farmers as all the methods employed were below the bench mark mean score. The findings implied that extension agents' ability to use these listed methods in transferring new innovations and evaluating results did not yield the needed outcome for effective extension service delivery for cocoyam farming. The outcome of this study is contrary to the result of the study conducted by Onuegbu *et al*. (2021) on the dissemination techniques of NRCRI cocoyam technologies in Ikwuano LGA. The results from their study showed that farmers' cooperative, extension agents, establishment of demonstration farms in the study area, encouraging farmers visits to research farms, promotional campaign to encourage cocoyam farming, and radio/television programme on cocoyam production were the effective dissemination techniques used in conducting extension activities in cocoyam farming in Ikwuano LGA.

Adoption level of technologies disseminated by local government extension department

The result showed that ridge planting technique, corn planting technique, time of planting, intercropping, pest/disease control and mound planting technique had high percentages of awareness level as reported by extension staff in the study area of 27.5%, 27.5%, 22.5%, 22.5%, 22.5%, and 20.0%, respectively when compared to other technologies on cocoyam production disseminated by extension agents in the study area. The result of the adoption of cocoyam production technologies disseminated by extension agents is in line with the diffusion theory of innovation. This theory explains that farmers can only use innovations when they are aware of them, therefore awareness is a prerequisite. It goes on to clarify that farmers can become aware of innovations when they have access to the necessary information from reliable sources (Rogers, 2003).

Table 3 shows that for cocoyam minisett, about 43% of farmers had no knowledge of the technology, but only 8 farmers that is 20 percent were aware, 5% had interest, 17.5% carried out the trial and 12.5% of the farmers adopted it. This however, indicated low adoption rate. The low rate of adoption of cocoyam minisett could be due largely to the fact that the farmers have not been able to reap sufficient monetary rewards from cocoyam minisetts and the small size nature of cocoyam minisetts which give low yield.

Table 2: Distribution of respondents according to the effectiveness in conducting extension activities

S/No.	Variables	Mean	SD	Remark
1	Farmers' cooperatives	1.85	0.77	Disagree
2	Extension Agents	1.88	0.75	Disagree
3	Establishment of demonstration farms	1.75	0.77	Disagree
4	Encouraging farmers' visit to research farms	1.75	0.70	Disagree
5	Promotional campaign to encourage cocoyam production	1.73	0.78	Disagree
6	Personal contact method	1.90	0.67	Disagree
7	Radio/television programme on cocoyam programme	1.65	0.73	Disagree
	Grand mean	**1.78**		
	Decision mean cut-off point	**2.00**		

Source: Field survey data (2023)

This result is in line with those of Onuegbu *et al*. (2021) who reported very low mean score of adoption of cocoyam minisett in Ikwuano LGA, Abia State but contrary to the studies of Nwobiala and Uchechi (2016); Agbarevo and Okringbo (2020) whose studies recorded high mean adoption scores of cocoyam minisett.

Factors affecting local government extension staff in carrying out extension activities

Table 4 below showed that poor linkages between the federal and state agricultural institutions, shortage of subject matter specialist, and lack of operation fund with mean scores of 3.13, 2.80, and 2.75, respectively, as the major factors that affect their performance in conducting extension activities in disseminating cocoyam production technologies to farmers. Other factors that resulted to poor performance of staff were mismatch between extension approaches and farmers' needs, lack of definite policy is driving the programmes, poor staff remuneration which is evident in the average annual income of staff to be ₦68125.00 (Table 1), lack of mobility for agriculture staff, insufficient numbers

of trained staff members, and inappropriate budget allocation. However, unavailability of physical facilities was not an organizational factor that affected the performance of extension field agents. The outcome of this result may be attributed to the ineffectiveness of the methods or approaches used by extension staff in disseminating cocoyam production technologies to farmers in Yenagoa as seen in Table 2.

Similar findings on factors affecting extension agent performance have been reported by Ejiogu-Okereke and Onu (2007); Okeowo (2015); Olorunfemi and Oladele (2021) in south west Nigeria, Uzoechi *et al.* (2002) in south east, Nigeria. Onu (2005) posited that well planned extension programmes are often disrupted by lack of transport facilities. According to Ejiogu-Okereke and Onu (2007), management efforts at boosting workers' morale such as releasing operational funds have the ultimate target of more productive job performance. Thus, motivation and workers performance are related. The reward system must also be internally equitable. This reward system should come in form of paying compensation and other forms of benefits. This agrees with Adesope and Agumagu (2003) who reported that when hardworking extension workers are encouraged using financial gains and promoted, performance is created. Policies and programmes associated to various agriculture production systems are needed in driving extension programmes to meet the needs of farmers.

Table 3: Awareness level of technologies disseminated by local government extension department staff

Variable	Unaware		Aware		Interest		Evaluation		Trial		Adoption	
	F	%	F	%	F	%	F	%	F	%	F	%
Cocoyam minisett	17	42.5	8	20	2	5.0	1	2.5	7	17.5	5	12.5
Intercropping	3	7.5	18	45	5	12.5	0	0	5	12.5	9	22.5
Mound planting technique	5	12.5	12	30	2	5	4	10	9	22.5	8	20
Ridge planting technique	1	2.5	12	30	6	15	7	17.5	3	7.5	11	27.5
Corn Planting technique	2	5	14	35	6	15	5	12.5	2	5	11	27.5
Pre sprouting techniques	6	15	13	32.5	5	12.5	3	7.5	8	20	5	12.5
Time of planting	3	7.5	15	37.5	3	7.5	4	10	6	15	9	22.5
Weed control methods	1	2.5	18	45	5	12.5	5	12.5	5	12.5	6	15
Pest/disease control	2	5	18	45	4	10	3	7.5	4	10	9	22.5

Source: Field survey data (2023). F = Frequency; % = percentage.

Table 4: Factors influencing the local government extension staff in carrying out extension activities

S/No.	Variables	Mean	SD	Remark	Rank
1	Operational fund	2.75	1.06	Agree	3rd
2	Staff remuneration	2.63	0.80	Agree	6th
3	Mobility for agriculture staff	2.60	0.92	Agree	7th
4	Unavailability of physical facilities	2.48	0.96	Disagree	10th
5	Inappropriate budget allocation	2.53	0.96	Agree	9th
6	Mismatch between extension approaches and farmers' needs	2.68	1.04	Agree	4th
7	No definite policy is driving the programmes	2.68	0.94	Agree	4th
8	Shortage of subject matter specialist	2.80	0.91	Agree	2nd
9	Poor linkages between the federal and state agricultural institutions	3.13	0.96	Agree	1st
10	Insufficient numbers of trained staff members	2.58	1.10	Agree	8th
	Grand mean	**2.69**			
	Decision mean cut-off point	**2.50**			

Source: Field survey data (2023).

Hypothesis Testing

Table 5 shows the result of regression analysis on some selected socio economic characteristics effects on the effectiveness of conducting extension activities in the study area. The R^2 is 42.1% that gives the total variations due to the effects of socio economic characteristics on extension agents' activities. Based on the multiple regression models, four predictor variables were found to have significant effects on the effectiveness of extension activities of extension workers. The four socio economic characteristics variables were: age (t = -2.255, p = 0.031), marital status (t = -2.156, p = 0.038), education level (t = 2.239, p = 0.032) and

income (t = 2.262, p = 0.030). The study implies that some socio economic characterizes had significant effects on the effectiveness of conducting extension activities by extension workers in the study area.

Result from the study showed that age was negatively and significantly related to effectiveness of conducting extension activities. This means that the older the extension worker, the lower his or her job performance which implies that younger field extension workers will perform better than older workers. This finding is against *a priori* expectation with the result of the average age of the extension staff which is 39.98 years. The failure of the effectiveness of conducting extension activities in cocoyam production could be as a result of the approaches or methods outlined in Table 2 and also the factors affecting the performance of these extension staff as outlined in Table 4. Contrary to the result of this study on age of the worker, study of Uzoechi *et al*. (2022) reported a positive relationship between age of extension worker and competency level. Owen (2004) suggested a long term specialized development plan for extension agents towards their evaluation in their early years of service, to ensure development of their desired competencies.

Level of education was positively and significantly related with to effectiveness of conducting extension activities by extension staff at 5% level of significance (coefficient =. 1.242, t = 2.239, p = 0.032). The positive relationship means that those with higher qualification perform better. The implication of this finding is that respondents with higher education qualification will be qualified for special extension field work and will be in their active stage of learning on job and extension delivery which will enhance their effective performance of their duties. This confirms Ijatuyi *et al.* (2017) that education is very important to the success of agricultural production and enhances the effectiveness of extension agent work in disseminating new agriculture technologies.

The coefficient for income is 0.867, and t-value of 2.262. The positive relationship means that the higher the income of an extension worker, the better his or her effectiveness in performing the extension activities. The average income of the extension workers obtained in this study was ₦68125.00. This is however not adequate considering the present economic situation in the country. Enhanced incentive is an important motivator to average worker and is also important for sustained staff morale.Therefore, the null hypothesis (H_{01}) that there was no significant influences of some selected socioeconomic characteristics on effectiveness of local government extension service department staff in conducting extension activities in the study area was rejected and the alternative hypothesis (H_{A1}) was upheld in respect of significance of age, marital status, level of education and income.

Table 5: Effects of selected socio economic characteristics on the effectiveness of conducting extension activities in the study area

Socioeconomic variables	Coefficient	Std. error	t-value	p-value
Constant	18.879	3.497	5.399	0.000***
Age	-1.371	0.608	-2.255	0.031**
Marital status	-2.376	1.102	-2.156	0.038**
Education level	1.242	0.555	2.239	0.032**
Household size	0.189	0.767	0.246	0.807
Income	0.867	0.383	2.262	0.030**
Years of experience	-0.288	0.594	-0.485	0.631
R^2	0.421			
Adj. R^2	0.315			
F-statistic	3.991***			

Source: Field survey data (2023). ***, ** shows significant levels at 1% and 5%, respectively.

Conclusion

Result from the study showed that all the methods used by Local Government Extension Services delivery department in Yenagoa Local Government Area, Bayelsa State, in disseminating cocoyam production technologies were ineffective due to organizational factor that affect performance such as poor linkages between the federal and state agricultural institutions, shortage of subject matter specialist, and lack of operation fund, inadequate mobility for agriculture staff. Some of the technologies in cocoyam production adopted by farmers as reported by extension staff were ridge planting technique, corn planting technique, time of planting, intercropping, pest/disease control and mound planting technique. Also, the study concluded that extension workers' age, education qualification, marital status, and income had significant effects on the effectiveness of staff working in the Local Government Extension Services delivery department on cocoyam farming.

Based on the findings of this study, the following recommendations are made;

i. It is recommended that stakeholders in extension delivery should consider these crucial socioeconomic characteristics of the extension agents in Yenagoa LGA that had influence on their competency level and effectiveness of service delivery level favourable for effective extension outcomes. The income of the income of extension staff should be critically looked into since income is a key component of service delivery;
ii. Extension communication infrastructure should be provided in indigenous language of farmers to aid the dissemination of technologies. This will help in reducing to the over reliance on extension contacts. Also, such extension communication and training process should be participatory involving farmers;
iii. Local Government Extension Delivery system on cocoyam farming in Yenagoa Local Government Area, Bayelsa State should develop technologies and make efforts to disseminate such technologies. This will enable farmers adopt these technologies so as to increase cocoyam production;
iv. Trainings should be organized for extension agents towards bettering their skills and competence in their extension activities. Field agents must be part of decisions concerning their personal welfare and job trainings;
v. Government should improve the working conditions of field agents through provision of transport allowances, basic infrastructural facilities in rural communities to enable extension agents carry out their service delivery. Also, staff welfare should be paramount to enhance adequate commitment to organizational goal and extension service delivery

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EVALUATION OF FERTILIZER SOURCES ON GROWTH, YIELD AND SHELF LIFE OF TOMATO (*Lycopersicon esculentum* Mill.) VARIETIES

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Abstract

This study was carried out on the evaluation of different fertilizers on growth, yield and shelf life of Tomato, *Lycopersicon esculentum* (Mill). The study aimed to compare the effect of moringa leaf extract, poultry manure and NPK fertilizer on agronomic growth performance and yield of tomato varieties. The 10 tomato varieties utilized for this study were obtained from the tomato germplasm collection at the National Center for Genetic Resources and Biotechnology (NACGRAB), Department of Plant Genetic Resources, Ibadan, Oyo state, Nigeria. The experiment was a factorial potted experiment whereby the tomato varieties were subjected to 4 treatments which comprises Treatment 1 (no fertilizer application), Treatment 2 (moringa leaf extract), Treatment 3 (poultry manure application), Treatment 4 (NPK fertilizer application). Data were collected on 10 agronomic characters. The application of NPK 15:15:15 fertilizer was found to greatly influence the rate of growth and yield of the tomato varieties followed by the application of Poultry manure and the application of Moringa leaf extract for all the parameters studied. Varieties NGB00724, NGB00711 and NGB00695 were found outstanding among the tomato varieties in terms of number of fruits, number of clusters per plant, individual fruit weight and yield per plant irrespective of the type of fertilizer applied. The shelf life of the tomato varieties varied from 3.60 days to 10.60 days being maximum at 10.60 days with the application of Moringa leaf extract and Poultry manure respectively. It can be concluded from this study that NGB00724, NGB00711 and NGB00695 could be improved upon and released as high yielding tomato varieties to farmers. The use of moringa leaf extract and poultry manure for the production of tomato is a worthwhile cost effective and hazardless alternative in place of NPK fertilizer.

Keywords: Fertilizer, growth, yield, shelf life

INTRODUCTION

Tomato, *Lycopersicon esculentum* (Mill) is a plant in the Solanaceae family known as nightshade family. Tomato is adapted to a wide range of climatic conditions from temperate to hot and humid tropic (Shamshiri *et al.*, 2018). In recent years, there has been growing interest in the use of moringa leaf extract as a plant growth promoter and biostimulant (Karthiga *et al*., 2022). The resulting extract of moringa leaf contains a complex mixture of bioactive compounds, including phenolic acids, flavonoids, alkaloids, saponins, and glucosinolates, as well as macro- and micronutrients like nitrogen, phosphorus, and potassium (Kumar and Sharma, 2023). The beneficial effects of moringa leaf extract on plant growth and productivity have been demonstrated in a wide range of crop species, including cereals, legumes, vegetables, and fruits (Attanayaka and Harris, 2019). On the other hand, poultry manure is a valuable source of nutrients for plants and has been used as a natural fertilizer for centuries (Das *et al*., 2017). It contains essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients that are beneficial for plant growth and development (Agu *et al*., 2015). In addition, poultry manure also improves soil structure and enhances soil fertility by increasing soil organic matter content (Kabir *et al*., 2013). NPK fertilizer refers to a type of fertilizer that contains nitrogen, phosphorus, and potassium in varying proportions (Adhikary *et al*., 2018). NPK fertilizer is commonly used in agriculture to supplement the nutrients in the soil and increase crop yields (Kumar *et al*., 2018). Research has shown that organic based fertilizers are less leached into ground water than the chemical fertilizers (Khan *et al.*, 2018). As a result of this, the use of organic based fertilizers has found favour in Nigeria due to its cost effectiveness and less pollution caused to the environment (Jaja and Barber, 2017). The dependency on the use of inorganic fertilizer as a source of plant nutrient by improving the soil fertility has been found to be associated with high cost, soil degradation due to long term use and environmental pollution which can be detrimental to human health (Pahalvi *et al*., 2021). Hence, there is an increase in studies on organic wastes as alternative form of fertilizer. Moringa has been investigated to ascertain its effect on growth and yield of crops and its efficacy as a substitute to inorganic fertilizer (Mashamaite *et al.*, 2022). There is now a growing demand for sound and ecologically, compatible and environment friendly soil fertility management strategy in

agriculture which is capable of providing enough food for the growing population, retaining and maintaining soil quality as well as improving the quantity of agricultural produce (Verma *et al.*, 2020). This research is designed to determine: the effect of fertilizer sources on growth, yield and shelf life of tomato varieties.

MATERIALS AND METHODS

The experimental materials for this research consist of ten varieties of tomato, *Lycopersicon esculentum* (Mill.). The tomato varieties were obtained from the tomato germplasm collection of National Center for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Oyo State, Nigeria.

Table 1: The names and sources of tomato, *Lycopersicon esculentum* (Mill.) varieties

S/N	Variety code	Variety name	Source
1	G1	NGB00695	NACGRAB
2	G2	NGB00696	NACGRAB
3	G3	NGB00708	NACGRAB
4	G4	NGB00711	NACGRAB
5	G5	NGB00713	NACGRAB
6	G6	NGB00714	NACGRAB
7	G7	NGB00715	NACGRAB
8	G8	NGB00721	NACGRAB
9	G9	NGB00724	NACGRAB
10	G10	NGB00725	NACGRAB

The research was carried out in two phases. The first phase is the nursery preparation while the second phase is the field evaluation of the tomato seedlings

Nursery preparation
The tomato varieties were broadcasted in nursery trays filled with sterilized top soil. The seeds after emergence were adequately cared for and at 4 weeks after emergence, the seedlings were transplanted to the field for field evaluation.

Field evaluation
The experiment is a factorial potted experiment consisting of polythene bags filled with 5kg topsoil. The factors represent the four (4) treatments (amendment) which were applied to the tomato varieties: T1 = No amendment; T2 = Moringa leaf extract as a foliar spray; T3 = poultry manure; T4 = NPK 15:15:15. Staking was done at 4 weeks after transplanting. All agronomic practices were carried out as and when due. Moringa leaf extract, poultry manure and NPK 15:15:15 were applied at 4 weeks after transplanting and this continued on forthnight basis until maturity at 50mls/plant each for the moringa leaf extract, and poultry manure and 50g for NPK 15:1515 respectively.

Preparation of Moringa Leaf Extract (Mle)
200g of air dried tender leaves of moringa were collected and blended. The powdered moringa leaves was soaked in 1litre of water and allowed to stand for 24hours. The MLE was further diluted to 1: 5 ratio of extract: water and then applied to the tomato plants starting at 4 weeks after transplanting (4WAT) till maturity at 50mls / plant on forth night basis.

Poultry manure
The poultry manure was put under the shed for some time so as to allow the manure to cure before application to plants so as not to cause injury to the plants. The poultry manure was sieved so as to remove the pebbles. 1kg of the poultry manure was soaked in 5litres of water and filtered using a muslin cloth. The filtrate which is a concentrated poultry manure extract was further diluted in ration 1:2 before being applied to the plants at 4WAT and subsequently on forthnight basis till maturity at the rate of 50mls per plant.

Data collection
Data were collected on five plants on the following agronomic characters at 4WAT**:-** Number of leaves per plant at flowering (NLPF), Number of branches per plant at flowering (NBPF), Plant height at flowering (PHTF), Plant height at maturity (PHTM), Number of clusters per plant (NCP), Number of fruit per plant (NFP), Individual Fruit weight per plant (IFWt/P), Fruit yield per plant (FYP) and Shelf life (SL). The mean of all characters were considered for the purpose of analysis using MINITAB Version 17

RESULTS AND DISCUSSIONS

The estimates of the growth performance of the tomato varieties are presented in Table 2. The highest plant at flowering was observed in V10 (53.40cm NPK), 49.80cm (PM) and 38.20cm (MLE) while the shortest plant height was observed in V7 (39.40cm (NPK) 36.00cm (PM) and 27.00cm (MLE). As regards NPK fertilizer, the highest number of leaves was recorded in V1(36.20) followed by V9 (34.40) while the lowest was recorded in V5 (28.40). As regards the source of fertilizer, the highest number of branches was recorded in V10 (11.20) with NPK followed by MLE in V10 (10.80) followed by PM in V10 (10.00).

Table 2: Mean performance of growth rate in the tomato varieties

	No Fertilizer				MLE				Poultry Manure				NPK Fertilizer			
Varieties	NLPF	NBPF	PHTF	PHTM	NLPF	NBPF	PHTF	PHTM	NLPF	NBPF	PHTF	PHTM	NLPF	NBPF	PHTF	PHTM
V1	26.00a	8.40a	32.40a	111.50a	29.00a	8.40ab	38.10a	145.13a	28.80a	7.80ab	46.00a	170.08a	36.20a	8.60ab	48.00a	176.60a
V2	24.40a	7.60ab	30.40a	110.80a	25.40ab	7.60b	38.20a	145.50a	25.60a	7.20ab	43.80a	156.82ab	32.20a	9.60a	50.40a	175.90a
V3	24.00a	7.40ab	28.20ab	102.40a	23.80ab	8.00b	36.60a	139.50a	26.20a	7.20ab	41.60ab	149.80ab	31.20ab	7.40b	45.60a	159.10ab
V4	23.40a	7.20ab	25.00ab	90.50ab	26.20a	8.40ab	30.40ab	116.25b	26.80a	8.80a	42.60ab	141.22ab	33.40a	9.00a	43.80ab	152.80b
V5	19.40ab	7.40ab	25.00ab	90.70ab	22.60b	8.00b	29.40b	112.50b	22.60b	8.60a	38.20b	138.88b	28.40ab	6.60b	43.60ab	152.10b
V6	22.00ab	8.00ab	26.00ab	94.30ab	25.60ab	8.60a	36.20a	138.00a	25.60a	8.40a	44.00a	163.84a	32.80a	8.00ab	49.40a	172.40a
V7	22.40ab	8.80a	23.40b	84.50b	24.20ab	9.80a	27.00b	99.70bc	23.40ab	7.60ab	36.00b	124.06b	31.00ab	9.40a	39.40b	137.40bc
V8	23.00a	8.60a	26.40ab	95.80ab	26.20a	8.40ab	31.20ab	119.40b	25.00a	8.60a	41.80ab	145.12ab	32.60a	8.40ab	46.60a	162.60ab
V9	25.40a	7.20ab	28.00ab	101.70a	26.00a	8.40ab	35.80a	136.50ab	26.40a	7.40ab	45.60a	159.94ab	34.40a	9.40a	44.80ab	156.30ab
V10	23.20a	8.90a	32.20a	117.40a	26.60a	10.80a	38.20a	145.50a	23.80ab	10.00a	49.80a	176.32a	31.00ab	11.20a	53.40a	186.40a
Grand Mean	23.32	7.95	27.7	99.96	25.56	8.64	34.11	129.798	25.42	8.16	42.94	152.608	32.32	8.76	46.5	163.16

NLPF = Number of leaves/plant at flowering; NBPF = Number of branches/plant at flowering; PHTF = Plant height at flowering; PHTM = Plant height at maturity; V1=NGB00695; V2= NGB00696; V3= NGB00708; V4= NGB00711; V5= NGB00713; V6=NGB00714; V7 =NGB00715; V8 =NGB00721; V9 =NGB00724; V10 =NGB00725

Table 3: Mean of yield and its related characters in tomato varieties

	No Fertilizer				MLE				Poultry manure				NPK Fertilizer			
Varieties	NCP	NFP(g)	IFWt/P(g)	FYP (g)	NCP	NFP(g)	IFWt/P(g)	FYP (g)	NCP	NFP	IFWt/P(g)	FYP (g)	NCP	NFP	IFWt/P(g)	FYP(g)
V1	5.60a	32.80a	4.09b	135.61ab	7.80ab	42.40a	4.43bc	187.00ab	9.80a	52.20a	4.23bc	219.98bc	8.80ab	59.20a	4.69	278.10b
V2	5.40ab	30.80ab	4.14b	126.44b	7.6ab0	40.00ab	4.44bc	178.00ab	6.60b	48.40ab	4.10bc	195.23c	9.00a	50.80ab	4.30	217.90bc
V3	4.60b	25.60b	5.06ab	129.53b	5.60b	34.00b	7.15a	175.00ab	6.20b	42.60b	5.27b	224.74b	7.20bc	46.40b	5.60	259.60b
V4	4.80b	31.80ab	6.54a	208.53a	6.40ab	43.60a	6.40b	278.00a	5.40bc	55.20a	6.87a	379.31ab	9.60a	60.40a	6.94	420.08a
V5	6.20a	29.20ab	5.18ab	151.25ab	6.80ab	36.60b	5.35b	196.00ab	6.60b	43.80b	5.58ab	245.34b	8.20ab	49.20ab	6.07	299.50ab
V6	5.60a	34.00a	6.59a	224.17a	6.80ab	44.60a	6.90ab	307.00a	7.00ab	56.40a	7.15a	403.32a	10.40a	64.80a	7.09	461.08a
V7	5.00ab	24.20b	4.39b	107.35bc	8.40a	41.20ab	6.71ab	148.00b	5.20bc	40.80c	4.39bc	180.36c	7.60b	48.00ab	4.58	219.92bc
V8	5.20ab	25.60b	5.70ab	147.10ab	5.80b	41.80ab	6.74ab	182.00ab	5.40bc	41.20bc	5.97ab	245.88b	8.00b	49.60ab	6.34	313.60ab
V9	6.00a	35.20a	5.35ab	259.50a	8.20a	42.00a	6.94ab	292.00a	7.20ab	59.60a	7.23a	430.42a	9.60a	62.80a	7.31	459.02a
V10	5.40ab	27.20b	6.20a	169.05ab	6.20ab	32.00bc	6.25b	201.00ab	5.00c	41.80bc	6.40ab	268.35b	9.20a	50.80ab	6.42	325.30ab
Grand Mean	5.38	29.64	5.32	165.85	6.96	39.82	6.13	214.4	6.44	48.2	5.719	279.29	8.76	54.2	5.93	325.41

NCP = Number of clusters per plant, NFP = Number of fruit per plant, IFWt/P = Individual Fruit weight per plant, FYP = Fruit yield per plant; V1=NGB00695; V2= NGB00696; V3= NGB00708; V4= NGB00711; V5= NGB00713; V6=NGB00714; V7 =NGB00715; V8 =NGB00721; V9 =NGB00724; V10 =NGB00725

The shelf life of the tomato varieties is presented in Table 4. The longest shelf lives were associated with the application of poultry manure and moringa leaf extract whereas the use of NPK reduced the shelf life of the tomato varieties. All the tomato varieties recorded high values of shelf life with the application of either poultry manure or moringa leaf extract. V4, V6 and V9 recorded Shelf life of 10.60 days and 10.40 days respectively using poultry manure whereas with the application of moringa leaf extract, these varieties recorded shelf life of 10.20 days and 10.60 days.

Optimum crop performance is usually limited by inadequate availability of essential nutrient (Aleminew and Alemayehu, 2020). The result of this research, revealed the superiority of tomato plant, supported with fertilizers over the ones not supported with fertilizer, in terms of growth and yield (Hasnain *et al*., 2020). Application of organic manure allows protection of soil fertility, improving soil composition and also enhancing the availability of different elements (Assefa and Tadesse, 2019). In reality, the increase in soil organic material to the best level is a key feature of any organic production system (Lorenz and Lal, 2016). The use of organic manure guarantees the possibility of increasing tomato production (Chatterjee *et al*., 2014). The increase in number of leaves recorded in this study is in agreement with the findings of Abolusoro and Abolusoro, (2012) who reported that plant leaves increased with increasing organic manure application. According to Meddish *et al.,* (2020), the application of organic manure enhanced plant vegetative growth and biomass production in crops. The high number of leaves per plant at flowering recorded as a result of Moringa leaf extract application in this study corroborates the findings of Emongor (2015) in Snap beans. The effects of Poultry manure on number of fruits and yield per plant recorded in this research is similar to the findings of Ansa and Woke (2018).

The higher number of fruits produced by organic fertilizer amended plants could be attributed to improved soil physical, biological contents and nutrient availability [Hasnain *et al*., 2020]. The findings on increased number of fruits in this study corroborate the findings of (Adeyeye *et al.,* 2018). Several studies demonstrated that organic fertilizers improve soil fertility and productivity, thus enhance crop yield and quality (Thomas *et al.,* 2019) which was also observed in this study.

Table 4: Shelf life of the tomato varieties

Varieties	No Fertilizer		MLE		Poultry Manure		NPK Fertilizer	
	SL(days)	HD	SL(days)	HD	SL(days)	HD	SL (days)	HD
V1	5.80a	5.20a	9.80a	7.60a	9.80a	6.60a	3.80b	6.80a
V2	5.00b	5.20a	9.00ab	6.00a	9.60a	6.80a	3.80b	6.80a
V3	5.40ab	4.40b	9.20ab	5.40ab	9.40ab	5.60ab	4.20ab	5.20ab
V4	5.60a	5.40a	10.20a	5.60ab	10.60a	6.00ab	4.60a	5.80ab
V5	5.40ab	5.20a	8.80ab	4.80b	9.20ab	6.00ab	3.80b	6.40a
V6	5.60a	5.20a	10.20a	5.80ab	10.40a	6.80a	3.60b	6.80a
V7	5.40ab	4.20b	9.40ab	4.20b	8.80b	5.80ab	3.80b	5.00b
V8	5.40ab	4.40b	8.80ab	4.60b	9.00ab	5.20b	4.20ab	5.60ab
V9	6.20a	5.60a	10.60a	6.20a	10.40a	6.60a	4.80a	6.00ab
V10	5.60a	5.00ab	8.20	5.60ab	9.20ab	5.80ab	3.60b	5.20ab
Grand mean	5.54	4.98	9.42	5.58	9.64	6.12	4.02	5.96

HD = Harvest duration SL = Shelf life (SL); V1=NGB00695; V2= NGB00696; V3= NGB00708; V4= NGB00711; V5= NGB00713; V6=NGB00714; V7 =NGB00715; V8 =NGB00721; V9 =NGB00724; V10 =NGB00725

Conclusion

It could be concluded from this study that application of NPK 15:5:15 fertilizer greatly increased the growth performance and yield of the tomato varieties and this was followed by the application of Poultry manure and Moringa leaf extract. NGB00724, NGB00711 and NGB00695 were found to be outstanding in terms of number of fruits and total yield per plant irrespective of the type of fertilizer applied. It can also be concluded from this study that, the shelf life of the tomato varieties was greatly reduced with the application of NPK 15:15:15 fertilizer whereas the shelf life was prolonged with the application of Moringa leaf extract and Poultry manure.

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CONSUMERS' PREFERENCE, ATTRIBUTE AND ACCEPTABILITY OF ORGANICALLY PRODUCED ORANGE FLESHED SWEET POTATO AMONG CIVIL SERVANTS IN ABIA STATE, NIGERIA

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Abstract

The study provided empirical information on the consumers' preference, attributes and acceptability of organically produced orange-fleshed sweet potato among civil servants in Abia State, Nigeria. A cross-sectional data from 160 civil servants randomly selected from the State were used for the study. The study employed descriptive statistics to describe the socio-economic characteristics of the respondents, and ascertain the level of preference and attributes of organically producedOrange fleshed sweet potatoes (OFSP)Logit regression was used to estimate factors influencing the acceptability of organically produced orange fleshed sweet potatoes OPOFSPamong the staff. The study showed a mean age of 47.26 years, with an average of 4 persons per household, 9.40 years of working experience and a monthly income of N130.506.25. A greater percentage (43.75%) of the staff indicated that they like very much the organically produced orange fleshed sweet potato, than like slightly (18.50%) dislike very much (16.20%) and neither dislike nor like (15.60%). Among the crop attributes ascertained, nutritional benefits (4.48), health benefits (4.06), taste (3.81), appearance (3.69), and quantity (3.22) were what the consumers looked for in organically produced OFSP. The coefficients for household size, educational status and income were significant socio-economic factors, while nutritional benefits and price were crop attributes influencing consumer's acceptability of OPOFSP among the civil servants staff in the State. The study therefore recommends that the benefits of organic foods (such as OFSP) over inorganic foods should be made publicized through relevant agencies and actors such as Organic associations and experts, extension agencies, health workers, NGOs and media to increase the crops' acceptability and consumption.

Keywords: Adoption, Awareness, Nutrition, Willingness and OFSP

INTRODUCTION

Presently, consumption of organic food has grown remarkably, both in developed and developing countries. Although organic food comprises only a small fraction of the food market in Nigeria and other countries, its rapid growth has generated much interest among consumers, processors and businesses as well as researchers. This may generally due to the healthier, safer, better tasting and more nutritious benefits of organically produced food (Perrini et al. 2019). Inspite of these, the relatively higher prices of organic food, together with lack of availability, lack of awareness, nonchalant attitude of farmers and consumers, and uncertainty over the truthfulness of organic food claims are hindering more widespread preference, acceptability and consumption (Umeh et al., 2023). According to the FAO/IFOAM workshop on Organic Agriculture-Organic Food Consumption (2010), organic foods are somewhat unpopular with consumers in developing countries due to their high price. However, this also highlights market opportunities and provides strong incentives for organic farming. Organic agriculture can be an important alternative to intensive agriculture in developing countries though its' economic sustainability varies across geographies and crops.

Understanding organic foods/products as final output or products from organic farming/agriculture is crucial. Cukur et al. (2019) defined organic farming as an alternative production method which aims to improve not only the quantity but also the quality of production and includes human and environmentally friendly production systems for restoring the natural balance that has been lost as a result of defective practices in the ecological system and prohibits the use of synthetic chemical pesticides. Organic farming also is a production system that avoids the use of artificial fertilizers, pesticides, growth regulators and feed additives (Abdullah, 2019). Adhikari et al. (2016), emphasized that organic farming is both a philosophy and an agricultural system that avoids or largely excludes the use of synthetic fertilizers, pesticides and, to the maximum extent possible, relies on crop rotations, crop residues, animal manures, legumes, green manures, organic waste from the farm, mineral rocks and bio-fertilizers to

maintain soil production. However, organic foods drawing from the above definitions are loosely defined along dimensions such as biological, naturally produced, green, environmentally friendly, sustainable and limited use of artificial chemicals (Imiru, 2021). Interestingly, all crops have the potential to yield well in organic environment including Orange Fleshed Sweetpotato (OFSP).

Of the entire varied flesh storage root colour (white, yellow, cream, orange, and purple) of sweetpotato varieties existing, the orange fleshed root sweetpotato varieties are growing popularity in Nigeria and can be produced organically. It is one of the staple crops in Nigeria, as it plays a major role in household food security, nutrition, income, and cash for subsistence and commercial smallholder farmers (Bocher et al. 2019). Orange Fleshed Sweetpotato (OFSP), which is naturally bio-fortified; high in beta-carotene, a precursor of Vitamin A; is proofed to be an alternative means to address vitamin A deficiency in children below five years of age, the aged, lactating and pregnant women (Bocher et al., 2015) and good for everyone. At the same time has the potential to maintain human health by mitigating diseases and generating income to improve the livelihood of the people (Nwankwo et al., 2019). OFSP can easily be absorbed by the body than any others leaves or vegetables, easy to grow and affordable to resource-poor households in developing countries (Bocher et al. 2019). The growing demands for nutritionally based food especially OFSP in Nigeria has an advantage to consumers to reap the benefits of the entire crop especially its organic produce.

OFSP has emerged as an alternative approach to artificial supplementation to combat micronutrient deficiencies, higher in organic produced ones (cite reference). Addressing malnutrition through organic-based approaches has received less attention from the scientific community than the conventional. Low consumers acceptability and consumption have contributed to the low market share of the farmer's, smallholder inclusion and increased food and nutrition insecurity. However, market dynamics, failures and shortcomings often diminish the desired impacts and/or long-term effects. Imiru (2021) highlighted responsible factors such as environmental concern, perceived knowledge, social norms, and perceived usefulness, as well as purchase behavior regarding environmentally friendly products as it relates with preference, attribute and acceptability. Again, Chen (2017) noted that variety of dietary factors such as health, mood, convenience, personal need, and environmental protection also influence the consumer acceptability decision indirectly.

The growing demand of OFSP and consumption of organic food is recently increasing among consumers not necessarily due its identified numerous health benefits but a way of life. Although Umeh et al., (2023) and Lockie et al., (2012) have shown that acceptance of organic foods/products have being found among the socio-demographic profile of more educated than non-organic consumers and to consume more organic food when their income rises. However, the consumer acceptability for products has been extensively researched in marketing studies as relationships between a variety of purchase factors such as environmental concern, perceived knowledge, social norms, and perceived usefulness, as well as purchase behavior with regard to environmentally friendly products (Imiru, 2021).

The level of consumer's acceptability of organic products in the entire commercialization process had been a difficult task probably due to inappropriate policies, high price, limited produce, institutional obstacles, weak infrastructure and lower productivity of organic crops as demand for disease and chemicals free food production has steadily increased worldwide (Abdulraheem et al., 2022). Krystallis and Chryssohoidis (2018) also added that the relatively higher prices of organic food, together with lack of availability, lack of awareness of the organic concept and uncertainty over the truthfulness of organic food claims are hindering more widespread consumption. Hence the relationship between the consumer's attribute and preference, and /or acceptability of organic produces are yet to be established. However, this study analyzed the consumers' preference, attribute and acceptability of organically produced orange fleshed sweetpotato roots among civil servants of Abia State, Nigeria. The study will discuss level of preference of organically produced OFSP, attributes consumers look for organically produced OFSP, consumers' acceptability behavior for OFSP and determinants of consumer's acceptability of organically produced OFSP among civil servants in Abia State.

METHODOLOGY

The study was carried out in Abia State, in South East Nigeria. The study adopted a multi-stage sampling procedure to select civil servants from the State. In the first stage, , 8 LGA out of 17 LGA in the State were randomly selected, two government institutes in each of the LGA selected were randomly selected in the second stage while 10 civil servants were also randomly selected from each of the Institutions in the third stage, given a total of 160 respondents for the study. Data for the study were collected with the use of structured questionnaire

administered directly to the staff. The level of preference and attributes for organically produced OFSP among Civil servants were realized using mean counts. Responses from 5-point scale using Dislike very much (1), Dislike slightly (2), Neither dislike or like (3), Like slightly (4), Like very much (5) was used to calculate the percentage for preferences responses. To determine the attribute of OPOFSP among the respondents, the mean count obtained from the Lickert Scale analysis of strongly agree (5) agree (4), undecided (3), disagree (2) and strongly disagree (1) were used. Variables with mean score of 3.0 (which is the average mean score of the rating level) and above imply that they are positive and in affirmative to the objective being measured while factors with mean score of less than 3.0 are negative and rarely have an influence on the objective being measured.

The determinant of acceptability of OPOFSP was analyzed using Logit regression Model as specified thus,

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11\ldots}X_n + ei$$

Y= Decision to accept OPOFSP = Yes, Otherwise=No

X_1= Sex (Male =1, Female =0), X_2 = age (years), X_3 = marital status (married=1, single=0), X_4 = =household size (number), X_5 academic qualification (Prof= 6, PhD=5, Msc =4, Bsc =3, Secondary =2, Primary =1),X_6 = Monthly income (Naira), X_7 = nutritional benefit (Dummy, Yes=1, No=0), X_8 = Taste (Dummy, Yes=1, No=0), X_9= Price (Dummy, Yes=1, No=0), X_{10}=accessibility (Dummy, Yes=1, No=0), X_{11} storability = (Dummy, Yes=1, No=0), ei = error term

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

The study presented the socio-economic characteristics of the respondents in the Table 1. The study showed the age mean of the respondents as 47.26 years, 4 persons per household, and working experience of 9.40 years with average monthly income of ₦130.506.25. This indicated that the respondents were young, strong, and still approaching their middle age of service, thus expected to go for organically produced food such as OFSP for their nourishment and growth. In line with expectation, Voona et al. (2011) noted that organically produced food is generally regarded as healthier, safer, better tasting and more nutritious than conventionally produced food. Age significantly influenced the level of household consumption following Ayanwale and Ajetomobi, (2010). Okoye et al., (2020) also observed that the aged category values strong health and are more likely to accept the importance of exercise, maintain and eat a healthy diet, refrain from smoking and consume moderate amounts of alcohol. The moderate household size found in this study simply explained the number of persons eating from the same pot hence expected to influence the acceptability and consumption of healthier foods such as organic OFSP. Okoye et al., (2021) noted that as production increases with more members in the household so also does consumption thus the acceptability of healthier food for the household. However, the average working experience of 9 years was an indication of longer years of experience and exposure.longer or increased number of years of working experience thus is expected to expose one to certain behavioral changes such as increasing purchasing power and consumption (Okoye et al., 2021).

Table 1: Socioeconomic Characteristics of the Respondents

Variables	Mean
Age	47.26(8.20)
Household size	4.36(1.75)
Working experience	9.40(5.20)
Monthly income	130,506.25(27,298.695)
	Dummy (%)
Sex (female)	90(56.30)
Marital status (married)	120(75.00)
Membership of cooperative society (yes)	98(61.10)
Knowledgeable about Organic sweetpotato	96 (60.00)

Source: Field survey, 2023; Figures in parentheses are standard deviation for mean and percentage values for Dummy

The majority (56.30%) of the respondents was female, married (75.00%), belonged to one cooperative society (61.10%) and knew about organic OFSP production (60.00%). Interestingly, females and married women are culturally assigned and known for decision making when it comes to what to eat and cook, however, the large inclusion of women in this study is ideal for exploring more vital information on organic OFSP acceptability and preference. In line with the discussion, Okoye et al. (2021) noted that the choice of food consumption decision is mainly done by women. The married have an advantage over others since the spouse and children also will determine what to accept and consume in the family. The study also showed that more (61.10%) of the staff belonged to one cooperative society or the other than indicating their level of access to information especially on agricultural products such as OPOFSP. Many

(66.10%) of the respondents had BSc. certificate, then WASSC (21.30%), MSc. (6.30%) and Ph.D. (6.30%). Basic education enhances the overall quality of a person by providing him/her with basic numeric and literacy skills (Okoye, 2020). Education also increases consumers' prior access to external information, and analyzing the information. Education is a crucial variable in studying of food demand and consumption (Onyemauwa, 2018). The high levels of education found in the study are expected since the respondents are within the educational system that would enhance and improve quality access to higher formal of learning. Studies have shown that duration or level of education is positively related to nutrition knowledge and those with high levels of education are more likely to demand quality products (Okoye et al., 2021).

Level of preference of organically produced OFSP

The study depicted the level of preference of organically produced OFSP among civil servants in Abia State, Nigeria in Table 2. The results showed that a greater percentage (43.75%) of the staff indicated that they liked very much the organically produced orange fleshed sweetpotato, followed by like slightly (18.50%) while about 16.20% and 15.60% indicated dislike very much and neither dislike or like respectively. However, the results of the findings simply implied that the consumers preferred organic foods such as OFSP to inorganic foods in the study though with less than half of the population. These findings alien with the previous findings and might be due to their knowledge on the benefits of organic produce and OFSP as a crop. The highest level of preference of like very much found in the study was also in corroboration with Food and Agricultural Organization (2019) which estimated the gradual growth in demand for organic foods and the value of the global market for organic food as of 2007.

Table 2: Level of preference of organically produced OFSP among Civil servant Staff in Abia State, Nigeria (Likert Scale Analysis)

Items	Frequency	Percentage
Like very much LWM (5)	70	43.75
Like slightly LS (4)	30	18.75
Neither dislike or like NDL (3)	25	15.625
Dislike slightly DS (2)	9	5.625
Dislike very much DVM (1)	26	16.25

Source: Field survey, 2023; Figures in parentheses are percentage values

Attributes consumers (Civil Servants) look for organically produced OFSP

The results in Table 3 presented the Likert scale analysis of the attribute for organic OFSP among civil servants in Abia State. The general attributes for buying organic food vary, and different people may buy organic foods for different attributes. This may also differ by locality or geographical regions, age, sex or ethnic groups and many others. Among the attributes examined, nutritional benefits (4.48), health benefits(4.06), taste (3.81), appearance (3.69), and quantity (3.22) were the common attributes consumers look for in organically produced OFSP having scored a mean score of 3.0 and above, the acceptable mean and ranked from 1to 5th position. In line with the findings, Islam (2018) found characteristics associated with taste, freshness, quality, and safety and health conditions as consumers' preference for buying organic foods.

The nutritional values of OFSP cannot be over emphasized, Mitra (2012) noted that OFSP being rich in β-carotene is gaining importance as the cheapest source of antioxidants having several physiological attributes like anti-oxidation, anti-cancer and protection against liver injury and is most suiting as a bio-fortified crop to combat malnutrition in the small and marginal farming community. Taste is always mentioned as a factor influencing preferences of a product to others as found in Adebisi et al., (2021). However, factors such as aftertaste (2.95) and size of the roots (2.80) had negative responses with a mean less than the acceptable value of 3.0, hence, was not among the attributes for OPOFSP consumption among the civil servants in the State.

Consumers' Acceptability Behavior of OFSP

The results in Table 4 showed the distribution of utilization of OFSP and organically produced OFSP among the Civil Servants in the study area. The findings showed that out of 160 respondents only 81(50.60%) indicated having consumed OFSP in the past, of which 27.20% were sure that the OFSP was organic, while 55.60% were not sure if organic or not. This simply showed consumer's level of consumption of OFSP whether organic or not. However, the low record of utilization of organic OFSP produce among the respondents might be attributed to low level of availability and accessibility of the product within the reach of the respondents.

Determinants of consumer's acceptability of organically produced OFSP

The Probit Regression estimate of factors influencing the acceptability of organically produced OFSP among civil servants in Abia State was presented in Table 5. The results showed a Chi-squared value was highly significant at a 1% level of probability indicating goodness of fit of the Probit regression line. The study also showed the pseudo-R-squared of 0.4958 indicating that 49.58% of the variability in probability of accepting OPOFSP was

Table 3: Attribute Consumers Looks for in Organic OFSP among Civil Servant staff

Items	SA	A	U	D	SD	Total	Mean	Rank
Appearance	64(320)	41(164)	23(69)	6(12)	2(26)6	591	3.69	4th
Taste	73(365)	32(128)	27(81)	9(18)	19(19)	611	3.81	3rd
Size	29(145)	29(116)	34(102)	20(40)	48(48)	451	2.80	7th
Aftertaste	36(180)	24(96)	30(90)	37(74)	33(33)	473	2.95	6th
Quantity	24(120)	56(224)	36(108)	20(40)	24(24)	516	3.22	5th
Nutritional value	98(490)	46(184)	14(42)	0(0)	2(2)	718	4.48	1st
Health benefit	93(465)	28(112)	12(36)	11(22)	16(16)	651	4.06	2nd

Source: Field Survey, 2023; SA= Strongly (5) Agree, A= Agree (4), U= Undecided (3), D= Disagree (2) and SD= Strongly Disagree (1); Acceptable mean score = 3.00

Table 4: Distribution of utilization of OFSP

Responses	Frequency	Percentage
Consumed OFSP (n=160)	81	50.6
Consume organically produced OFSP (n=81)	22	27.2
Never consume OFSP (n=160)	79	49.4
Consumed, but not sure if organic or not (n=81)	45	55.6

Multiple Responses; Source: Field survey, 2023;

Table 5: Probit Regression Estimates of factors influencing consumers acceptability of OPOFSP among Civil Servants in Abia State

Variables	Parameter	Coefficient	Std. Error	Z
Constant	b_o	-0.8578	1.3684	-0.63
Socio-economic factors				
Sex	X_1	-0.3409	0.3964	-0.86
Age	X_2	0.0100	0.0320	0.31
Marital status	X_3	0.1343	0.4585	0.29
Household size	X_4	0.3550	0.1145	3.10**
Educational qualification	X_5	0.5032	0.2996	1.68*
Monthly Income	X_6	5.24e-06	2.83e-06	1.86*
OPOFSP Attribute				
Nutritional Benefit	X_7	0.9379	0.5031	1.86*
Taste	X_8	-0.4081	0.5211	-0.78
Price	X_9	-1.2433	0.5534	-2.25*
Accessibility of the roots	X_{10}	-0.4418	0.5391	-0.82
Storability	X_{11}	0.3326	0.4631	0.72
Number of observation	160			
LR Chi^2	42.06			
Prob chi^2	0.0007			
Log likelihood	-36.3973			
Pseudo R2	0.4958			

Source: Survey Data, 2023; * and ** is significant at 10% and 5% level of probability

explained by the independent variables. Interestingly the study found that the staff with large household sizes were probably (10% probability) to consume organic OFSP than their counterparts with small households. This was against a prior expectation as increased household size would increase household spending more on available and conventional OFSP and other foods than organic. Household size played a very important role in the selection of food consumption (Umeh et al, 2023) and (Okoye et al, 2020) and quantity of consumption (Tomlins *et al.,* 2007). The coefficient for educational qualification was positive and significantly related to consumer's acceptability of OFOFSP at a 10% level of probability indicating that there was 90% probability that an increase in the educational status of civil servants in Abia State would increase the acceptability of OFOFSP. As expected, an increase in education attainment makes a person to be receptive to innovations, knowledge and consumption of nutritional value which in turn improves their acceptability and consumption decisions. The study showed that the coefficient for income was positive and significantly related to the acceptability of OFOFSP in the study area at a 10% level of probability. This was an indication that staff with higher income will probably (90%) accepts OPOFSP than their counterparts with lower income.

In line with the findings, Njuguna (2020) noted that income facilitates adoption, consumption () and decision. Among the OPOFSP attributes estimated, the nutritional value and price of the crops were significant factors influencing the consumers' acceptability of OPOFSP at 10% level for each. The findings of the study showed that the staff would probably accept OPOFSP due to its nutritional value and if the price of the crop is lesser. As expected, consumer's willingness to accept foods product depends on the nutritional benefits and affordability. Chowdhury et al. (2011) noted that the nutritional information of orange fleshed sweetpotato was among the factors that boosted the dissemination and acceptance of bio-fortified sweetpotato (OFSP) products among consumers.

Conclusion and Recommendations

The study found a high perception and acceptability of consumer towards organically produced orange flesh sweetpotato root among Civil Servants of Abia State, Nigeria. Hence, to enhance acceptability of organic foods like OFSP, attention should be given targeting different socioeconomic factors (household size, educational status and income) and the crop attributes (nutritional value and price). Additionally, promoting the benefits of organic foods through intense awareness, training, publications and advocacy is recommended especially among civil servants in the State and beyond

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