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SUPPRESSION OF DAMAGING EFFECTS OF *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) BY PLANT POWDERS

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ABSTRACT

Powders prepared from plant species available in Nigeria are reported to possess ovicidal, larvicidal, pesticidal, antifeedant and repellent properties against various insect pests and are regarded as environmentally compatible pesticides. This study evaluated the action of *Azadirachta indica* A. Juss*, Hyptis suaveolens* Poit*. Piper guineense* Thonn. & Schum *and Cymbopogon citratus Gaern against the damaging effects of Callosobruchus maculatus* (F.) in stored cowpea. The experiment was carried out at temperature of 30 ± 1^{o}C and relative humidity of 72 ± 3%. The plant powders were compared at the rate of 2.5 g per 50 g cowpea seeds including the untreated control. The experiment was laid out in a completely randomized design with three replications. The results showed that all the botanicals gave protection to the stored cowpea seeds and significantly ($p<0.05$) reduced mean adult emergence and seed weight loss (3.75-4.06%) caused by *C. maculatus* when compared with the untreated control (6.07%). The number of emerged adults from untreated seeds progressively increased with time of exposure compared to the treated seeds. The increasing order of effectiveness of the botanicals in terms of their insecticidal activities against *C. maculatus* was *P. guineense, C. citratus, H. suaveolens,* and *A. indica.* The study, therefore, shows that the botanicals could serve as protectants against *C. maculatus* in stored cowpea seeds.

Keywords: Botanicals, *Callosobruchus maculatus*, Cowpea, Damage, Mortality, Protectants

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) originated from Africa where a large number of primitive cultivars and semi-wild forms are found (Kwaifa *et al.,* 2012). It is grown for food and animal feed in the semi-arid tropics of Africa, Asia, *Europe*, Central and South America (Asante *et al.,* 2001). The crop is an important edible grain legume being very rich in protein required by man and livestock (Akinkurolere *et al.,* 2006). Cowpea, therefore, nutritionally complements staple low protein cereals and tuber crops and provides income for farmers and traders (Lanyintuo *et al.,* 2003).

In addition to the high protein content of cowpea, it also has high iron content but is low in fats. Cowpea has also been valuable in nitrogen fixation through its root nodules, and it grows well in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels of phosphorus (Singh *et al.,* 2003).

Seed beetle, *Callosobruchus maculatus* (F.) is unarguably a major insect pest militating against food availability and security (Adedire, 2008). Storage of cowpea seeds over long periods, especially at small holder levels, is limited by bean beetle infestation. Huge losses of between 20 and 50% have been reported on stored cowpea due to attack by bean beetle, *C. maculatus* and sometimes the loss could be complete accounting for 100% loss (Udo and Harry, 2013). Bean beetle also attacks chickpeas (*Cicer* sp.)*,* lentils (*Lens* sp.), garden peas (*Pisum* sp.) and mung beans (*Vigna* sp.) with distinctive damage. Their damage causes loss of weight, nutritional value and viability of stored seeds particularly caused by larvae. Adult female *C. maculatus* lays half its total eggs in the first two days after copulation (Uddin II and Sanusi, 2013).

The major problems associated with the use of synthetic pesticides against the pest include the dangers to the user, exorbitant costs, pesticide resistance and food residue. Improper application of synthetic pesticides poses a threat to man and the environment, particularly among rural farmers in Africa (Ofuya, 2003). These setbacks have made the quest for alternative approaches to the pest control including plant products, very expedient (Lale, 2002).

Currently, global research efforts now support the development of plant products with proven crop protection potentials (Aliyu *et al.,* 2011). Rahman and Talukder (2006) reported that grains mixed with leaf, seed powder, or plant extracts reduced oviposition, inhibited damage and suppressed adult emergence of *C. maculatus*.

In another investigation, plant powders applied at 2% of the weight of stored beans effectively controlled cowpea seed beetle in storage (Lale, 2002). In the tropics, some of the plant species that have been screened for insecticidal properties include *Azadirachta indica* A. Juss, *Piper*

guineense Schum. & Thonn. and *Dennettia tripetala* G. Baker (Lale, 2006). The inclusion of plant products in pest management may offer a reliable and environmentally safe alternative to synthetic insecticides. This study therefore determined the efficacy of *A. indica, Hyptis suaveolens* Poit*., P. guineense* and *Cymbopogon citratus* Gaern against bean beetle*, C. maculatus* (F.) in stored cowpea.

MATERIALS AND METHODS

Experimental Study

The research was carried out at the Biotechnology Laboratory, University of Ilorin, Ilorin, Nigeria. The cowpea (variety *Beluko*) used for this experiment was purchased from an agro-allied shop, Amilegbe, Ilorin.

Insect Culture

The initial stock culture of *C. maculatus* was maintained in the laboratory of the Department of Crop Protection, University of Ilorin, Ilorin, Nigeria. Sub-cultures of the insect were prepared from 25 pairs of the adult insect randomly picked from the stock culture. The insects were raised on dry susceptible white cowpea seeds in plastic containers covered with muslin cloth to allow aeration and prevent insect escape. The culture was maintained under prevailing temperature of 30 ± 1^{o}C and relative humidity of 72 ± 3%. Freshly emerged adults were used for the study.

Seed Sterilization and Plant Powder Preparation

The cowpea seeds were sterilized in a freezer compartment of a refrigerator for 14 days to eliminate possible hidden insect infestation (Musa and Lawal, 2016). Four researched plants identified as *Azadirachta indica* A. Juss. (Ivbijaro, 1989), *Piper guineense* Thonn. & Schum. (Musa, 2007), *Hyptis suaveolens* Poit. (Musa, 2008; 2013), and *Cymbopogon citratus* Gaern (Dike and Mbah, 1992) were collected from the University of Ilorin campus and its environs. The leaves were air-dried for three weeks, ground separately and thereafter passed through a sieve to obtain fine powder. The plant powders were kept in air-tight vials prior to use.

Experimental Design

Azadirachta indica, *P. guineense*, *H. suaveolens*, and *C. citratus* leaf powders were evaluated for their ability to protect cowpea seeds against damage by *C. maculatus*. Each plant powder was applied at 2.5 g per 50 g cowpea seeds in separate plastic containers (7.5 cm in diameter) with ten *C. maculatus* (1-2 day old) adults introduced into each of the containers. Cowpea seeds

without plant powder were put into a container and served as untreated control. The containers were covered with muslin cloth to allow aeration and prevent insect escape. The experiment was laid out in a completely randomized design with three replications.

Data Collection

Data collected included adult beetle mortality, adult beetle emergence, seed weight damaged and seed weight loss. The mortality rates were recorded at 1, 2, 3 and 4 days after infestation (DAI) and then expressed as percentage. The newly emerged adults were from the first day of emergence (29 DAT) to 35 DAT. The damaged seeds (seeds with exit holes) in each sample were determined by weighing. The seed weight loss was computed using the method of Musa and Lawal (2016) as follows:

$$W = W_1 - W_2$$

where:

W=weight difference

W_1=original weight (before infestation)

W_2=final weight (after infestation)

Data Analysis

Data were subjected to analysis of variance while means separation was carried out using Least Significant Difference at p=0.05 level of significance.

RESULTS

Effect of Plant Powders on the Mortality of *C. maculatus* Adults

Table 1 shows that *H. suaveolens* and *C. citratus* leaf powders had insecticidal effects against bean beetle at 1 DAT. At 2 DAT, *H. suaveolens* leaf powder caused significantly ($p<0.05$) higher mortality (40.0%) than *C. citratus* (20.0%) and *P. guineense* (20.0%) leaf powders against the insect. At 3 DAT, there were significantly ($p<0.05$) higher mortality of *C. maculatus* adults in seeds treated with *A. indica* (100.0%) than *P. guineense* (20.0%), *H. suaveolens* (60.0%) and *C. citratus* (60.0%). However, *H. suaveolens* leaf powder caused total mortality of *C. maculatus* adults at 4 DAT. On the whole, seeds treated with the leaf powders caused varying rates of mortality compared to no mortality in the untreated control during the study period.

Effect of Plant Powders on Adult Emergence of *C. maculatus*

Table 2 shows the emergence of *C. maculatus* adults from cowpea seeds treated with leaf powders of *A. indica, P. guineense, H. suaveolens* and *C. citratus* from 29 to 35 DAT. *Hyptis suaveolens* inhibited progeny emergence from 29 to 31 DAT while *C. citratus* inhibited progeny emergence from 29 to 30 DAT. The results for the number of emerged adults indicated a highly significant ($p<0.05$) difference. From 32 to 34 DAT, *H. suaveolens* recorded the lowest mean numbers of emerged adults ranging from 0.67-10.33, while the untreated control consistently recorded the highest mean numbers of emerged adults ranging from 10.33 to 70.00 between 29 and 35 DAT. *Azadirachta indica* and *H. suaveolens* showed significant ($p<0.05$) difference in the mean numbers of emerged adults compared to the untreated control except at 33 DAT. *Hyptis suaveolens*, *C. citratus* and *A. indica* were statistically the same in reducing the adult emergence at 35 DAT but the *H. suaveolens* caused significantly lower mean adult emergence compared to *C. citratus* and *A. indica* at 34 DAT. However, the performance of *H. suaveolens* in reducing adult emergence was significantly better than *A. indica, P. guineense* and *C. citratus* at 34 DAT.

Effect of Plant Powders on Cowpea Seed Damage

Table 3 shows the mean weight of cowpea seeds damaged by *C. maculatus* after being treated with the four different leaf powders. The highest mean weight of seeds damaged by the insect was recorded in *P. guineense* (4.02 g) while *A. indica* had the lowest mean value (1.57 g). All other treatments had intermediate values. There were no significant ($p>0.05$) differences among the mean weight of seeds treated with *A. indica, P. guineense, H. suaveolens*, *C. citratus* and the untreated control. The mean weight of undamaged cowpea seeds with different leaf powders was recorded to be the highest mean value in *A. indica* (46.55) and lowest mean value in *P. guineenses* (43.95) while other treatments had intermediate values. There were no significant ($p>0.05$) differences in the mean weights of undamaged cowpea seeds for all the treatments including the untreated control.

Effect of Plant Powders on Seed Weight Loss

Table 4 shows the mean seed weight loss caused by the four different leaf powders. There were no significant ($p>0.05$) differences among the mean weight loss of cowpea seeds treated with *A. indica, P. guineense, H. suaveolens, C. citratus*, ranging between 1.88 and 2.09 and the untreated control (3.18 g). The highest value (6.07%) and the lowest value (3.75%) of mean percentage loss of cowpea seeds were recorded in the untreated control and *A. indica* leaf powder respectively. Also, there was no significant ($p>0.05$) difference in mean percentage

weight loss of cowpea seeds treated with the leaf powders of *A. indica, P. guineense, H. suaveolens, C. citratus* and the untreated control.

DISCUSSION

The literature shows that plant powders have insecticidal action against *C. maculatus* and other stored product insect pests (Adedire and Lajide,, 1999; Asawalam and Emosairue, 2006; Musa and Uddin II, 2016). Also, in a previous study, Oparaeke *et al*., (2002) reported that cowpea seeds treated with *Ocimum gratissimum* and *H. suaveolen* caused reduction in progeny development of *C. maculatus.*

The results of this study agree with the findings of Idoko and Adesina (2012) who reported that *P. guineense* caused the mortality of *C. maculatus* adults and eventual suppression of progeny emergence due to contact toxicity of the powder. Previous investigation showed that mortality of *C. maculatus* increased with increase in the rate of plant part powder applied with higher rate assumed to be having higher active ingredients against the insect (Musa, 2012).

The adult mortality recorded might be attributed to the leaf powders that may have caused abrasion of the insect cuticle. The increasing order of effectiveness of the botanicals in terms of their insecticidal activities against *C. maculatus* was *P. guineense, C. citratus, H. suaveolens,* and *A. indica.* The insecticidal properties of *A. indica* and *P. guineense* could be attributed to the presence of azadirachtin and piperine respectively (Oparaeke, 2006).

Hyptis suaveolens offered the better protection against the number of emerged adults of *C. maculatus* because it was consistently significantly better than the untreated control during the study period. Reduction in the number of emerged adults may be associated with possible ovicidal and larvicidal activities of the botanicals. In this study, *A. indica* had the lowest emergence of *C. maculatus* adults. The reduced adult emergence in all the plant powders may also be due to mortality of the adult beetle before oviposition. It could also be that the plant materials made the male sterile; thus made the females produced non-fertile eggs (Ojianwuna and Umoru, 2010). Among the plant powders, *H. suaveolens* conferred better protection of cowpea seeds through prevention of emergence during the study period. Generally, adult emergence increased with increase in exposure period despite the presence of the plant powders.

CONCLUSION

This study shows that the leaf powders afforded varying degrees of cowpea seed protection against bean beetle, *C. maculatus* under small scale storage. However, *A. indica* and *H. suaveolens* leaf powders offered better protection than *P. guineense* and *C. citratus* and are

therefore recommended for further empirical investigation to be able to incorporate them into much desired preservation of bulk commodities.

Table 1: Mean percentage mortality of *Callosobruchus maculatus* adults on cowpea seeds treated with the same rate of different leaf powders

Plant Powder	Days after treatments (DAT)			
	1	2	3	4
A. indica	0.0_b (0)	0.0_b (0)	30.0_a (100)	30.0_a (100)
P. guineense	0.0_b (0)	6.0_b (20)	6.0_c (20)	18.0_b (60)
H. suaveolens	6.0_a (20)	12.0_a (40)	18.0_b (60)	30.0a (100)
C. citratus	6.0_a (20)	6.0_b (20)	18.0_b (60)	18.0_b (60)
Control	0.0_b (0)	0.0_b (0)	0.0_d (0)	0.0_d (0)
SE±	0.21	0.97	0.53	2.30
LSD $_{(0.05)}$	**0.73**	**3.36**	**1.84**	**8.04**

Values in the same column followed by common subscript do not differ significantly different at p = 0.05 using Least Significant Difference. Values in parentheses represent percentage mortality.

Table 2: Emergence of *Callosobruchus maculatus* adults on cowpea seeds treated with the same rate of different plant leaf powders

Plant Powder	Progeny emergence of *C. maculatus* (DAT)						
	29	30	31	32	33	34	35
A. indica	5.0_b	1.0_b	1.00_d	1.33_c	8.00_{ab}	18.3_d	21.33_b
P. guineense	6.0_b	3.33_{ab}	3.33_b	7.00_b	7.67_{ab}	27.00_b	70.00_a
H.suaveolens	0.0_c	0.00_b	0.00_d	0.67_c	1.00_b	10.33_c	21.67_b
C. citratus	0.0_c	0.00_b	1.33_c	2.00_c	16.33_a	18.67_d	34.00_{ab}
Control	10.33_a	10.33_a	11.0_a	13.00a	18.33_a	48.00_a	70.00_a
SE±	0.30	2.55	0.33	1.59	3.35	1.11	12.36
LSD $_{(0.05)}$	**1.04**	**8.86**	**1.15**	**5.53**	**11.65**	**3.86**	**42.99**

Values in the same column followed by common subscript(s) do not differ significantly different at p = 0.05 using Least Significant Difference. DAT= Days after treatments SE= Standard error

Table 3: Effects of different plant powders on cowpea seed damage

Plant Powder	39 DAT			
	Rate (g)	Wt. of damaged seeds (g)	Wt. of undamaged seeds (g)	Total weight (g)
A. indica	2.5	1.57 ± 0.89	46.55 ± 1.01	48.12 ± 0.14
P. guineense	2.5	4.02 ± 3.90	43.95 ± 4.45	47.97 ± 0.55
H. suaveolens	2.5	1.87 ± 0.77	46.16 ± 0.92	48.04 ± 0.21
C. citratus	2.5	1.83 ± 0.46	46.31 ± 0.60	48.11 ± 0.13
Control	0.0	0.56 ± 0.40	46.41 ± 0.82	46.97 ± 1.07
$LSD_{(0.05)}$		**NS**	**NS**	**NS**

NS: Not Significant

Table 4: Effects of different plant powders on the weight loss of cowpea seeds

Plant Powder	Mean Wt. loss (g)	Wt. loss (%)
A. indica	1.88 ± 0.14	3.75 ± 0.28
P. guineense	2.09 ± 0.61	4.06 ± 1.10
H. suaveolens	1.96 ± 0.21	3.87 ± 0.25
C. citratus	1.88 ± 0.13	3.77 ± 0.25
Control	3.18 ± 1.22	6.07 ± 2.13
$LSD_{(0.05)}$	**NS**	**NS**

NS: Not Significant

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GROWTH, NUTRIENT UTILIZATION, HAEMATOLOGY AND BIOCHEMICAL PARAMETERS OF AFRICAN CATFISH (*Clarias gariepinus*, BURCHELL, 1822) FED WITH VARYING LEVELS OF BACILLUS SUBTILIS

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ABSTRACT

This study examined the growth response, nutrient utilization, biochemical and haematological properties of *Clarias gariepinus* juveniles, fed with graded levels of *Bacillus subtilis*. Five diets were formulated (35% crude protein; 3127 kCal/kg energy), comprising 0 (T_1), 20 mg/100g oxytetracycline (T_2), 10^5 (T_3), 10^7 (T_4) and 10^9 (T_5) *B. subtilis* CFU/ml. African catfish, *C. gariepinus* (n=150; mean weight =94.33±0.67g) were allotted to 15 rectangular tanks and fed experimental diets apparently to satiation for 8 weeks. Growth performance, nutrient utilization, haematological and biochemical parameters were examined using standard methods. The results showed that fish fed with Diet T_5 recorded significantly high values for mean weight gain (MWG) (116.67±5.70g), specific growth rate (SGR) (1.58±0.07%) and percentage weight gain (PWG) (133.62±7.47%), while Diet T_1 had least values for MWG (89.00±0.58g), SGR (1.36±0.01%) and PWG (94.35±0.91g). Feed conversion ratio (FCR) and protein efficiency ratio (PER) were significantly different (p<0.05) across the test diets, with Diet T_5 having the best values for FCR (1.17±0.04) and PER (3.27±0.18). No significant differences (p>0.05) were observed in the haematological, AST, ALP and GSH indices between the fish fed graded levels of probiotic and control diets. The excellent growth performance recorded at the highest inclusion level (T_5) of *B. subtilis* showed that the probiotic could be favourably incorporated into the diet of *C. gariepinus* juveniles.

Keywords: Growth, Nutrient Utilization, Blood Parameters, *Clarias gariepinus*, *Bacillus subtilis*

INTRODUCTION

The farming of catfish is important in Nigeria because, it provides income, creates employment and addresses food insecurity with the provision of low cholesterol animal protein to the majority of African populations (Adebayo and Daramola, 2013). Presently, aquaculture is the fastest growing food production sector in the world (FAO, 2014). However, diseases, especially bacterial infections, can be a significant limiting factor to its continued expansion. This necessitates the intensive use of antimicrobials in the industry (Du and Liu, 2012).

In recent years, a wide variety of chemicals have been used in aquaculture for fish health management. These include disinfectants (hydrogen peroxide and malachite green), anthelmintic (avermectin) and antibiotics (sulfonamide and tetracycline) (Rawn *et al*., 2009). However, the public health concern relating to the use of antibiotics in aquaculture is primarily the development of antibiotics-resistance and immunosuppressant conditions in humans (Cruz *et al*., 2012). It also includes the presence of antibiotic residues in aquaculture products and the environment (Romero-Geraldo and Hernández-Saavedra, 2014).

Hence, in order to ensure sustainable aquacultural development, diseases control strategies must go beyond antibiotics and chemotherapeutics, to new methods gaining recognition for controlling pathogens (Edun and Akinrotimi, 2011), which include the use of probiotics (Suvarna and Boby, 2005). Probiotics, the beneficial live microorganisms, are considered to promote growth, enhance the immunity of fish under stressful environmental conditions, as well as production of antibodies, acid phosphatase, lysozyme and antimicrobial peptides (Abareethan and Amsath, 2015).

Bacillus species, belonging to the phylum Firmicutes, are used in huge amount as human probiotics, and has shown remarkable health benefits (Rane and Markad, 2015). The genus *Bacillus* is a Gram-positive, catalase-positive bacterium, found in soil and the gastrointestinal tracts (GIT) of ruminants and humans (Casula and Cutting, 2002; Duc *et al*., 2003). *Bacillus subtilis* is rod-shaped, and can form a tough, protective endospore, allowing it to tolerate extreme environmental conditions (Barbosa *et al*., 2005). Some bacilli strains have been chosen for use in animal nutrition because of their beneficial effects (Busch *et al*., 2004). Consequently, the objective of this study was to examine the effects of *B. subtilis* on growth response, nutrient utilization, biochemical and haematological properties in African cat fish, *Clarias gariepinus* juveniles.

MATERIALS AND METHODS

The catfish, *C. gariepinus* used for this study were obtained from a reputable fish farm in Egbeda, Lagos State, and the experiment was carried out at the Nutrition Unit, Department of Marine Sciences, University of Lagos, Akoka, Lagos, Nigeria.

Bacterial Strain and Sub-culturing

B. subtilis U146A (NCBI accession number: JN255713) previously isolated from *iru* (an alkaline fermented legume seed condiment in Nigeria) (Adewumi *et al*., 2014), and deposited in the culture collection of the Department of Microbiology, University of Lagos, was incorporated into the fish diets. For sub-culturing a pure strain of *B. subtilis* U146A was inoculated into brain heart infusion broth (HiMedia, Mumbai, India) overnight at 37 ^{o}C in incubator shaker at 160 rpm. The broth culture was centrifuged at 8000 rpm for 7 min to make pellets, which were washed twice using phosphate buffer saline (PBS, pH 7.4), and re-suspended in PBS, corresponding to 10^5, 10^7 and 10^9 CFU/ml (Oguntoyinbo and Narbad, 2012).

Feed Formulation

Feed ingredients were sourced from Abattoir, Agege, Lagos, Nigeria. Five experimental diets with crude protein value of 35% and energy content of 3127 kCal were formulated with the following ingredients: fish meal, soybean meal, maize, wheat, dicalcium phosphate (DCP), oil, premix and salt. Measured quantities of all the ingredients were mixed, blended, and passed through a 2 mm die using a local pelletizer. The experimental diets consist of a control, i.e., Diet 1 without antibiotic or probiotics; Diet 2 had antibiotic (oxytetracycline) added to the formulated feed at 20 mg/100 g, while Diets 3, 4 and 5 had *B. subtilis* U146A at the graded levels of 10^5, 10^7, and 10^9 CFU/ml. After pelletizing, the feed was sundried to reduce moisture, after which it was packed in dry plastics. All experimental diets were kept at -20 ^{o}C till when required for the experimental feeding. The feed composition and formulation of the experimental diets are as shown in Table 1.

Table 1: Nutrient composition of experimental diets

			Graded probiotic inclusion levels		
Ingredients (%)	Diet 1 (Control)	Diet 2 (Oxytetracycline)	Diet 3 (10^5)	Diet 4 (10^7)	Diet 5 (10^9)
Fish meal	17.15	17.15	17.15	17.15	17.15
Soybean meal	19.10	19.10	19.10	19.10	19.10
Groundnut cake	19.10	19.10	19.10	19.10	19.10
Maize	20.40	20.40	20.40	20.40	20.40
Noodle waste	20.40	20.40	20.40	20.40	20.40
Palm oil	1.0	1.0	1.0	1.0	1.0
DCP	0.4	0.4	0.4	0.4	0.4
Lysine	0.2	0.2	0.2	0.2	0.2
Methionine	0.2	0.2	0.2	0.2	0.2
Mineral/vits. premix	1.5	1.5	1.5	1.5	1.5
Salt	0.2	0.2	0.2	0.2	0.2
Probiotics (CFU/mL)	-	-	10^5	10^7	10^9
Oxytetracycline	-	20mg/100g	-	-	-
Total	100	100	100	100	100
Calculated CP (%)	35	35	35	35	35
Cal. energy (kCal/kg)	3127	3127	3127	3127	3127

Vitamin A, 10,000,000 I.U.D.; D3, 2,000,000 I.U.D.; E, 23,000 mg; K3, 2,000 mg; B1, 3000 mg; B2, 6,000 mg; niacin, 50,000 mg; calcium pathonate,10,000 mg; B6, 5000 mg; B12, 25.0 mg; folic acid, 1,000 mg; biotin, 50.0 mg; choline chloride, 400,000 mg; manganese,120,000 mg; iron, 100,000 mg; copper, 8,500 mg; iodine, 1,500 mg; cobalt, 300 mg; selenium, 120 mg; antioxidant, 120,000 mg.

Experimental Procedure and Feeding Trials

The experiment was carried out in holding plastic tanks (52.5 × 33.5× 21cm^3). One hundred and fifty (150) juvenile cat fish (average weight = 94.33±0.67g) were acclimatized for 2 weeks prior to the commencement of experiment, and were fed *ad libitum* with control feed (35% crude protein and 3127 kCal/kg energy). Ten (10) fish were randomly allocated to five experimental treatments (T_1, T_2, T_3, T_4 and T_5) in three replicates at the end of the adaptation period. Water exchange was done thrice a week with de-chlorinated water supply from a borehole to maintain good water quality. The dissolved oxygen ranged from 4.5 to 6.0 mg/L, while pH and temperature ranged from 6.5 to 7.0, and 26 to 29 ^oC respectively, during the experimental period.

Growth and Nutrient Utilization Parameters

Fish sampling was carried out on a weekly basis by transferring fish from tanks into a weighing bowl. The weights of fish were taken using an electronic weighing balance (2000 ×

0.1 g), and after weighing fish were returned carefully into their respective tanks. The weight data were used to calculate other growth indices using the formulae below:

Mean Weight Gain (MWG) g

MWG = mean final body weight (MFW) – mean initial body weight (MIW)

Percentage weight gain (PWG) %

PWG (%) = 100 $(W_2-W_1)/W_1$

where W_2 = mean final body weight and W_1 = mean initial body weight

Specific growth rate (SGR) = $(Log_e W_2 – Log_e W_1)/(culture\ days)\times100$

where W_2 = final weight, W_1 = initial weight, e = natural logarithm, T = culture days.

Nutrient utilization indices were expressed in terms of Total Feed Intake (TFI), Feed Conversion Ratio (FCR), Protein Intake (PI) and Protein Efficiency Ratio (PER) using the formulae below:

Total Feed Intake (TFI) = Feed intake during experimental period (g)/Number of days

Feed Conversion Ratio (FCR) = Feed intake (dry weight of feed fed in g)/Fish wet weight gain in g

Protein Intake (PI) = Total feed intake/Protein content of feed

Protein Efficiency Ratio (PER) = Mean weight gain/Protein intake

Procedures for Collection of Blood Samples for Haematological and Biochemical Analysis

Haematological Analysis

At the 8th week of feeding, blood samples were collected with the aid of 2 mL syringes from the caudal vasculature of the fish from each treatment group, and emptied into Heparin bottles for haematological analysis at the Department of Medical Laboratory Sciences, Lagos University Teaching Hospital, Idi-Araba, Lagos. Haematological values were measured following standard methods (Blaxhall and Daisley, 1973; Joshi *et al*., 2002). White blood cells (WBC) and red blood cells (RBC) were counted by Neubauer's improved haemocytometer, using Turk's and Hyem's solutions as diluting fluids respectively, packed cell volume (PCV) and haemoglobin (Hb) concentration were analyzed using haematocrit and cyanmethemoglobin methods respectively. Mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were estimated using the standard method described by Dacie and Lewis (1991). Blood smear were stained using Grunwald-Giemsa stain, for lymphocytes and neutrophils examination (Tavares-Dias *et al*., 1999).

Biochemical Analysis

Blood samples were also collected and emptied into plain bottles for biochemical analysis at the Department of Clinical Chemistry laboratory, Lagos University Teaching Hospital, Idi-

Araba, Lagos. Blood samples were centrifuged at 3000 rpm for 10 min, while the serum obtained were stored at −20 ˚C prior to further analyses.

Serum enzymes: The aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities were determined according to Reitman and Frankel (1957) colometric method using Randox kits, while alkaline phosphatase activity was determined according to phenolphthalein monophosphate method (Babson *et al*., 1966).

Liver antioxidant enzymes: The liver was excised and homogenized in ice-cold 0.25 M sucrose buffer, pH 7.4. The homogenate was centrifuged at 5000 rpm for 15 min at 4 ^{o}C and preserved prior to analysis. Superoxide dismutase (SOD, units/mg protein) activity was determined by its ability to inhibit the auto-oxidation of epinephrine, determined by the increase in absorbance at 480 nm as described by Sun and Zigma (1978). The reaction mixture (3 mL) contained 2.95 mL of 0.05 M sodium carbonate buffer (pH 10.2), 0.02 mL of the blood sample and 0.03 mL of epinephrine in 0.005 N HCl. Catalase (CAT, µmol/mg protein) activity was determined according to Sinha (1972), wherein dichromatic acetic acid, following heating in the presence of H_2O_2, undergoes reduction to chromic acetate, with perchloric acid being formed; this was analyzed spectrophotometrically at 590 nm. The activity of glutathione (GSH, units/mg protein) was determined in the tissue homogenates using Ellman's reagent, 5-5-dithio-bis (2-nitrobenzoic acid) (DTNB) as a colouring reagent (Sedlak and Lindsay, 1968).

Statistical Analysis

Data were analyzed with one-way ANOVA, and means were compared using Duncan Multiple Range Test (Duncan, 1955) at significant level of 0.05. All computations were performed using statistical package IBM 20.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The results of growth and nutrient utilization parameters of *C. gariepinus* juveniles fed with experimental diets are as shown in Table 2. The results showed that the highest significant (p<0.05) mean weight gain was achieved with fish fed diet 5 (116.67±5.70), followed by diet 4 (103.17±3.79), diet 2 (103.00±4.16), diet 3 (96.42±6.43), and the least value by the group fed diet 1 (89.00±0.58). In addition, the highest percentage weight gain (PWG) was recorded by diet 5 (133.62±7.47%). This was significantly different (p<0.05) from other experimental groups, and the least value (94.35±0.91) was recorded for the control group. The highest values for total feed intake (154.63±7.19) and daily feed intake (3.16±0.15) were recorded among the groups of fish fed diet 2 (oxytetracycline); these values were significantly different (p<0.05) from other groups of fish fed probiotic diets. The best significant value (p<0.05) for feed conversion ratio (FCR) was recorded with diet 5 (1.17±0.04), while the least (1.60±0.06)

was recorded for the control diet. The PER for diets 1 and 5 recorded the lowest (2.54±0.02) and highest (3.27±0.18) values respectively, and were also significantly different (p<0.05) from other diets. No significant variation was observed in groups fed diets 2, 3 and 4 whereas, diets 1 and 2 fed groups differed significantly (p<0.05). Furthermore, no significant difference (p>0.05) was recorded in the values of protein intake (PI), with the exception of diets 1 and 2. The highest PI (54.12±2.52) was recorded by the group fed diet 2, while the group fed diet 5 recorded the least value (46.28±1.32). The groups of fish fed diet 2 (oxytetracycline) and diet 5 recorded the highest (154.63±7.19) and lowest (132.23±3.77) values for total feed intake (TFI), while the groups of fish fed with *B. subtilis* differed significantly (p< 0.05) from diets 1 and 2.

Table 2: Growth and nutrient utilization parameters of *C. gariepinus* juveniles fed with experimental diets, containing probiotic *Bacillus subtilis* U146A

Parameters	Diet 1 (Control)	Diet 2 (Oxytetracyline)	Diet 3 (10^5)	Diet 4 (10^7)	Diet 5 (10^9)
MFW g	183.33±0.88^{a}	197.00±5.03^{ab}	189.75±6.32^{a}	199.67±3.60^{ab}	212.33±5.57^{b}
MIW g	94.33±0.67	94.00±2.00	93.33±0.99	96.50±0.89	95.67±0.33
MWG g	89.00±0.58^{a}	103.00±4.16^{ab}	96.42±6.43^{a}	103.17±3.79^{ab}	116.67±5.70^{b}
PWG %	94.35±0.91^{a}	109.63±4.40^{ab}	103.31±7.17^{ab}	106.91±4.10^{ab}	133.62±7.47^{b}
SGR %/day	1.36±0.01^{a}	1.51±0.04^{ab}	1.44±0.07^{ab}	1.42±0.04^{ab}	1.58±0.07^{b}
TFI g	142.13±5.09^{ab}	154.63±7.19^{b}	133.72±2.74^{a}	136.23±6.00^{a}	132.23±3.77^{a}
DFI g/day	2.90±0.10^{ab}	3.16±0.15^{b}	2.73±0.06^{a}	2.78±0.12^{a}	2.70±0.08^{a}
FCR	1.60±0.06^{c}	1.50±0.03^{bc}	1.41±0.09^{bc}	1.37±0.06^{ab}	1.17±0.04^{a}
PER	2.54±0.02^{a}	2.94±0.12^{ab}	2.75±0.18^{ab}	2.86±0.11^{ab}	3.27±0.18^{b}
PI	49.75±1.78^{ab}	54.12±2.52^{b}	46.80±0.96^{a}	47.68±2.10^{a}	46.28±1.32^{a}

Values on the same row with different superscripts are significantly different (p<0.05). Mean final body weight (MFW), mean initial body weight (MIW), mean weight gain (MWG), percentage weight gain (PWG), specific growth rate (SGR), total feed intake (TFI), daily feed intake (DFI), feed conversion ratio (FCR), protein efficiency ratio (PER), protein intake (PI).

The effects of the *B. subtilis* U146A probiotic on the blood parameters of experimental fish are recorded in Table 3. Although, the values of the haemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), packed cell volume (PCV) decreased with the increasing inclusion of graded levels of probiotic and oxytetracycline. However, no significant difference (p>0.05) was recorded among dietary treatments. Equally, there was no significant difference (p>0.05) across all experimental groups in the following parameters; mean corpuscular haemoglobin concentration (MCHC), neutrophils (NEUT), lymphocytes (LYM), monocytes (MONO) except, mean corpuscular haemoglobin (MCH) in which diets 2 and 3 significantly different (p<0.05) from other experimental diets (Table 3).

Table 3: Haematological parameters of *C. gariepinus* juveniles fed with experimental diets, containing probiotic *Bacillus subtilis* U146A

Parameters	Diet 1 (Control)	Diet 2 (Oxytetracyline)	Diet 3 (10^5)	Diet 4 (10^7)	Diet 5 (10^9)
WBC X(10^9/L)	63.13±9.08	53.83±9.24	50.00±4.28	41.17±8.44	53.53±4.80
PCV (%)	39.23±2.63	32.27±1.18	33.35±1.58	28.07±5.39	35.40±1.97
Hb (g/L)	15.10±0.91	13.10±0.61	12.65±0.56	10.78±1.98	13.63±0.53
RBC X(10^9/L)	2.53±0.17	2.32±0.18	2.09±0.11	1.83±0.35	2.34±0.11
MCH(Pg)	155.13±3.40^{ab}	139.57±5.55^{a}	160.58±6.05^{b}	153.43±6.68^{ab}	151.22±4.01^{ab}
MCHC (g/L)	59.73±0.60	56.87±1.68	60.97±1.22	60.08±1.55	58.45±1.19
MONO (%)	38.53±0.95	40.77±0.44	38.10±0.93	39.63±2.43	38.72±1.04
LYM (%)	0.27±0.03	0.20±0.06	0.65±0.15	1.13±0.46	0.28±0.06
NEUT (%)	61.10±0.05	59.10±0.09	61.25±0.37	59.24±1.83	61.00±0.08

Values on the same row with different superscripts are significantly different (p<0.05) from each other. White blood cells (WBC), red blood cells (RBC), haemoglobin (Hb), packed cell volume (PCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), neutrophils (NEUT), lymphocytes (LYM), monocytes (MONO).

The biochemical characteristics of *C. gariepinus* fed diets with different levels of *B. subtilis* U146A and antibiotic are shown in Table 4. There was no significant difference (p>0.05) in the values recorded for AST, ALP and GSH across diets. Similarly, no significant difference (p>0.05) was found in values of ALT, with the exception of control (35.67±18.17), which differed significantly (p<0.05) across experimental diets. Likewise, SOD values were significantly high (p<0.05) in fish fed diet 4 (158.44±1.88) and antibiotic diet (157.81±5.73), which showed remarkable increase over other dietary groups. Furthermore, CAT values were significantly high (p<0.05) in fish fed control diet (655.22±89.48) and antibiotic diet (749.28±3.26), which also showed remarkable increase over other groups (Table 4).

Table 4: Biochemical parameters of *C. gariepinus* juveniles fed with experimental diets, containing probiotic *Bacillus subtilis* U146A

Parameters	Diet 1 (Control)	Diet 2 (Oxytetracyline)	Diet 3 (10^5)	Diet 4 (10^7)	Diet 5 (10^9)
AST (U/L)	65.67±16.76	63.33±14.08	60.83±12.48	58.00±5.26	59.20±4.53
ALT (U/L)	35.67±18.17^b	18.00±1.53^a	18.50±1.18^a	14.80±2.37^a	15.40±1.17^a
ALP (U/L)	12.00±0.58	16.33±1.86	12.33±1.67	12.40±0.51	12.40±1.60
GSH (units/mg protein)	49.92±11.02	44.08±1.31	41.54±16.04	42.17±2.67	50.11±4.56
SOD (units/mg protein)	145.47±3.18^b	157.81±5.73^c	139.22±4.67^b	158.44±1.88^c	82.70±1.66^a
CAT (µmol/mg protein)	655.22±89.48^b	749.28±3.26^b	522.80±113.79^a	453.62±67.08^a	391.16±21.81^a

Values on the same row with different superscripts are significantly different (p<0.05) from each other. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT), alkaline phosphatase (ALP), superoxide dismutase (SOD), catalase (CAT), reduced glutathione (GSH).

DISCUSSION

Probiotics, which are live microorganisms that confer health benefits on the host, have been used in aquaculture as a means of disease control, supplementing or even in some cases replacing the use of antimicrobial compounds (Tekinay and Davies, 2001**)**. In this study, the growth parameters of the experimental fish were significantly enhanced by the supplementation of the probiotic microorganism (*B. subtilis*) at all the inclusion rate, especially at the highest level. In addition, the group of fish fed diet 5 recorded the lowest total feed intake with highest mean weight gain. These results shows the beneficial effects of *B. subtilis*, which enhances gut functions, thereby helping the activities of endogenous enzymes like protease, whose main function is to digest protein into components required for tissue growth. This was corroborated by the work of Hauville *et al*. (2016), who reported positive results when they fed a mixture of commercial *Bacillus* to Florida pompano and common snook larvae during their early larval stages, to determine the effect on growth and digestive enzyme activities. Several other studies have demonstrated the positive effects of *Lactobacillus*

species on the growth response of gilthead sea bream (Suzer *et al.*, 2008), African catfish (Al-Dohail *et al.*, 2009), Persian sturgeon and beluga fry (Sarker *et al.*, 2010).

The possible reason for the improved growth performance of *C. gariepinus* after feeding with probiotic diets might be due to improved gut functions and feed efficiency of diet (Al-Dohail *et al.*, 2009), which ultimately stimulated the appetite of fish (Irianto and Austin, 2002). The enhanced growth could be due to the ability of *B. subtilis* to stimulate appetite and improve the absorption of nutrients (Wang *et al*., 2008). Other microorganisms such as *Agrobacterium* sp., *Pseudomonas* sp., *Brevibacterium* sp., *Microbacterium* sp. and *Staphylococcus* sp. have also been documented as having the potential to contribute to nutritional processes (Lara-Flores, 2011). Similar observations have been reported for the microbial flora of adult penaeid shrimp (*Penaeus chinensis*), where a complement of enzymes exists for digestion and synthesis of compounds that are assimilated by the animal (Mohammed, 2015). Also, there were reports that *B. subtilis* can improve the growth, survival and immune system of *Oreochromis niloticus* (Aly *et al*., 2008) and shrimp (*Penaeus monodon*) (Rengpipat *et al*., 2000).

Haematological parameters, especially PCV, total and differential leukocyte counts in the blood, provide an indication of the health status of the fish (Hrubec *et al*., 2000). Equally, blood characteristics of most fish have been studied to establish normal value range, and deviation from it may indicate a disruption in the physiological process of fish (Rainza-Paiva *et al*., 2000; Joshi *et al*., 2002). Consequently, the mean values obtained in this study were within the normal ranges recommended for *C. gariepinus* and also exhibited that its wellbeing is in good condition (Erhunmwunse and Ainerua, 2013).

Similarly, *O. niloticus* fed diet supplemented with *B. subtilis* (Soltan and El-Laithy, 2008) and *Pediococcus acidilactici* (Ferguson *et al.*, 2010) showed some variation, but no significant difference in Hb and PCV contents among control and the other experimental fish groups fed diet enriched with probiotics. On the contrary, Abd El-Rhman *et al*. (2009), reported significant effects on haematological parameters when probiotics were applied in Tilapia diet. The reason for this may be due to the different genera of probiotic bacteria used for feed formulations. *B. subtilis* was included in fish feed meal in this study, while *Micrococcus luteus* and *Pseudomonas* species were employed in the study conducted by Abd El-Rhman *et al*. (2009).

Modulation of immune system is one of the numerous benefits attributed to probiotics (Nayak, 2010). *B. subtilis* cells as probiotics have been reported to shape the immune system by their physiological action in the intestines, and upon colonizing the gut they trigger an immune response because the intestinal cells can produce a series of immunoregulatory molecules when stimulated by bacteria (Corcionivoschi *et al*., 2010). This was the case in the present study.

The results obtained on the effect of probiotics on biochemical indices showed that the control diet had the highest values for ALT and AST. In addition, the value of ALT for control group was significantly higher than other diets. This has revealed that the probiotic *B. subtilis* has positively modulated the above parameters, resulting in the improved health status of the fish. This was in agreement with the work of Adorian *et al*. (2019) who reported that liver enzymes (AST, ALT and ALP) were lower in fish fed diet supplemented with 1×10^6 CFU g^{-1} probiotic *Bacillus* compared with the control group.

Antioxidant enzymes are crucial in the effort to counteract oxidative stress caused by toxicants once the supply of other antioxidant compounds is depleted. These enzymes, which remove peroxides, and superoxide radicals including SOD, catalase and GSH are of essence in oxidative stress to deal with free radicals causing several disturbances (Saglam *et al*., 2014). Catalase degrades the hydrogen peroxide produced by the dismutation of superoxide ion by SOD during oxidative stress. In this study, the effect of *B. subtilis* has greatly suppressed the activities of antioxidant enzymes, particularly at the highest supplementation with probiotic, the values of SOD and CAT were greatly reduced. This further buttresses the fact that the group of fish fed probiotic were not under stress compared to the control and oxytetracycline groups. According to Han *et al*. (2016), SOD concentration increases with the intensity of stress, but the activity of catalase and GSH can vary depending upon the type of stress. This was further corroborated by the work of Shaheen *et al*. (2014) who reported that commercial feed supplemented with probiotic resulted in lower expression levels of glutathione peroxidase (GPx), SOD and cytochrome c oxidase subunit 1 (COX1), compared to the control feed in two yellow perch. They attributed the differences in gene expression to be due to the presence of probiotic, assuming a possible involvement in the modulation of the antioxidant system in the fish. Therefore, from this study we could conclude that among probiotic beneficial effects, is to provide protection against oxidative stress, and the ability to decline the risk of accumulation of reactive oxygen metabolites, which are harmful to the host.

CONCLUSION

The results obtained from this study show that *B. subtilis* modulates the gut microbes, thereby enhancing nutrients absorption and consequently improves the weight gain, at 10^9 CFU/mL level in the diet of *C. gariepinus* for a sustainable high productivity in African mud cat fish farming.

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PHYSICOCHEMICAL PROPERTIES OF FLOUR AND STARCH FROM TWO CASSAVA VARIETIES

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ABSTRACT

In this study, the physicochemical properties of flour and starch from two cassava varieties (TME 419 and TMS 326) were determined using standard methods. Cassava roots were obtained from University of Ilorin Agricultural research farm. Proximate composition of TME 419 cassava were different from that of TMS 326 roots. The two cassava roots had carbohydrate as their major components (approx. 84%). TMS 326 showed significantly higher protein, fats and ash contents than the TME 419 genotype. Amylose content (approx. 27 %) of TMS 326 starch was higher than TME 419 starch (approx. 22%). Cassava starch granules of both varieties had smooth surfaces with mostly round granules while some granules were spherical, elongated and irregular in shape. TME 419 had smaller granule (approx. 11 µm) compared to that of TMS 326 (13 µm). Both starch type showed the A-type crystallinity pattern. The peak gelatinisation temperature of TMS 326 starch (approx.71 ^{o}C) was higher than that of TME 419 starch (approx. 61^{o}C). Peak viscosity of TMS 326 starch was significantly ($p<0.05$) higher than that of TME 419 starch, which could be related to the higher amylose content. However, the peak viscosity of flour from TME 419 cassava was significantly ($p<0.05$) higher than that of TMS 326. Cassava starches displayed higher swelling power than the flour samples. TME 419 flour and starch showed higher swelling power and cold paste viscosity suggesting that the starch could be used as thickening agents in various food applications.

Keywords: Cassava, Flour, Starch, Pasting properties, Functional properties

INTRODUCTION

Root and tuber crops such as yam and cassava are second only in importance to cereals as a global source of carbohydrates (Oladipo *et al.,* 2017). However, cassava is the second most important tropical root crop in West Africa (Adisa *et al.,* 2015; Falola *et al.,* 2017). Cassava (*Manihot esculenta*) is a root crop that is consumed in many parts of the world. It is drought tolerant and can withstand harsh climatic conditions and can thrive well on poor soils and marginal lands (Ezui *et al.,* 2018). Cassava root is a starchy crop that has been processed into various forms for utilisation. For example, it may be processed into high quality cassava flour (HQCF). HQCF is an unfermented cassava product that has been successfully used as a partial and complete replacement for wheat flour in processing of bread, cookies, and other confectioneries (Maziya-Dixon *et al.,* 2017). In Nigeria and some parts of the tropics, cassava roots are processed into traditionally fermented food products such as *gari*, *fufu*, *elubo* and *tapioca* (Balogun *et al.,* 2012). Furthermore, cassava is considered a good source of dietary fibre which may be used to increase bulkiness and facilitate digestion. More importantly, cassava is also an important source of starch for various industrial applications.

Several factors such as processing methods, growing conditions and genotypic differences may influence the composition and physicochemical properties of cassava flour and starch. For instance, Janket *et al.,* (2018) studied the effect of varying seasons on starch accumulation and starch granule size in cassava genotypes grown in tropic Savana climate. These authors reported that amylose content of the extracted starch was greatly influenced by genotype. Furthermore, higher temperature and solar radiation received during October and December of the growing period resulted in significantly higher starch yield and starch content compared to those planted in other periods of the year (Janket *et al.,* 2018). Some authors similarly found significant variation in the pasting properties of two varieties of bitter yam (Oyeyinka *et al.,* 2018). Yellow bitter yam starch reportedly displayed lower peak viscosity compared with the white bitter yam starch (Oyeyinka *et al.,* 2018). Variation in the peak viscosities was associated with the differences in amylose contents. Other factors such as growing season and period of harvest may also influence starch granule size and amylose content, which may influence starch physicochemical properties and functionality. Asaoka *et al.,* (1991), found variation in granule size of starch extracted from cassava root grown at different seasons. In addition, the period of harvest reportedly altered the proportion of amylose in cassava starch (Sriroth *et al.,* 1999).

Different varieties of cassava have been bred to suit varying agro-ecological requirements and to have improved agronomic traits. However, these breeding efforts may alter composition of the roots and influence the functional properties of major components such as starch. Furthermore,

the functionality of flour and starch from different cassava varieties grown under the same conditions may show some variations. Thus, it may be important to understand the physicochemical properties of starch and flour from cassava varieties grown at different regions. In this study, the physiochemical functional properties of flour and starch from two cassava varieties (TMS 326 and TME 419) grown at University of Ilorin Agricultural farms were investigated.

MATERIALS AND METHODS

Materials

Fresh matured cassava roots of variety TMS 326 and TME 419 were harvested from the University of Ilorin, Agricultural research farm. The cassava roots were immediately transferred to the food processing laboratory in the Department of Home Economics and Food Science, University of Ilorin for processing. All other chemicals used were laboratory-grade.

Methods

Flour production

Cassava roots (2 kg) were peeled manually with stainless steel knife, washed with 25 litres of potable water to remove adhering soil and then grated using a grating machine powered by Lister Diesel engine (5-1 6HP 650RPM, UK). The grated cassava was packed in bags and pressed to remove excess water, thereby reducing the cyanide content. After pressing, the cassava mash was sun dried for a total period of 24 hrs, in a batch of 8 hrs a day. Dried samples were milled, sieved (sieve size: (180 µm) and samples were packaged in Ziplock bags prior to analyses.

Starch extraction

Cassava roots (2 kg) were processed as described above for flour except that after grinding, the mash was submerged in 25 litres of potable water and sieving was done using a muslin cloth into a fresh bowl of potable water. The extract was left to settle for 24 hrs. After settling, the supernatant was disposed and fresh water (10 litres) was added to the sediment. The washing procedure was repeated five times until a clean white starch was obtained. Starch slurry was pressed in a muslin cloth to remove excess water and the starch sample was sun dried for a total period of 24 hrs, in a batch of 8 hrs a day. Dried samples were milled, sieved (sieve size: (180 µm) and packaged in Ziplock bags prior to analyses.

Chemical Composition of Cassava Flour

Moisture, crude fat and total ash contents were determined using AOAC (2000) methods. Protein content was determined by the Kjeldahl method (6.25×N) and total carbohydrate was calculated by difference. Crude fibre were determined by standard laboratory procedure (Olagunju *et al.,* 2018). Mineral contents of the flour was determined as previously described using Inductively Coupled Plasma (ICP) spectroscopy (Amonsou *et al.,* 2014).

Microscopy and Objective Colour Measurement

Starch granule morphology was examined using a scanning electron microscope (EVO 15 HD, CarL Zeiss, Jena, Germany) with an accelerating potential of 4 KV. Briefly, a thin layer of the starch granule was mounted on the aluminium specimen holder with double-sided tape. Starch samples were coated with a thin film of gold for 2 min with a thickness of about 30 nm (Naidoo *et al.,* 2015).

The tristimulus L, a, b parameters of starch were determined after standardization with a white tile using a Colorflex-EZ bench top spectrophotometer (A60-1014-593, Hunter Associates, Reston, VA, USA). Digital color photos were taken in duplicate and values read directly from a digital print.

Amylose Contents

The iodine binding method previously reported was used to determine the amylose content of the extracted starches (Oyeyinka *et al.,* 2015).

X-ray Diffraction

X-ray diffraction patterns of cassava starches were done as described by Oyeyinka *et al.,* (2015).

Pasting Properties of Flour and Starch

The pasting properties of cassava flour and starch were examined using a Rapid Visco-Analyzer (Newport Scientific, Australia) as previously reported (Oyeyinka *et al.,* 2016a). Briefly, samples (2.8 g) were weighed into the test canister containing 25 ml of distilled water. The mixture was agitated by mixing manually before inserting the canister into the instrument. Starch was stirred at 960 rpm for 10 s before the shear input was decreased and held constant at 160 rpm during the subsequent heating and cooling cycles.

Swelling Power of Flour and Starch

Swelling power was determined as previously reported (Oyeyinka *et al.,* 2015). Briefly, a 1% flour or starch suspension in water was heated for 30 min from 50 to 90^{o}C with constant stirring. The suspension was centrifuged (model 5810R, Eppendorf International, Frankfurt, Germany) at 3400×g for 20 min at 25^{o}C and the supernatant discarded. Swelling power was obtained by

weighing the residue after centrifugation and dividing by the original weight of flour or starch on a dry weight basis.

Thermal Properties of Starch

The gelatinisation temperatures of the starch samples were determined using a differential scanning calorimeter (SDT Q600, USA) as previously reported (Oyeyinka *et al.,* 2016b). Briefly, starch (3 mg) was weighed into the aluminum DSC pan and distilled water (12 µl) added before the pan was sealed. Pans were allowed to equilibrate and samples were scanned at 10-110°C with an interval heating rate of 10°C/min. An empty pan was used as reference for all measurements.

Statistical Analysis

All analyses were performed in triplicate. Data were analysed using analysis of variance (ANOVA) and means were compared using the Fisher Least Significant Difference (LSD) test ($p < 0.05$).

RESULTS AND DISCUSSION

Proximate and Cyanide Composition of Cassava Flour

The proximate composition of flour from TMS 326 and TME 419 cassava roots were slightly different (Table 1). Carbohydrate (average of 84%) was the major component in the flour samples. TME 419 flour had slightly higher carbohydrate (85.44%) compared to TMS 326 (83.88%). Cassava is generally known to be rich in carbohydrates including starch. Uchechukwu-Agua *et al.,* (2015), similarly reported high carbohydrate content (83.63%) for TME 419 grown in Abia state, Nigeria. Other components of the flour samples such as crude protein (average of 0.89%), crude fat (average of 1.27%), crude fibre (average of 2.05%) and total ash (average of 2.25%) were generally low. Previous researchers working with five genotypes of cassava similarly reported low values for crude protein (1.2-1.8%), crude fat (0.1-0.8%), crude fibre (1.5-3.5%) and total ash (1.3-2.8%) contents (Charles *et al.,* 2005).

Cyanide content (7.7 mg/100 g) of TMS 326 was higher (almost double) than that of TME 419 (Table 1). The cyanide contents of cassava root in this study were much lower than values (12-13 mg/100 g) reported by previous authors (Idowu and Akindele, 1994; Oyeyinka *et al.,* 2019). However, some authors reported cyanide contents of 4.9 mg/100 g for cassava variety TME 419 grown in a different location (Uchechukwu-Agua *et al.,* 2015). Differences in the cyanide contents may be attributed to cassava variety used and the growing conditions. Other factor such as pH have also been suggested to influence the cyanide content of cassava (Uchechukwu-Agua *et al.,*

2015). Hydrogen cyanide is a well-known anti-nutritional factor in cassava roots and is toxic for humans when consumed above certain levels. For instance, consumption above 50-100 mg/kg cyanide has been linked with acute poisoning, with reported lethality in adults (Halstrøm and Møller, 1945).

Table 1: Proximate and cyanide composition of cassava flour (%)

Parameters	TMS 326	TME 419	Mean
Moisture	8.84±0.12	8.99±0.01	8.92
Protein	1.26±0.06	0.51±0.08	0.89
Fat	1.59±0.13	0.94±0.16	1.27
Fibre	1.95±0.08	2.15±0.14	2.05
Ash	2.50±0.03	1.99±0.09	2.25
Carbohydrate	83.88±0.12	85.00±0.05	84.44
Cyanide (mg/100 g)	7.70±0.05	4.30±0.01	6.00

Mineral Composition of Cassava Flour

The mineral composition of the cassava flours was similar with the exception of sodium and manganese (Table 2). Iron followed by magnesium, calcium and manganese were the major mineral in both cassava varieties. The values of magnesium and calcium obtained for both cassava flours are higher than the values reported previously (Charles *et al.,* 2005). Iron is essential for the formation of haemoglobin and oxygen transport; it is also needed for increases in the resistance to infection. This result shows a low value of sodium, phosphorus, zinc and copper for both cassava flour varieties and is in agreement with the literature (Charles *et al.,* 2005; Oboh and Akindahunsi, 2003).

Table 2: Mineral composition of cassava flour (mg/100 g)

Parameters	TMS 326	TME 419
Phosphorus	0.057	0.032
Zinc	0.045	0.046
Calcium	0.583	0.584
Copper	0.137	0.137
Manganese	0.371	0.585
Sodium	0.175	0.175
Magnesium	0.580	0.585
Iron	0.853	0.818

Amylose Content of Starches

The amylose content (approx. 27 %) of starch from TMS 326 was higher than TME 419 variety (approx. 22 %) (Figure 1). Differences in amylose content may be associated with inherent genetic differences in the plant species, botanical origin, physiological state of the plant and environmental growth conditions (Hoover *et al.,* 2010). In this study, both cassava varieties were grown under the same conditions and were harvested at the same time. Thus, inherent genetic differences between the two cassava varieties may account for the variation in amylose content. The ratio of amylose to amylopectin in starch is well-known to influence starch functional and physicochemical properties. The amylose contents of the starches in this study are higher than values (average of 19%) reported for starch extracted from two cassava varieties grown at two different locations in Colombia (Aldana and Quintero, 2013) but lower than value (29.29%) reported by other authors (Nwokocha *et al.,* 2009).

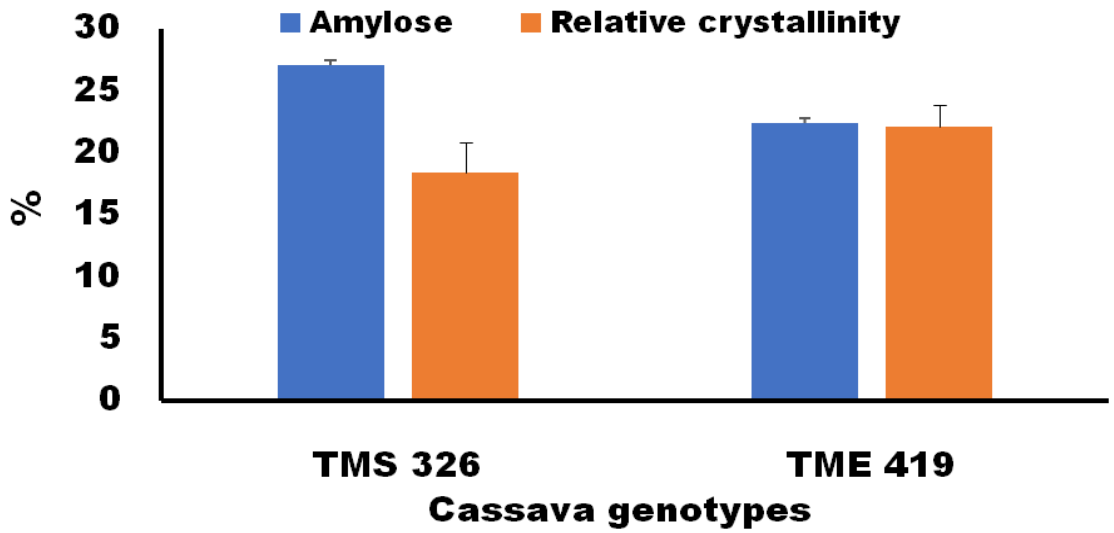

Figure 1: Amylose content of cassava starches
Error bars indicate standard deviation (N=2)

Microscopy and Colour of Cassava Starch

By scanning electron microscope (SEM), starches extracted from TMS 326 and TME 419 had mostly round granules with some granules spherical, elongated and irregular in shape (Figure 2). Previous studies described the starch from cassava as round or spherical while some were truncated (Zhu, 2015). TMS 326 starch granules appear bigger (1.2 times) compared to those of TME 419 (Figure 2). Differences in starch granules size may be attributed to the botanical origin as well as variety of the crop. Starch extracted from TMS 326 showed diameter ranging between 6 and 20 µm, while those of TME 419 ranged between 7 and 21 µm. The average diameter (12 µm) of the starch in this study is comparable to values (11.3-15.7 µm) reported by Wickramasinghe *et al.,* (2009) but slightly higher than value (8.42 µm) reported for cassava starch by other authors (Nwokocha *et al.,* 2009). All extracted starches were smooth with no fissures suggesting that these starches are relatively pure. Starch purity was assessed using the colour parameters (Table 3). The L* value indicates whiteness ranging from white (L*=100) to black (L*=0), a* value represents the value of colour in the region red (+a*) to green (−a*), while b* represents the colour range from yellow (+b*) to blue (−b*). Starch extracted from both cassava varieties had very high L* values (approx. 94), further confirming that the extracted

starches are pure. Previous studies associated high L* value with high level of purity in starch samples (Oyeyinka *et al.,* 2015).

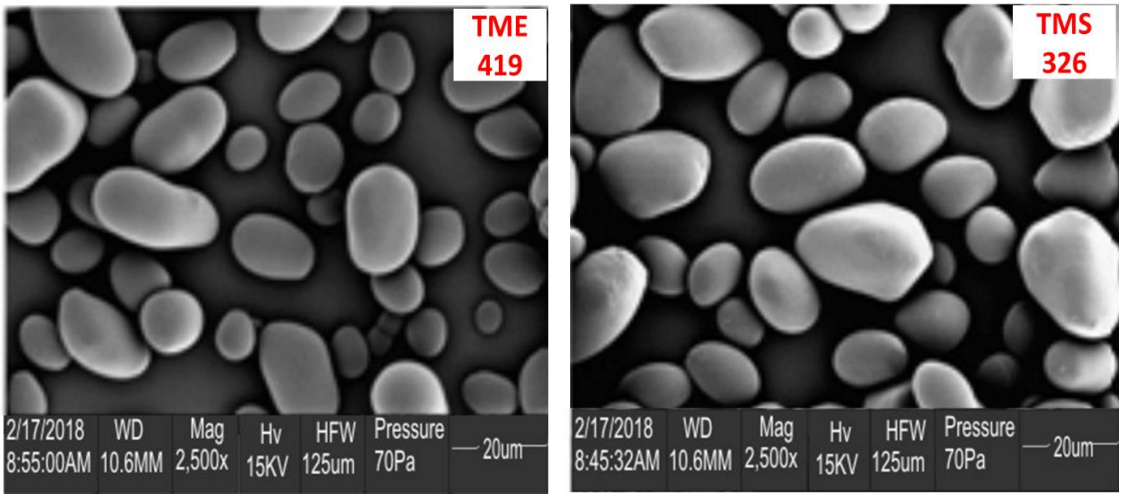

Figure 2: Microscopy of newly bred cassava starches

Table 3: Colour parameters of starch from two cassava genotypes

Parameters	TMS 326	TME 419
L*	93.2±1.75	96.3±0.31
a*	-0.67±0.03	-1.28±0.40
b*	4.66±0.05	4.65±0.33

Values expressed as Mean± Standard deviation.

X-ray Diffraction Pattern of Cassava Starch

The X-ray diffraction pattern of starches extracted from TME 419 and TMS 326 cassava roots is shown in Figure 3. Both starch samples exhibited strong peaks at 15, a doublet at 17 and 18 and another peak at 23 (2Θ), suggesting that the samples are A-type starch. Most of the studies reported for cassava starch in the literature similarly found the A-type crystalline pattern (Anggraini *et al.,* 2009; Charoenkul *et al.,* 2011; Nwokocha *et al.,* 2009). However, some authors found the C_a-type for cassava starch (Asaoka *et al.,* 1991, 1993; Safo-Kantanka and Owusu-Nipah, 1992). Starch may show different crystallinity pattern such as type A, B and C

depending on the botanical origin of the starch (Imberty and Perez, 1988). The differences in the crystalline types are in their packing arrangements and helical water contents. In general, A-type crystallinity is reported for cereal starches, B-type for tuber starches and C-type for legume starches. Many factors such as processing conditions may influence the crystalline patterns of starch. For example, previous research found that increasing the moisture content of starch led to a change of crystalline pattern from A-type to the C-type (Da Cruz Francisco *et al.,* 1996).

The relative crystallinity (RC) of starch from TMS 326 (18.4%) was lower than that of TME 419 (22.1%) (Figure 1). The lower RC of TMS 326 may be explained by its high amylose content (Figure 1). Starch RC is inversely related to the amylose content since the side chains of amylopectin forms the crystalline structure in starches (Sandhu and Lim, 2008).

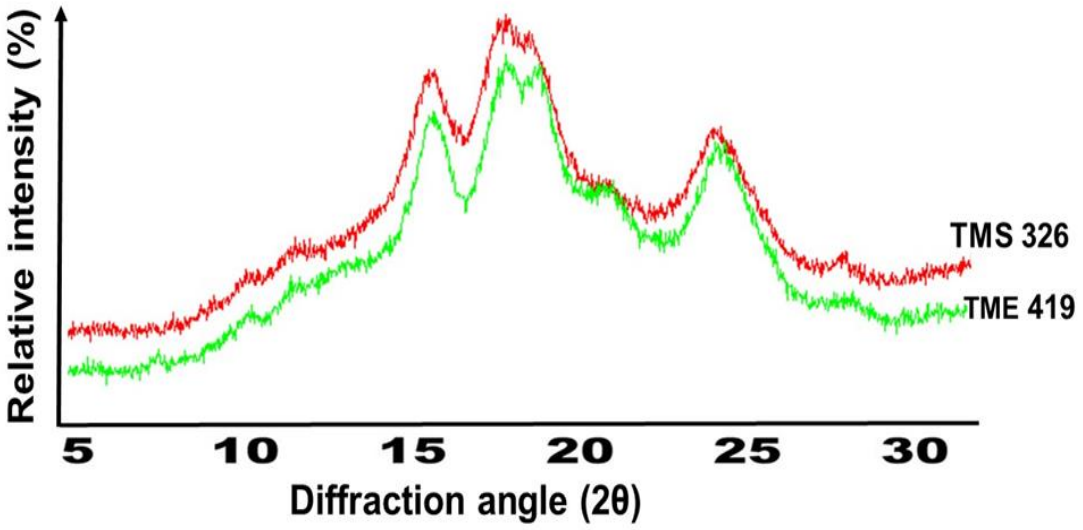

Figure 3: Diffractograms of cassava starches

Pasting Properties of Cassava Flour and Starch

The pasting properties of starches and flours were significantly ($p<0.05$) different between the two cassava varieties (Table 4). Peak viscosity which represents the swelling peak was higher for the starch samples compared with the flour. This is expected because the presence of non-starch components such as fibre and proteins may limit the absorption of water resulting in lower peak viscosity. Cassava flour from TMS 326 had higher fat (1.59%) and protein (1.26%) contents (Table 1), which may account for the lower swelling power compared with the flour from TME 419

cassava. The peak viscosity of the starch samples showed a different trend between the two cassava varieties. TMS 326 starch had higher peak viscosity (480.5 RVU) than the TME 419 sample (439.1 RVU). Several factors including starch granule size, chain length distribution of amylopectin chain and amylose content may influence the peak viscosity of starch. In general, low amylose starch displays high peak viscosity. However, in this study, TME 419 with a lower amylose (22.1%) showed low peak viscosity, suggesting that other factors were responsible for the variation in peak viscosity. Huang *et al.,* (2007), studied the effect of chain length distribution on the physicochemical properties of cowpea and chickpea starches. These authors reported that cowpea starch with more proportions of long chain amylopectin exhibited higher peak viscosity (Huang *et al.,* 2007). Thus, it seems TMS 326 has higher proportions of long chain amylopectin.

Cold paste viscosities of flour and starch samples were generally higher than their hot paste viscosities (Table 4). This could be due to the influence of temperature on viscosity of biological materials. Starch extracted from TME 419 had significantly higher cold paste viscosity (599.9 RVU) than starch from TMS 326 (349.9 RVU), which could be due to the difference in carbohydrate contents (Table 1).

Breakdown viscosity measures the susceptibility of the starch granule to disintegrate during heating and this may affect the stability of the flour product (Oyeyinka *et al.,* 2019). The breakdown viscosity of the flours (approx. 211) is significantly different compared to that of starch (approx. 158) (Table 4).

The pasting temperature of TMS 326 (80.1^{o}C) and TME 419 (76.3^{o}C) starches are within the range of the values (60-80^{o}C) previously reported for tuber starches (Ezeocha and Okafor, 2016; Farhat *et al.,* 1999). Pasting temperature represent the temperature at which the sample will cook. The variation in pasting temperature of the extracted starches could be due to differences in the granules size (Figure 2). TMS 326 starch samples were bigger than the TME 419. Bigger starch granules may require longer time to hydrate and melt compared with starch granules that are small.

Table 4: Pasting properties of starch extracted from two cassava genotypes

Parameters	TMS 326		TME 419	
	Flour	Starch	Flour	Starch
PV (RVU)	256.8^{d}±5.32	480.5^{a}±9.70	337.7^{c}±1.68	439.1^{b}±16.7
HPV (RVU)	80.2^{c}±0.35	255.1^{b}±3.92	80.9^{c}±0.79	335.7^{a}±4.82
CPV (RVU)	195.9^{c}±3.58	349.9^{b}±0.95	162.8^{d}±0.15	599.9^{a}±0.37
BDV (RVU)	169.3^{c}±1.04	221.2^{b}±0.25	252.9^{a}±4.39	94.9^{d}±0.04
PT (^{o}C)	70.7^{c}±0.35	80.1^{a}±0.04	63.8^{b}±0.91	76.3^{b}±0.70
Peak time (min)	5.88^{a}±0.13	4.26^{c}±0.03	4.48^{b}±0.02	4.39^{bc}±0.02

Mean± SD. Mean with different superscript along the row are significantly different (p<0.05)
PV: Peak viscosity; HPV: Hot paste viscosity; CPV: Cold paste viscosity; BDV: Breakdown viscosity; PT: Pasting temperature.

Thermal Properties of Cassava Starch

TMS 326 showed a significantly ($p < 0.05$) higher onset gelatinisation (T_o), peak gelatinisation (T_p) and conclusion gelatinisation temperatures (T_c) compared with TME 419 (Table 5). The differences in gelatinisation temperatures between the two cassava genotypes could be related to the higher amylose content of TMS 326 (Figure 1). Furthermore, it has been suggested that the gelatinisation temperatures of starch depends on the distribution of short chains amylopectin rather than the proportion of amylose to amylopectin (Noda *et al.,* 1996). Starches with abundant short chain amylopectin will generally display low gelatinisation temperature compared with those with longer amylopectin chains. Earlier studies reported a higher peak viscosity for cowpea starch with more proportions of long chain amylopectin (Huang *et al.,* 2007). Noda *et al.,* (1996), also reported that low values of peak viscosity in sweet potato and wheat starches was due to the presence of abundant short amylopectin chains. Thus, it seems that TME 419 has higher proportion of short amylopectin chains and this possibly explains the lower peak viscosity of TME 419 starch (Table 4) and agrees with the small granule size of the starch (Figure 2). TME 419 showed a higher gelatinisation enthalpy (4.42 J/g) than that of TMS 326 (3.88 J/g) (Table 5). The gelatinisation enthalpy (ΔH) of the starch granules is associated with the energy required for breaking of double helices. It is a reflection of the loss of double helical order (Cooke and Gidley 1992) or the overall crystallinity of amylopectin (Tester and Morrison, 1990).

Table 5: Thermal properties of starch from two cassava genotypes

Samples	T_o (°C)	T_p(°C)	T_c(°C)	ΔH (J/g)
TMS 326	67.60±0.71	71.48±0.04	76.10±0.57	3.88±0.01
TME 419	54.97±0.07	61.11±0.98	73.65±1.20	4.42±0.07

T_o: Onset gelatinisation temperature; T_p: Peak gelatinisation temperature; T_c: Conclusion gelatinisation temperature; ΔH: Gelatinisation enthalpy

Swelling Power of Cassava Flour and Starch

The swelling power of cassava flours and starches generally increased with increase in temperature (Figure 4). Cassava starches showed significantly higher swelling than their flour counterparts. This is expected because starch is relatively pure while flour contains other minor constituents which limit the rate of swelling. Starch extracted from TME 419 cassava root displayed higher swelling than TMS 329, which could be attributed to the lower amylose content (Figure 1) and smaller granule size (Figure 2) of the TME 419 starch. Previous studies indicated that starches with low amylose content will exhibit higher swelling power (Oyeyinka *et al.,* 2015). Other factors such as botanical sources, starch granule size, the magnitude of interactions between amorphous and crystalline regions may also influence the swelling power of starch (Naidoo *et al.,* 2015) and the molecular structure of amylose and amylopectin (Oyeyinka and Oyeyinka, 2018). In comparison with potato starch, the swelling power of the cassava starches in this study seems very low. This may be attributed to the high phosphate monoester content in potato starch which has been reported to contribute significantly to greater hydration and swelling of potato starch granules (Jane *et al.,* 1999; Mcpherson and Jane, 1999).

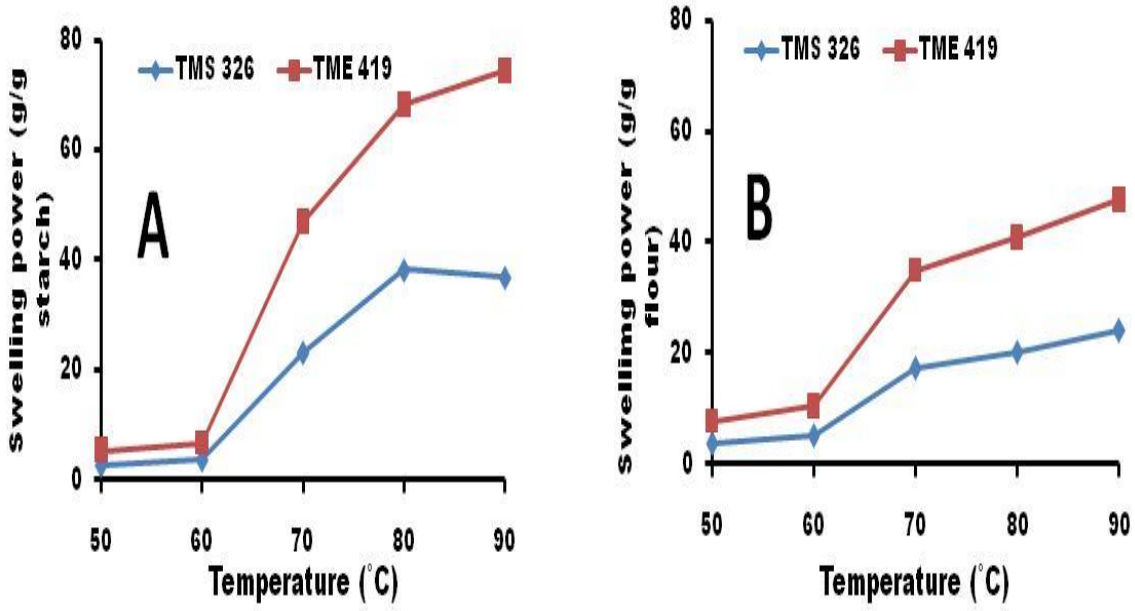

Figure 4: Swelling power of starch and flour from two cassava genotypes
A: Starch; B: Flour

CONCLUSION

Cassava varieties TME 419 and TMS 326 are good sources of carbohydrate including starch. TME 419 showed significant variations in proximate composition as compared to TMS 326. TMS 326 showed significantly higher crude protein, crude fats and total ash contents than the TME 419 root. Amylose contents of TMS 326 starch were higher than TME 419 starch. Cassava starch granules of both genotypes had smooth surfaces with round shapes and some portions being irregular, elongated, and spherical in shape. Both starch types showed the A-type crystalline pattern. The peak gelatinisation temperature of TMS 326 starch was higher than that of TME 419 starch. Starch peak viscosity of TMS 326 was significantly higher than that of TME 419, which could be related to the higher amylose content.

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INFLUENCE OF PLANT SPACING ON THE GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum Mill*.) VARIETIES

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ABSTRACT

Field studies on the effect of plant spacing on three varieties of tomato (*Lycopersicon esculentum Mill.)* was carried out at the Experimental Farm of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City. Three varieties of tomato and three spacing regimes were used. The experiments were laid out in 3x3 factorial combination in a randomized complete block design (RCBD) in three replications. The treatments had three varieties of tomato (Roma savanna, UC 82, and Roma VF) and three plant spacing regimes (75 cm x 40 cm, 75 cm x 50 cm, and 75 cm x 60 cm). The results obtained showed that the effect of variety on the vegetative characters was significant ($p \leq 0.05$) but did not follow a particular order. The narrowest spacing of 75 cm x 40 cm showed superiority in plant height and leaf area compared with the wider plant spacing of 75 cm x 50 cm and 75 cm x 60 cm. Roma savanna attained 50% flowering earlier and had the highest number of fruits per plant (10.01) and fruit yield (10.87 t/ha) compared with UC 82 (6.73 and 8.73 t/ha) and Roma VF varieties (7.66 and 8.28 t/ha). Significant yield differences were recorded in tomato plants spaced at 75 cm x 40 cm and 75 cm x 50 cm which produced statistically similar fruit yield of (10.41 t/ha) and (9.76 t/ha) respectively above the yield of (7.72 t/ha) obtained from plants spaced at 75 cm x 60 cm.

Keywords: Flowering, plants, Roma savanna, UC82, yield

INTRODUCTION

Tomato (*Lycopersicon esculentum)* production in Nigeria is constrained by many factors. These include shortage of improved varieties, disease and pest infestation, poor agronomic practices and poor postharvest handling. Although traditional agriculture was based on the use of low yielding varieties and low planting densities, attitudes moved in modern agriculture towards dense planting populations and use of varieties with high yield potential. Obtaining maximum yield depends on optimum planting density, cropping systems and the cultivar used (Dong *et al.,* 2013). Plant spacing is the most important factor that affects yield and fruit quality of tomato (Tesfaye, 2008). Khan *et al.,* (2002) also stated that plant population is one of the management practices that greatly influence tomato yield. The distance between row and plant depend on the production purpose, soil fertility and plant structure. According to Ibrahim (2012), plant density per unit area determines the optimal above the ground conditions that allow the plant to be affected by the growth factors, light, water, temperature, nutrition. These influence productivity and hence the final yield. Space is needed for weeding along and between rows, to create good air circulation and to allow each crop to grow to its determined size.

This study was therefore carried out to evaluate the growth and yield responses of three varieties of tomato (*Lycopersicon esculentum)* to plant spacing.

MATERIALS AND METHODS

Description of Experimental Area

The study was conducted during the dry cropping seasons of (October-February) 2015/16 and 2016/17 in the Experimental Farm of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The location lies between latitude 6° 14'N and 7° 34' N and longitude 5° 40' E and 6° 43' E. Meteorological data during the experimental period was obtained from Nigerian Institute for Oil Palm Research (NIFOR). The portion of land for the experiment had previously been cultivated with leafy

vegetables but was left fallow for one year and was over grown with mainly spear grass (*Imperata cylindrica*) and sensitive plant (*Mimosa pudica).*

Source of Seeds

Tomato seeds of three varieties, Roma Savanna, UC 82 and Roma VF were obtained from National Institute for Horticulture and Research (NIHORT).

Soil Sampling and Analysis

Before planting and after harvest, composite soil samples were collected from a depth of 0 – 30 cm using soil auger, air-dried and were crushed to pass through a 2 mm sieve and packaged for routine soil physical and chemical analysis according to standard laboratory procedures. Soil pH was determined using a pH meter. Organic carbon was determined by (Walkley and Black, 1962) wet oxidation method as modified by Jackson (1969). Total nitrogen was obtained by macro Kjeldahl method as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and P was estimated by the blue colour method of Murphy and Riley (1962). Exchangeable K and Na were determined using flame photometer, and Ca and Mg using the Atomic Absorption Spectrophotometer.

Treatments and Experimental Design

The experiment was a factorial combination of 3 × 3 in randomized complete block design (RCBD) with nine treatments in three replications. The treatments used for the trial were three varieties of tomato (Roma savanna, UC 82 and Roma VF) and three spacing regimes. (75 cm x 40 cm, 75 cm x 50 cm and 75 cm x 60 cm) which corresponded to 33,333, 25,925 and 22,222 plants ha^{-1} respectively. Each replicate had nine plots for a total of 27 plots in this experiment.

Cultural Practices

The land was cleared with the debris worked into the soil with a hoe. Beds for planting were prepared and tomato seeds were sown in the nursery. Plots were mulched to conserve soil moisture and suppress weeds. Two weeks before transplanting, the field was marked out and beds of 3 m x 1.8 m were prepared with 20 t/ha poultry manure as basal application applied thereafter, three weeks old tomato seedlings were transplanted to the field depending on the treatment and maintained till harvest.

Sampling and Measurements

Data collection commences four weeks after transplanting. Four plants were randomly selected from each plot and tagged for the purpose of collecting data. Vegetative growth, and yield components of tomato were evaluated. Vegetative growth parameters measured included plant height (cm), number of leaves, stem diameter (cm), leaf area $(cm)^2$ and number of branches while the yield components measured number of days to 50% flowering, number of flowers, number of fruits, fruit weight per plant (g) and fruit yield (t/ha).

Statistical Analysis

The data obtained were subjected to statistical Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) version 1998, following the model for factorial experiment in a randomized complete block design and differences among treatments means were separated using the Least Significant Difference (LSD) at ($p \leq 0.05$).

RESULTS

The meteorological data during the experimental period showed that the rainfall was sparse throughout the experimental period with no rain in December and January, 2015/16 and in January, 2017 which necessitated the need for irrigation (Table 1).

Table 1: Weather condition during the period of the experiment

Year	Weather condition	October	November	December	January	February	March
2015/16	Rainfall (mm)	247.80	62.80	0.00	0.00	126.10	80.45
	Temperature(°C)	25.36	27.40	26.75	26.05	25.75	24.70
	Relative humidity (%)	78.95	74.1	63.65	53.35	69.90	72.3
2016/17	Rainfall (mm)	157.70	58.80	31.10	0.00	7.00	155.10
	Temperature(°C)	39.00	33.60	33.60	34.90	34.70	33.50
	Relative humidity (%)	83.00	75.1	61.80	44.30	48.20	66.3

Source: Nigerian Institute for Oil Palm Research (NIFOR)

In Table 2, the physical and chemical properties of the soil used for the experiment gave the textural class as sandy loam. The organic carbon (0.40) g g^{-1}, total nitrogen (0.04)%, available phosphorus (3.33) mg/kg, were all below recommended critical levels of 0.15% N, 10 – 16 mg/kg P and 0.34 cmol/kg K for crop production. Hence the need for additional nutrient amendments to the soil. The effect of variety on plant height was significant ($p \leq 0.05$). Roma Savanna had the highest plant height though it was statistically same with the UC 82 variety while Roma VF variety had the lowest plant height (Table 3). Plant spacing increased plant height significantly as spacing decreased. The narrowest spacing of 75cm x 40 cm produced significantly highest plant height. The number of leaves were significantly increased by the varieties used, Roma savanna produced significantly higher number of leaves (191.87) above Roma VF (147.64) while the narrower spacing of 75cm x 40 cm and 75cm x 50 cm increased number of leaves (214.12 and 171.37) respectively above the wider spacing of which produced (132.61). The effect of variety on stem

diameter was not significant but it ranged from 1.59 cm - 2.85 cm for varieties and 1.66 cm - 3.01 cm for plant spacing (Table 3). However, the effect of variety was significant for the number of branches and leaf area and these followed a similar trend UC82, produced the least number of branches (12.51) and leaf area (133.13 cm^2). Leaf area of tomato decreased with increase in spacing. The highest value (145.94 cm^2) for leaf area was recorded for the narrowest spacing of 75 cm x 40 cm while wider spacing of 75cm x 60 cm produced the least number of branches (11.26) and leaf area (129.15 cm^2). There were significant differences among treatments for effect of varieties on number of days to 50% flowering. Roma savanna variety attained 50% flowering (21.56) earlier than UC82 (28.00) and Roma VF (28.77). However, 50 % flowering, number of flowers per plant and fruit yield (t/ha) decreased with increase in spacing (Table 4). The highest fruit yield (10.87 t/ha) was produced by Roma savanna followed by UC 82 (8.73 t/ha) and then Roma VF (8.28 t/ha) which were statistically similar. The 75 cm x 40 cm spacing produced the highest fruit yield (10.41 t/ha) but was statistically similar to 75cm x 50cm spacing whose fruit yield was (9.76 t/ha). The lowest fruit yield (7.72 t/ha) was produced by the widest spacing of 75 cm x 60 cm.

Table 2: Physical and chemical properties of the experimental soils before planting and after planting

Soil properties	Before Planting	After Planting
pH (H_2O)	5.16	5.23
Organic Matter (g $100g^{-1}$)	0.40	0.79
Total N ($g100g^{-1}$)	0.04	0.03
Total P (mg kg^{-1})	3.33	20.69
K (cmol kg^{-1})	0.14	0.16
Ca (cmol kg^{-1})	1.30	1.20
Mg(cmol kg^{-1})	0.70	0.60
Sand (%)	66.43	66.87
Clay (%)	25.20	18.65
Silt (%)	8.00	8.12
Textural class	Sandy loam	

TABLE 3: Effect of varieties and spacing on some vegetative growth components of tomato (*Lycopersicon esculentum*) **per plant**

Treatment	Plant height (cm)	No. of leaves	No. of branches	Stem diameter (cm)	Leaf area (cm^2)
Varieties					
Roma savanna	57.24[a]	191.87[a]	12.17[ab]	1.59[a]	138.91[ab]
UC82	56.68[a]	172.59[ab]	11.56[b]	2.85[a]	133.13[b]
Roma VF	51.11[b]	147.64[b]	12.51[a]	2.02[a]	140.14[a]
Significance	*	*	*	N.S	*
LSD	3.52	49.36	0.83	1.87	6.42
Spacing(cm)					
75 x 40	59.89[a]	214.12[a]	12.58[a]	3.01[a]	145.94[a]
75 x 50	55.32[b]	171.37[ab]	12.39[a]	1.79[a]	137.08[b]
75 x 60	49.83[c]	132.61[b]	11.26[b]	1.66[a]	129.15[c]
Significance	*	*	*	NS	*
LSD	3.52	49.36	0.83	1.87	6.42

Means followed by the same letter in a column are not significantly different at 5% level of probability.

* Significant at 5% level of probability,

TABLE 4: Effects of varieties and spacing on yield and yield components of tomato (*Lycopersicon esculentum*)

Treatment	No of days to 50% flowering	No of flowers per plant	No of fruit per plant	Fruit wt per plant (g)	Fruit yield (t/ha)
Varieties					
Roma	21.56[b]	20.25[a]	10.01[a]	404.88[a]	10.87[a]
savanna					
UC82	28.00[a]	20.11[a]	6.73[b]	322.59[b]	8.73[b]
Roma VF	28.77[a]	18.33[a]	7.66[b]	310.32[b]	8.28[b]
Significance	*	NS	*	*	*
LSD	1.28	3.11	1.06	60.78	1.64
Spacing(cm)					
75 x 40	28.22[a]	23.44[a]	8.17[a]	324.63[a]	10.41[a]
75 x 50	26.22[b]	20.39[a]	7.98 [a]	383.24[a]	9.76 [a]
75 x 60	23.89[c]	14.85[b]	8.14 [a]	329.93[a]	7.72 [b]
Significance	*	*	NS	NS	*
LSD	1.28	3.11	1.06	60.78	1.64

Means followed by the same letter in a column are not significantly different at 5% level of probability.

* Significant at 5% level of probability,

DISCUSSION

The soil of the experimental site gave the textural class as sandy loam. The organic carbon, total nitrogen, available phosphorus, were all below recommended critical levels of 0.15% N, 10 – 16mg/kg P and 0.34 cmol/kg K for crop production (Aduayi *et al;* 2002). Fertilizer or manure application is required for optimum growth and yield of any crop in a nutrient deficient soil, hence the need for additional nutrient amendments to the soil. Previous findings revealed that tropical soils are usually deficient in one or more of the essential elements needed for crop growth (Adeoye and Agboola, 1985). The increase in plant height, number of leaves and most of the vegetative characters observed with the narrower spacing of 75 cm x 40 cm and 75 cm x 50 cm suggest that it could probably be the best spacings for these varieties of tomato plants. Plants under the closer spacings had adequate ground cover due to the tendency of plants to form canopy thereby conserving soil moisture, nutrients and regulating the soil temperature which could have resulted in a greater number of leaves and increase in plants height. The superiority observed in Roma savanna compared with the other two varieties in most of the yield and yield attributes is in accordance with the findings of (Law-Ogbomo and Egharevba, 2008) who reported that UC82 yielded low when compared with other varieties evaluated. The significant early flowering and subsequent highest fruit yield observed in Roma savanna is in agreement with the findings of Mehta and Asati (2008) and Sharma *et al.* (2009) who indicated that early flowering varieties would be beneficial for attaining higher yield of tomato. The decrease in the number of flowers per plant and in the fruit yield (t/ha) observed with the widest spacing suggests that the widest spacing of 75 cm x 60 cm would not be favourable and economical for these tomato varieties in this locality. The highest fruit yield obtained at the narrower spacing of 75 cm x 40 cm could also be attributed to the higher number of plants per unit area. Consequently, producing a greater number of fruits and fruit yield per hectare. Wider spacing reduced yield due to total reduction in plants per hectare and consequently spacing is not fully utilized. These results are evidently in accordance with those of Khan *et al.,* (2002) and Aliyu *et al*., (2008).

CONCLUSION AND RECOMMENDATION

This study shows that early flowering varieties have a beneficial effect for attaining higher yield of tomato. It was also observed that Roma savanna was superior to the other varieties in terms of the yield attributes. Increase in plant spacing from 75 cm x 40 cm to 75 cm x 60 cm resulted in decrease in some vegetative characters and fruit yield per hectare of tomato plant. Highest fruit yield was recorded with 75 cm x 40 cm though not statistically different from 75 cm x 50 cm for most parameters measured. In conclusion, Roma savanna variety produces the highest fruit yield (t/ha) at either 75 cm x 40 cm or 75 cm x 50 cm plant spacing and therefore should be recommended to farmers in this locality.

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EMPIRICAL ANALYSIS OF ADAPTATION STRATEGIES USED IN MITIGATING FLOOD RELATED LOSSES BY RICE FARMERS IN KWARA STATE, NIGERIA

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ABSTRACT

This study was designed to gain an insight into the adaptation strategies employed by smallholder rice farmers to mitigate flood losses as well as examine determinants of farmers' choice of adaptation strategy in Kwara State, Nigeria. Primary data were collected using semi-structured questionnaire administered to 240 smallholder rice farmers who were selected in a three-stage sampling procedure. Data were analyzed using descriptive statistics and multinomial logistic regression model. The study revealed majority (79.5%) of the rice farmers adopted the planting of early-maturing rice seedling variety so as to ensure early harvest before the peak of rainfall when floods are usually experienced. The least adopted strategy is the change of crop and upland cropping with only 2% of the rice farmers engaging in this. Educational status, past flood-related losses and savings positively influenced the adoption of early maturing rice varieties' relative to change of crop and upland cropping whereas household size and access to climate information had a negative influence on adoption of change in planting date relative to change of crop and upland cropping ($P < 0.05$). The study recommends an urgent need to address rice farmers' continuing dependence on flood plain farming in the study area through enlightening them on the locally adapted coping strategies such as upland cropping and planting of other crops.

Keywords: Climate change, Flooding, Multinomial logistic regression, Upland cropping

INTRODUCTION

Evidently, Nigeria has experienced devastating floods which affected millions of people and resulted in fiscal losses amounting to billions of US dollars (NEMA, 2013). In 2012, Nigeria experienced the worst flooding in over forty years as a result of heavy rainfall that lasted several days. The incidence affected 32 states with 24 considered severely affected (NEMA, 2013). The floods extended over a four-month period in the course of that year and affected 7.7 million people with more than 2 million other people considered as internally displaced. More than 5000 individuals suffered physical injuries along with over 5900 houses damaged; food crops were wiped away resulting in major threats to food security in the nation (Nkwunonwo *et al.,* 2015; Nemine, 2015). The National Emergency Management Agency (NEMA) estimated that a total of N2.29 trillion which represents 2.83 per cent of the rebased Gross Domestic Product of N81 million for 2013 was lost as a result of the floods (Okoruwa, 2014).

According to Anugwara and Emakpe (2013), the floods damaged over 1.9 million hectares of lands and reduced food production along flood plains. Rice production in the affected areas was reduced by 22.4%. The issue of flooding in Nigeria is one which requires urgent attention given its impact on agriculture especially on lowland rice production in the nation. With Nigeria being the highest rice producer in the West Africa sub-region (Kwari *et al.,* 2015), it is apparent that the country has high potentials yet unharnessed.

Flooding is unequivocally one of the major setbacks to rice production in Nigeria considering the common agricultural practice of farming along the flood plains of identified rivers. Flooding remains an issue of major concern given the threats it poses to food security and its negative impact on national wealth. According to Obalola & Tanko (2016), the huge reliance of agriculture in Nigeria on rainfall alone is becoming even more precarious in view of climate change. Nkwunonwo et al. (2015) debate that the impacts of flooding in Nigeria continue to trigger concerns for food security and as well vulnerability of the general public. In Nigeria, flooding and the means of addressing its challenges are issues of utmost concerns (Obeta, 2014). Serious damages from flooding incidences and the vulnerability of rural small holder farmers due to low capital has perpetually impacted negatively on their welfare and their ability to employ diverse adaptation techniques hence mitigating subsequent shock events is usually left to the government (Ajibade *et al.,* 2015).

Globally, many scholars have studied the behaviours of farmers in coping with agricultural risks, its effects and as well informal risk-sharing mechanisms among family and friends (Xu, 2000;

Chen *et al.,* 2005; Chen, 2007). Given the various constraints to rice production in Nigeria, of which flooding is cogent, farmers have been driven to seek ways of manoeuvering their challenges and this has made them gravitate towards developing some coping mechanism and adaptation strategy to enable them alleviate the issue which has supposedly perpetuated itself.
Asian Disaster Preparedness Center (2003) and Maskrey (2014) both noted that over the last two decades there has been a growing recognition of disaster management being most effective at the community level where specific local needs, resources as well as capacities are met. Several studies have indicated positive outcomes of community-based approaches in management of disasters worldwide (Zhang *et al.,* 2013; Zahari and Ariffin, 2013; Chen *et al.,* 2006). It is against this background that this study was carried out to gain insight into the various adaptation strategies employed post-2012 floods by affected rural rice farming households in Kwara State and also to identify factors that determine the farmers' choice of adaptation strategies. This study is justified because the locally devised coping strategies and adaptation mechanisms by the farmers are more feasible and realistic hence providing the rural farmers with sustainable approaches to tackling the challenge of flooding in their localities.

METHODOLOGY

Kwara State in Nigeria is the study area. The State was created in May 1967 as one of the twelve states that replaced the nation's four regions. Initially the State was known as West Central State before the name changed to Kwara, a local name for the Niger River. Kwara State, lies on Latitude 8^0 30 N and longitude 5^0 00 E of the equator and is situated in the transition zone between the forest savannah region of Nigeria, having Ilorin as the capital. Kwara State has an estimated population of about 2.5 million people (NPC, 2010), covers about 32,500 km² and consists of sixteen Local Government Areas (LGAs).

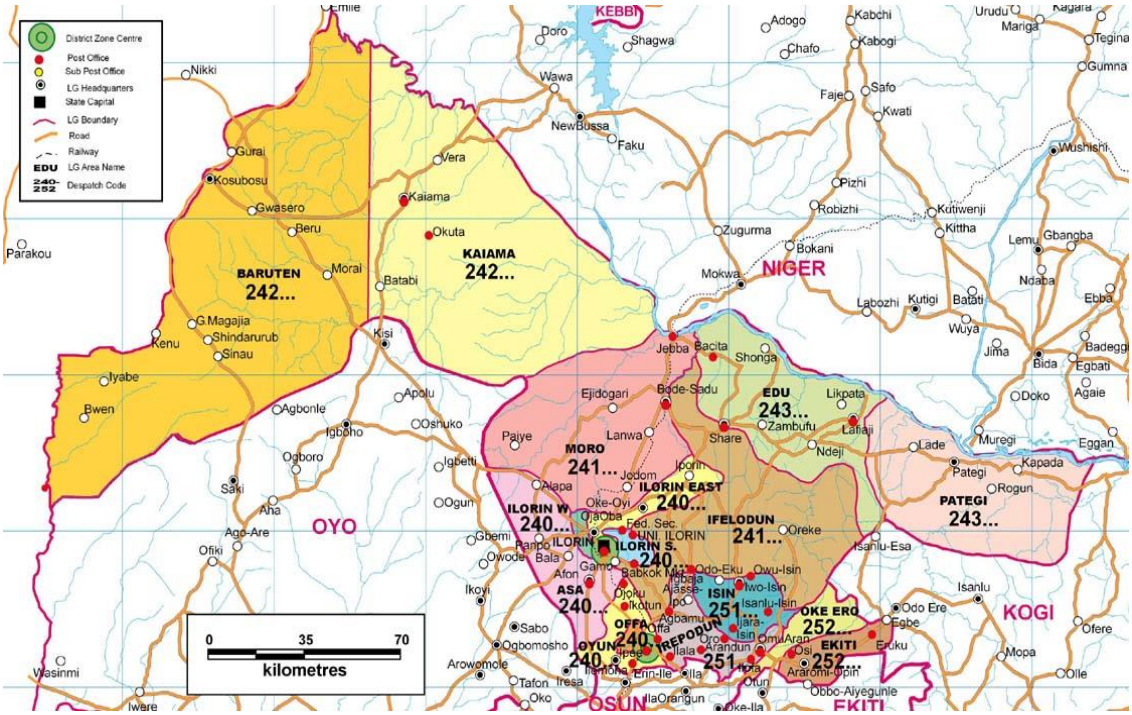

Figure 1. Map of Kwara State, Nigeria (Source: https://www.google.com.ph).

Kwara State has a total land mass of 32,500 square kilometres out of which 75.3% is cultivable (National Population Commission [NPC], 2010). Kwara State comprises rainforest in the southern parts with wooded savannah covering the larger part of the State. The soil is fertile and the state is well watered by the various tributaries of the Niger River which run through hills and valleys, none of which rise to any great height. The western section of the state is at a slightly higher altitude than the eastern. This is a summer rainfall area, with an annual rainfall range of 1000 mm to 1500 mm. The months of December and January coincide with the cold and dry harmattan period. Average maximum temperatures vary between 30°C and 35°C. Data used for this study were sourced primarily through the use of semi-structured questionnaire. Secondary information used in this study were sourced from journals, bulletins and reports of relevant agencies such as The Nigerian Meteorological Agency (NIMET), Kwara State Environmental Protection Agency (KWEPA), Nigerian Emergency Management Agency (NEMA) and Kwara State Agricultural Development Programme (KWADP).

A three-stage sampling technique was used in selecting the sample size for this study. The first stage involved the random selection of one of the five identified LGAs heavily affected by the

2012 flooding in Kwara State. The sampling frame includes: Edu, Ilorin South, Kaiama, Moro and Patigi. The selected Local Government Area was Patigi. The second stage involved random selection of 20 affected villages using the Kwara ADP village listing which comprised 663 villages. The randomly selected villages included Pkada, Bobagi, Emiworogi, Guluka, Gokpan, Ebu, Babogi, Jida, Duro, Kpevun, Wako, Gila, Kajika, Rokovi, Vabi, Chikangi, Dgakagi, Edogi, Gbaradogi, and Guluka. The third stage involved the random sampling of twelve (12) households from each of the twenty (20) selected villages to give a total number of 240 farmers.

In order to ascertain the various adaptation strategies utilized by affected rural rice farming households in Kwara State, descriptive statistics was used while the multinomial logistic regression model was used to identify factors that determine the farmers' choice of adaptation strategies. The empirical specification for examining the influence of explanatory variables on the rice farmers' choice of adaptation strategy against flooding (Y_i) is implicitly specified as follows:

$Y_i=f(X_1,X_2,X_3…X_n)$

$Y_i= \alpha + \sum\beta_iX_i + \mu_i \quad (\beta_i: i=1,2,3…n \; ; \; X_i: i=1,2,3…n)$

Where Y = 0 Change of Crop and Adoption of Upland Cropping, Y=1 Change of Variety and Planting Date, Y=2 Change of Planting date, Y=3 Change of rice variety; while the regressors X_1 = Farm Experience (in years), X_2 = Gender (1 for male and 0, otherwise), X_3 = Education (years), X_4 = Household size (persons), X_5 = Access to Yearly Climate Prediction (SRP: 1=have access, 0=otherwise), X_6 = Access to credit (1 = have access, 0 = otherwise), X_7 = Loss due to flooding (expressed in naira value of Output lost during the last flooding event in the farming season), X_8= Age (in years), X_9= Savings (Amount in Naira), X_{10}= Farm Size (Hectare), α = intercept, β= regression coefficient, μ_i = error term .

RESULTS AND DISCUSSION

Adaptation strategies devised by small-holder rice farmers in flood prone areas of Kwara State

Figure 2 gives a pictorial representation of the various flood adaptation strategies that were adopted by rice farmers in the study area. As revealed by the study, the smallholder rice farmers were more attuned to changing the variety of rice that they planted as a strategy to mitigate flood related losses.

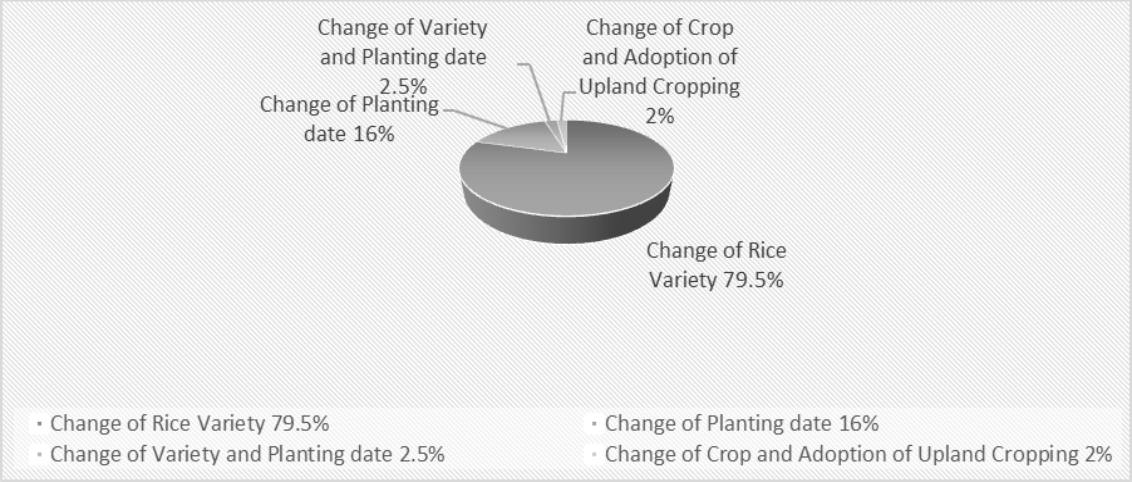

Figure 2: Flooding adaptation strategies adopted by rice farmers in the study area

As could be observed from the result in Figure 2, majority (79.5%) of the respondents adopted a change of rice seedling to a variety which matured earlier than the local rice and it may be said that this was to ensure early harvest of rice crops before the peak of rainfall when floods are usually experienced. Based on the focal group discussion held during survey in this study, one could observe a linkage between this adaptation strategy and the awareness programmes reportedly conducted for community members by various public and private entities such as Olam Nig. Ltd., Veetee Ltd. and also the agricultural extension work force which was operational in the study area. However, it is worthy of note that the information on such early maturing rice varieties was not fully explored by the rice farmers at the time of dissemination as there were still severe cases of rice losses due to flooding in 2012 despite the fact that the awareness had continually been created before then. Apparently, the major flooding of 2012 tipped numerous rice farmers towards adopting this strategy in the area. This finding is somewhat in tandem with Umoh (2013) which revealed that in the wetland regions of Ondo State, farmers plant flood resistant or flood tolerant varieties of crops they usually cultivate. As shown in the chart, up to 16% of the respondents adapted to flooding through a change in their planting date. This is in line with the findings of Mandal (2010) where it was stated that farmers try to minimize risk from various sources in their own way, often by adjusting the cropping pattern and/or cropping season.

Findings that the least adopted strategy (2%) in the study area was the adoption of change of crop and upland cropping may be attributed to the fact that farmers may be restrained by water availability and as well may not be open to such options considering the traditional method they

have used over the years which is basically planting along the flood plains of the Niger River. This is unanticipated as one would have expected that the upland cropping would be better explored given the innovation and technology which would readily facilitate irrigation of the farms. In Blade and Slinkard's (2002) research, diversification of crops was suggested as a risk reduction tool as well as inclusion of several species in a crop production plan such as to have the advantage of buffering low price in a specific crop. However, findings from this research indicate that such strategy has not been duly explored by rice farmers in Kwara State considering the low rate of adoption observed.

In order to examine the determinants of the rice farmers' choice of adaptation strategies in the study area, the multinomial logistic regression model was used and the result is as shown in Table 1. Change of crop and adoption of upland cropping was chosen as the reference category given that this strategy had the lowest frequency of occurrence.

Table 1: Determinants of the adoption of change of crop and upland cropping relative to adoption of other flood adaptation strategy by rice farmers in Kwara State.

	Change of Rice Variety		Change of Planting Date		Change of Variety and Planting Date		Change of Crop/Upland Cropping
Variables	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	
Intercept	-5.775	0.7549	-2.178	0.0953	-1.732	0.6510	9.685
	(11.86)		(2.36)		(1.06)		
Age of farmer	-0.743	0.0697	-0.851	0.1806	-0.482	0.7804	2.076
	(2.55)		(1.92)		(0.097)		
Gender	2.931	0.1425	40.83	0.6024	12.492	0.0826	-56.253
	(2.59)		(1.61)		(1.94)		
Education	2.497**	0.0387	3.826	0.3081	1.977**	0.0329	-47.3
	(17.19)		(0.51)		(0.81)		
Household size	-5.581	0.4593	-5.278**	0.0488	-5.456	0.0725	16.315
	(6.12)		(2.57)		(7.86)		
Access to climate information.	-34.766	0.6508	-6.32**	0.0038	-12.18**	0.0000	53.266
	(0.09)		(0.02)		(0.48)		
Access to credit	-0.743	0.3244	-0.002	0.0950	-0.001	0.9900	0.746
	(0.09)		(0.08)		(0.072)		
Flood related Losses	0.115	0.0962	0.783	0.9741	0.185**	0.0492	-1.083
	(0.04)		(0.04)		(0.014)		
Farming experience	1.009	0.2154	1.707	0.0859	0.041	0.9840	-2.757
	(3.43)		(18.61)		(3.59)		
Savings	1.568**	0.0471	0.002	0.3121	0.002**	0.0000	-1.572
	(0.027)		(0.026)		(1.02)		
Farm size	-3.906	0.7824	-4.353	0.2901	-9.323	0.9026	17.582
	(16.45)		(2.83)		(0.71)		
Log Likelihood Ratio (λ)	169.02**						
n	191		38		6		5

Source: Data Analysis **5% level of significance; Standard error in parenthesis

The multinomial logistic regression model fitting gave a test statistics value (λ) of 169.02 with the critical value significant at $p < 0.05$ which is an indication that the regression coefficients are significantly different from zero. This implies that the adaptation strategy groups are heterogeneous. As revealed in Table 1, level of education of the rice farmers and the savings were significant and positively influenced the adoption of change of rice varieties planted relative to change of crop and upland cropping. In other words, the level of education of rice farmers increased the probability of changing the variety of rice that the farmers planted by 2.497 relative to their opting for change of crop and upland cropping while the amount the rice farmers have in savings also increased the probability of adapting to flooding through changing of the rice variety planted relative to the change of crop and upland cropping.

In the case of the rice farmers adapting to flooding through changing of planting date, Table 1 revealed that the household size as well as access to climate information were significant and they both negatively influenced the adoption of change in planting date relative to change of crop and upland cropping. The size of the farming household decreased the probability of adapting to flood merely through change in the planting date by 5.278 relative to the use of change in crop and upland cropping strategy. This is in tandem with *apriori* expectation as a larger household size is expected to translate into more labour which may be very important when the farmer is taking decision to go for upland cropping rather than stay within the flood plains in a bid to reduce the labour required most especially when it comes to irrigation, crop management to mention a few. The rice farmers' access to climate information also reduced the probability of adapting to flood through change in planting date by a factor of 6.32 relative to adapting through change of crop and upland cropping which may be attributed to the fact that access to climate information would have equipped the rice farmers with adequate information on impending flooding and this may be a sort of red-alert or discouragement to the farmers making them risk averse and their likelihood to adopt the strategy of change of crop and upland cropping. From Table 1, it can be seen that in the case of the adaptation strategy involving change of variety and planting date, there were four variables that were significant and these include the educational level of the rice farmer, access to climate information, loss due to flooding and savings. The rice farmers' access to climate information negatively influenced their adaptation to flooding by changing the rice variety planted and the planting date relative to change of crop and upland cropping. The rice farmers' access to climate information reduced the probability of the farmer embracing the change in variety and planting date by 12.18 relative to the adaptation strategy of change of crop and upland cropping. The educational level of the rice farmer, past losses due to flooding and the

farmers' savings were all shown to have positive influence on the farmers' adaptation strategy of changing the plant variety and planting date relative to the change of crop and upland cropping. Educational level, past losses due to flooding and the farmers' savings increased the probability of the rice farmers adapting to flooding by changing the rice variety and planting date by 1.977, 0.185 and 0.002 respectively over the adaptation through change of crop and upland cropping.

This result corroborates that of Olayemi (2012) which reported that for every unit increase in age, years of formal education, farming experience and farm size of farmers there is probability of increase in coping strategies employed. It is also aligned with Adeloye and Sotomi (2013) which revealed that age, years of schooling and farming experience were significant in the adoption of coping strategies by young farmers in Osun State. The determinants of the adaptation strategy employed by farmers in the study area are also well in line with a study carried out in Faridpur by Biswas *et al.* (2015) where the variations in risk perception were influenced by various factors including age, gender, educational level, livelihood and socio-economic attributes whereas, to ensure their food cum nutritional security, farmers adopted diverse mitigation strategies like integrated farming system, changing cropping pattern, use of resistant, tolerant or hybrid varieties, good management practices, integrated pest management practices, appropriate diseases prevention and hygienic measures.

CONCLUSION AND RECOMMENDATIONS

There is the urgent need to address the respondent rice farmers' dependence on farming in the flood plains of the Niger River. It is paramount for the farmers to diversify their risks and take advantage of upland cropping of rice and even intensify efforts in the planting of other staple crops that are well suited to the area such as to be able to provide some form of buffer in the case of crop failures and flood related losses especially in this era of changing climate. Given that rice is of utmost importance in the diet of Nigerians its losses should be mitigated. Embracing the upland cropping and planting other crops such as grains, legumes, root and tuber crops will go a long way in securing or even improving the welfare of the respondent households in the study area, providing adjunct incomes to them. The government has been clamouring for a reduction in the import bills on rice annually, which is an indication of the need to gear up our level of rice production in Nigeria. In the bid to boost production, there is the need to guide against some avoidable losses which have somewhat remained unaddressed. An integrated irrigation scheme should be created to cater for communal farming needs as this is expected to encourage upland cultivation of rice away from river bodies thus reducing risk of flooding impacts on the rice growers. Likewise, there should be increased access to banking facilities in the vicinity of rice

farming communities as this will in turn encourage savings culture which impacts on the farmer's decision on strategies to employ against flooding challenges. There is the need to improve the farmer's level of knowledge and also to increase their access to timely and comprehensible information as related to climatic conditions as this will influence the farmers' agricultural planning and decision making in their efforts at imbibing strategies that will help them mitigate flood related losses. Farmers should have ready access to the seasonal rainfall prediction annual report (SRP) as this has proven to be fairly accurate and will be beneficial to farmers in decision making.

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GENDER DIFFERENTIALS IN FARMERS' INVOLVEMENT IN CASSAVA PRODUCTION ACTIVITIES IN ABIA STATE, NIGERIA

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ABSTRACT

This study assessed men and women differentials in cassava production activities in Abia State, Nigeria. A total of 120 cassava farmers comprising 60 men and 60 women were randomly selected. Data were collected with a structured questionnaire and analyzed using descriptive statistics, multiple regression and Z–test. Results show that the men had mean age of 44.5 years and 47 years for the women, majority 93.3% (men) and 81.6% (women) were married, most 61.6% (men) and 51.7% (women) attended secondary school and had mean farming experience of 14.9 years (men) and 12.7 years (women). The major sources of information on cassava production activities used by the farmers were Agricultural Development Programme (ADP) and fellow farmers. Results further showed that women were more involved ($\bar{x}$ = 2.0) than the male cassava farmers ($\bar{x}$ =1.8) in cassava production activities. The factors that influenced the men's involvement in cassava production activities were household size, farm income and farm size whereas marital status, farming experience and education were the major factors that influenced women's participation in the process. Meanwhile, there was a significant difference in the level of involvement of the men and women farmers in cassava production activities at 1.0% level of probability. The study concludes that women are more involved in cassava production activities than men. This study therefore recommends formulation of gender sensitive policies, land reforms, free and affordable education for women farmers for enhanced cassava production.

Keywords: Gender, Differentials, Cassava, Production, Activities

INTRODUCTION

Gender analysis of contribution to food output in rural households in Nigeria is an important aspect in the development of agriculture. This will ensure effective allocation of production resources within the rural households. Obinna and Nwaobiala (2015) noted that both men and women are involved in agricultural production activities taking into consideration the role they play. The problem of food shortages in Nigeria has been attributed to an acute dearth of male labour and a shift of farm responsibilities to the women following the findings of Olaoye (2014). There has also been a great disparity between women and men in the size of land holdings as well as their involvement in agricultural production (Agarwal, 2017).

Cassava is one of the major crops grown by the smallholder farmers in the southern and eastern part of Nigeria. At a growth rate of 5 per cent the annual cassava production in Nigeria has increased in 2014 from 38 million metric tons to 51million metric tons in the year 2017 (Federal Ministry of Agriculture & Rural Development, 2018). Before the Nigerian Civil war in south eastern Nigeria, from 1967-1970, cassava was regarded as a women's crop (Lagat and Maina, 2017). The National Root Crops Research Institute Umudike and International Institute for Tropical Agriculture Ibadan developed many cassava technologies such as; site selection, selection of improved varieties, making of ridges, planting of angle 45°, date of planting, spacing, weeding, fertilizer application, time of harvest and processing activities and they were transferred to farmers through ADPs for adoption and utilization in order to maximize profit (National Root Crops Research Institute, 2012; International Institute for Tropical Agriculture, 2010). Literature suggests that men are involved in cassava production and processing even though their level of involvement cannot be compared to their female counterparts. In view of this assertion, Odebode and Adetunji (2015) affirmed that there are different roles adult and young male and female play in cassava production activities. Okpara (2015) noted that men and women perform different functions, have unequal decision-making power and differences in access to agricultural production. As a result of these differences, their decisions, views, needs and priorities to improve their productive potentials also differ. It is not certain whether the level of involvement of men and women in cassava production activities are the same, as there is dearth of information in this regard. Hence, this study was undertaken to analyze the differentials in the level of involvement of men and women in cassava production activities in Abia State, Nigeria. The specific objectives of the study were to (i) describe the socio-economic characteristics of men and women cassava farmers in the study area; (ii) identify the farmers' sources of information on

cassava production activities; and to (iii) examine their involvement in cassava production activities.

Hypotheses of the Study

$H0_1$: Socio-economic characteristics of men and women cassava farmers do not influence their involvement in cassava production activities in the study area

$H0_2$: The involvement of male and female farmers in cassava production activities in the study area does not differ.

METHODOLOGY

The Study Area

The study area was Abia state, Nigeria. The state lies between Longitudes $7^0 23'$ and $8^0 2'$ east of the Equator and Latitudes $4^0 47'$ and $6^0 12'$ north of the Greenwich Meridian. The state is located East of Imo state and shares common boundaries with Anambra, Enugu and Ebonyi States on the North West, North and North East respectively. It is bounded by Cross River and Akwa Ibom States on the East and Southeast and Rivers State to the South.

Sampling Procedure and Sample Size

A multistage random sampling technique was used to select the cassava farmers. In the selection, two agricultural zones - Umuahia and Aba - were randomly selected out of the three agricultural zones that make up the state. In Umuahia agricultural zone, Ikwuano and Umuahia North blocks were selected while in Aba zone, Osiisoma and Isiala Ngwa South blocks were selected to give a total of four blocks. Three circles were randomly selected from each of the four blocks to give a total of 12 circles. From the 12 circles, five (5) men and women cassava farmers each were randomly selected to give a total sample size of 120 cassava farmers, comprising 60 men and 60 women cassava farmers.

Data Analysis

Descriptive statistics such as frequency counts, percentages and mean scores were used to realize the objectives of the study while the hypotheses were tested with multiple regression and Z - test analyses.

Measurement of Variables

In order to determine the levels of involvement of the men and women farmers in cassava production activities, a three-point Likert type rating scale of always=3, occasionally = 2 and never = 1 was used to measure their responses. The mean cut off mark was calculated by adding 3+2+1 = 6 divided by 3 to give 2.0. The following decision rule was obtained thus:

1.00- 1.50 (low), 1.51- 1.99 (moderate) and 2.0 and above (high)

Model Specifications

The four functional forms of regression-linear, exponential, double log and semi-log - were used to determine socio-economic factors influencing the farmers' involvement in cassava production activities in the study area. The four functional forms are explained in explicit form as:

The multiple regression analysis is stated thus

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, u_i)$

Where:

Y = levels of involvement men or women in cassava production activities (measured by number of involvement scores of the respondents)

X_1 = age (years)

X_2 = household size (numbers)

X_3 = farm income (naira)

X_4 = marital status (married = 1, otherwise = 0)

X_5 = farm size (hectares)

X_6 = farming experience (years)

X_7 = education (years)

X_8 = extension contact (numbers)

u_i = error term.

i. The mean difference of involvement of men and women in cassava production activities in the study area was tested using Z-test analysis

The model for Z-test analysis of comparison is specified thus:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

$n_1 + n_2$ - 2 degrees of freedom

Where

"Z" = "Z" statistic

$\bar{X}_1$ = sample mean of men involvement in cassava production activities

$\bar{X}_2$ = sample mean of women involvement in cassava production activities

σ^2_1 = standard deviation of men involvement in cassava production activities

σ^2_2 = standard deviation of women involvement in cassava production activities

n_1 = sample size for men cassava farmers

n_2 = sample size for women cassava farmers

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Farmers

Table 1 shows the socio-economic characteristics of the farmers. The table shows that the mean age of the men was 44.5 years and 47 years for the women. These results imply that the farmers were young, active and capable of undertaking activities involved in cassava farming. Michael (2014) posited that people of this age group constitute the major agricultural productive workforce. The majority of the farmers were married.

Table 1: Selected socio-economic characteristics of the respondents in the study area

Variables	Men (n = 60)	Standard Deviation	Women (n = 60)	Standard Deviation
Age (years)	44.5	± 39.7	47	± 42.8
Marital Status (%)	93.3		81.6	
Education (secondary) (%)	61.6		51.7	
Household Size (numbers)	6.5	± 4.8	6.2	± 4.4
Farming Experience (years)	14.9	±12.6	12.7	±10.4
Farm Size (hectares)	1.6	± 1.0	1.1	± 0.7

Source: *Field Survey, 2018*

About 62% of the men had secondary education while 51.7% of the women did. This result suggests that the farmers were literate and should have little or no difficulties in understanding, accepting and adopting innovations relating to cassava production. Nwaobiala (2017) reported that level of education of farmers enhances acceptance of innovations.

The mean farming experience of the men was 14.9 years while it was 12.7 years for the women. Experience gained by farmers in agricultural production activities helps them to bear the risk and uncertainties associated with farming. This concurs with the findings of Effiong, Ayanam and Umoh (2012) who reported that farmers' years of experience equips them to absorb shocks in farming.

The mean farm sizes of the respondents were 1.6 hectares for the men and 1.1 hectares for the women. This is expected because of the culture in the study area that suggests that women's right to land is not customary in Igbo land. The size of the land implies that the farmers were small scale farmers. This agrees with the findings of Arifin and Nirawal (2018).

The mean household size for the male farmers was 6.5 persons, while for the women it was 6.2 persons. Households has shown to be suppliers of farm labour for all farming activities. This result is in tandem with the findings of Aniedu (2016) who posited that the size of the household supplements farm labour thereby reducing cost.

Sources of Information on Cassava Production Technologies

Table 2 shows the distribution of the farmers according to their sources of information on cassava production technologies. The table shows that the majority of them, comprising 93.3% of the men and 81.7% of the women, sourced information on cassava production technologies from Agricultural Development Programmes (ADP). Similarly, 90% of the men and 88.3% of the

women sourced same from fellow farmers. The result suggests that fellow farmers who may be Agricultural Development Programme contact farmers play complementary role in disseminating innovations. The use of mass media is one of the fastest methods of technology dissemination, thereby informing farmers on latest available innovations (Badiru and Yekini, 2015).

Table 2: Distribution of respondents according to sources of information on cassava production technologies

	Men (n = 60)		Women (n = 60)	
Sources	**Frequency**	**Percentage***	**Frequency**	**Percentage***
Ministry of Agriculture/ ADP	56	93.3	49	81.7
Seminars/Workshops	7	11.7	9	15
Research Institutes	10	16.7	15	25
Television programmes	34	56.7	20	33.3
Radio programmes	38	63.3	39	65
Fellow famers	54	90	53	88.3
Personal observations	33	55	30	50

Source: *Field Survey, 2018*

*Multiple Responses Recorded

Involvement of Men in Cassava Production Activities

Figure 1 shows the pictorial representation of the level of men's involvement in cassava production activities. The figure shows that male cassava farmers were involved in site selection ($\bar{x}$ = 2.2) and making of ridges, planting date, planting spacing, fertilizer application and time of planting with mean scores of $\bar{x}$ = 2.0 respectively. The results infer that men farmers were moderately involved ($\bar{x}$ = 1.8) in cassava production activities. The result is in conformity with the findings of Okoroafor and Nwaobiala, (2014) who obtained a similar result among cassava farmers and processors in Abia state, Nigeria.

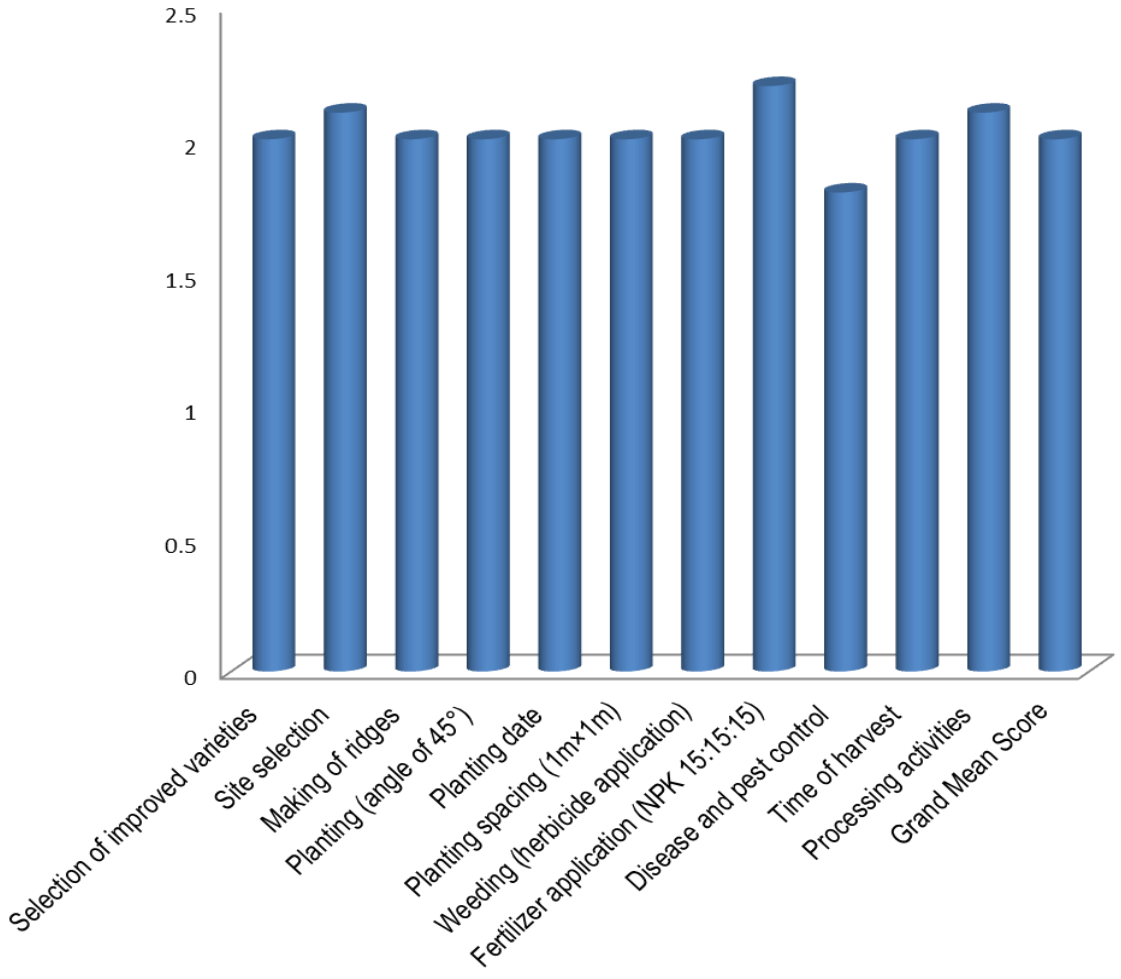

Figure 1: Mean Scores of Men Involvement in Cassava Production Activities

Involvement of Women in Cassava Production Activities

Figure 2 shows the involvement of women in cassava production activities. The result revealed that female cassava farmers were involved in site selection ($\bar{x}$ = 2.1) and selection of improved varieties, making of ridges, planting of angle 45°, date of planting, spacing, weeding, fertilizer application, Time of harvest and processing activities with mean score of $\bar{x}$ = 2.0 respectively. The grand mean score of female farmers were 2.0., indicating that women farmers were more involved than male farmers in cassava production activities in the study area. This result is in tandem with the findings of Etuk, Udoe and Okon (2018) and Nwakor et al., (2016) as they infer that women are more actively involved in both cassava production and processing activities in Nigeria.

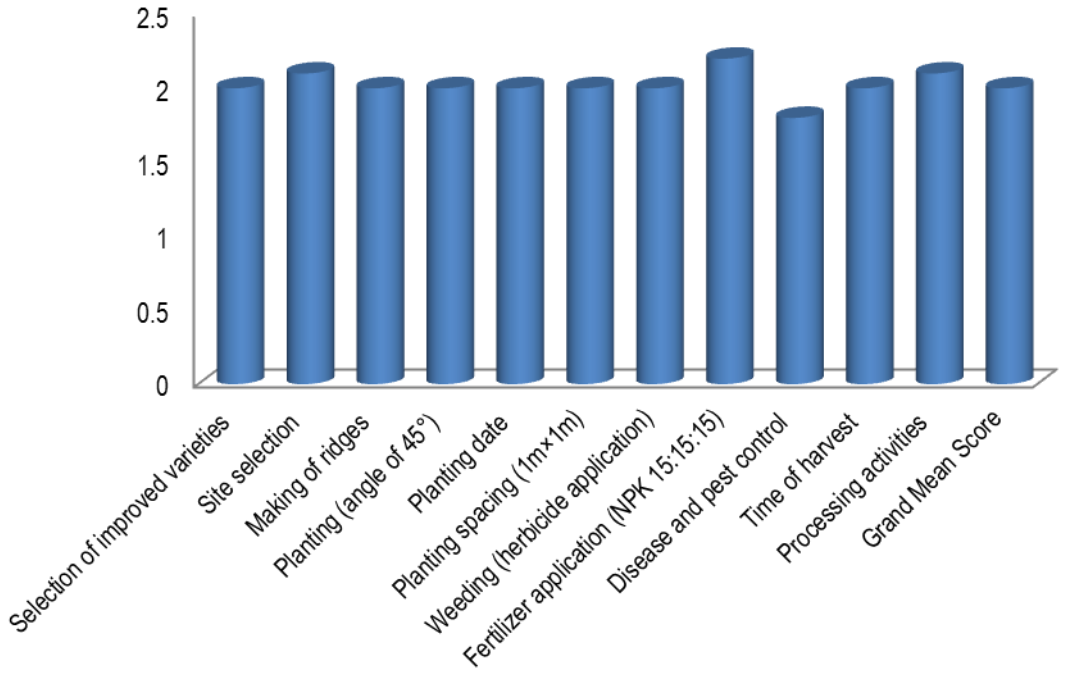

Figure 2: Mean Scores of Women Involvement in Cassava Production Activities

Determinants of the Level of Involvement of Men and Women Farmers in Cassava Production Activities

Table 3 shows the regression estimates of the determinants of men and women farmer's involvement in cassava production activities in the study area. The linear functional form was chosen on the lead because of higher R^2 value, number of significant factors and agreement with *a priori* expectation. The R^2 values of 0.5343 (men) and 0.5331 (women) explained 53.43% and 53.31% of the variation in their levels of involvement in cassava production activities in the study area. The F value of 1.91(men) and 1.94 (women) were significant at 10% level of probabilities indicating goodness of fit of the regression line.

Table 3: Linear regression estimates of the determinants of men and women cassava farmers' involvement in cassava production activities.

Variables	Men	Women
Constant	- 0.7274 (-0.06)	14.5267 (5.44***)
Age	0.1797 (1.22)	0.0147 (0.27)
Household size	0.8135 (1.88*)	0.1164 (0.66)
Farm income	0.00006 (3.13***)	-9.96x10-7 (-0.25)
Marital Status	5.4887 (1.38)	1.9073 (2.93**)
Farm size	4.4333 (3.64**)	0.2425 (0.46)
Farming experience	0.1569 (0.42)	0.1449 (2.83**)
Education	-0.1218 (-0.33)	0.1455 (2.98**)
Extension contact	-0.6632 (-0.75)	0.2760 (0.60)
R^2	0.5343	0.5331
Pseudo R	0.4118	0.4128
F – ratio	1.91*	1.94*

Source: *Stata Result Output*

*P≤ 10, ** P≤ 0.5 and ***P≤ 0.1

The coefficient of household size of the men farmers was positive and significant at 1.0% level of probability. This implies that any increase in household size will lead to a correspondent increase in the level of involvement in cassava production activities among the male farmers in the study area. This is expected because large household sizes may serve as a means of cheap labour for cassava production activities in the study area. This result is in consonance with Nwaobiala

(2018) who noted that relative large household size enhances the availability of labour for increased efficiency among farmers.

The coefficient of farm income of the male farmers was positive and significant at 1.0% level of probability. This implies that any increase in farm income will lead to a corresponding increase in their level of involvement in cassava production activities in the study area. This result agrees with the findings of Umunakwe et al. (2016) as they opined that farm income realized from any farming activity increases the levels of involvement.

The coefficient of farm size (men) was also positive and significant at 5.0% level of probability. This implies that any increase in farm size will lead to a corresponding increase in level of involvement in men cassava production activities in the study area. Farmers operating larger farms tend to have greater financial resources and access to credit to get more involved in cassava production activities. This corroborates the findings of Onyeneke et al. (2016) who suggested that farm size influences involvement of farmers in any farming activity.

In the female category, the coefficient of marital status was positive and significant at 5.0% level of probability. This implies that any increase in the number of women farmers whom were married will lead to a corresponding increase in the level of involvement in cassava production activities among the female farmers in the study area. This is expected probably because spouses make effective and better decisions and play different roles in production activities in the study area this result is in tandem with Tijani, Tijani and Audu (2018) who reported that decision by married people facilitate level of participation in cassava farming thereby reducing the constraint therein.

The coefficient of farming experience was also positive and significant at 5.0% level. This implies that any increase in farming experience will lead to a corresponding increase in their level of involvement in cassava production activities in the study area. This is probably because, with more experience they are better informed in role sharing for effective and efficient use of resources in the farm. The result is in consonance with the findings of Osondu, Emerole and Anyiro (2014) as they reported that farmers count more on their experience than educational attainment in order to increase in their productivity as a result of level of involvement in cassava production activities.

Similarly, the coefficient of education of the female farmers was positive and significant at 5.0% level of probability. This implies that any increase in level of education will lead to a corresponding increase in the level of involvement of women in cassava production activities in the study area. With more education farmers are more likely to adopt new technology and innovations, thereby increasing their level of involvement in cassava production activities. The

result corroborates with that of Abudu, Haruna, Idehen and Janiley (2014) who reported that education positively influence participation of farmers in agricultural activities.

Gender Difference in Level of Involvement in Cassava Production Activities

Table 4 shows test of significant difference in the level of involvement of male and female farmers in cassava production activities in the study area. The table shows mean level of involvement of 19.61 and 21.57 for the male and female farmers respectively. The results imply that there was a significant difference in men and women's involvement in cassava production activities in the study area. Result shows that the women were more involved in cassava production activities than the men. This result conforms the findings of Ejechi (2015); Adeoye and Ugala (2017) as they observed that cassava was mostly cultivated by women in South East, Nigeria.

Table 4: Test of significant difference in level of involvement of male and female cassava farmers in cassava production activities in the study area

Variables	Mean	Standard Deviation	Z-test
Level of involvement			
Male	19.6167	2.5184	-3.6205*
Female	21.5667	3.3262	

Source: *Field Survey*, *2018*

CONCLUSION AND RECOMMENDATIONS

The result from the study has proven that women farmers were more involved in cassava production than their men counterparts. Farmers also sourced cassava production technologies from Agricultural Development Programme and fellow farmers. Household size, farm income and farm size influenced male involvement in cassava production activities while marital status, farming experience and education influenced female involvement in cassava production activities in the study area.

The study therefore recommends

i. Formulation of policies, planning and preparation of projects/programmes by relevant agencies that would encourage gender sensitivity on cassava production is advocated.

ii. Since farm size influences male farmers involvement in cassava production activities, there is need to make more land available to both farmer groups in the study area. This will be achieved through land reform policies of the government.

iii. There is need to encourage experienced farmers to remain in farming by accessing farm inputs such as improved cassava cuttings and agrochemicals. This will be achieved through enlightenment programmes organized by relevant agencies.

iv. Policies on free and affordable education especially to the women farmers should be formulated. This will enhance their ability to access and process information on new cassava technologies for enhanced productivity.

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PHYSICAL CHARACTERISTICS OF STUDENTS' RESIDENTIAL ENVIRONMENT IN RELATION TO DIETARY HABITS IN UNIVERSITY OF ILORIN, NIGERIA

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ABSTRACT

The design of students' residential environment has implication on their dietary habits. This study, which was conducted through a cross-sectional survey of students' resident on-campus, describes the physical characteristics of students' residential environment in relation to dietary habits in University of Ilorin, Nigeria. A multi-stage sampling technique was adopted and twelve (12) residence halls were purposively selected out of the twenty (20) residence halls on campus based on three criteria, namely: ownership, gender and design type. The systematic selection of 12% of students in each of the twelve (12) residence halls gave a total of 430 students that were used in the study. The data for the study were collected through the use of self-administered questionnaire and personal observation. Statistical analysis was done using the Statistical Package for Social Scientists (SPSS) software. The analytical tools used for the study were mainly descriptive statistics such as frequency tables and percentages. The result of the data analysis revealed that most (67%) of the residence halls had kitchen en suite design and most (92%) had butteries and restaurants within them to enhance the cooking and eating habits of students. The result also revealed that most of the food outlets (72%) in the residential environment were mainly butteries and snack shops while few were restaurants (18%). The study recommends that developers and stakeholders in student housing should pay more attention to the provision of facilities such as kitchens and restaurants that would enhance the cooking and eating of students within the residential environment.

Keywords: Students' residential environment, Physical characteristics, University students, Cooking and eating

INTRODUCTION

Students' residential environments are integral parts of campuses that are expected to enhance the wellbeing of students as they live independently and take responsibility for all areas of life throughout their period of stay in the tertiary institution. University residential environments expose students to various lifestyle behaviours that can have immediate or long term health implications. Part of these lifestyle behaviours include nutritional intake (Brunt & Rhee, 2008). Students take responsibility for feeding and make food choices daily as they engage in many food-related activities on campus. Food is a basic necessity of life especially among young adults (Rahji & Rahji, 2014). Dietary habits may mean any task or action which has to do with food. These may include food acquisition, food preparation, food consumption and diet management. Preference for processed foods observed among students as a result of increased exposure to advertisements and easy access to supermarket, has become an issue of global concern (Akinleye & Rahji, 2006). This is because regular consumption of fast or processed foods is known to be associated with incessant rate of obesity and other diet-related illnesses particularly in developing countries (Duffey *et al,* 2009). This trend in fast food consumption is associated with increase in calories and poor diet quality because they lack basic nutrients needed for growth and cognitive development (Mancino, Todd & Lin, 2009). Other negative dietary habits common among university students include meal skipping and low fruit and vegetable consumption (Abdull-Hakim, Muniandy & Danish, 2012). These habits are influenced by poor food access and availability in the local environment (Chen & Yang, 2014).

The case of university students in developing countries like Nigeria is not different as the problem of poor dietary intake has been attributed to poverty (Otemuyiwa & Adewusi, 2013; Ahmadu & Edeoghon, 2018). Public universities in Nigeria used to operate the cafeteria system where the government took sole responsibility for the accommodation of all students on campus and the provision of quality dining facilities and services at subsidized rates. Since 1984, universities have witnessed massive increase in student population yearly without commensurate increase in the provision of housing facilities. This has led to the cessation of the cafeteria system, with students taking major responsibility for housing and feeding at increasing costs (National Universities Commission, 2003; Otemuyiwa & Adewusi, 2013). Students housing in Nigerian universities mainly comprise the on-campus and off-campus residential settings. Najib *et al* (2012) explained that on-campus housing is majorly situated on the campus environment, with the institution as the owner and manager while off-campus housing on the other hand is built and managed by private investors outside the campus premises. Student on-campus housing, which makes up the residential environment, bears much significance for institutions because it constitutes the largest facility asset of any

institution (Amole, 2009). As such, the design of student residential environment need to be specially considered because it creates the platform within which students make food choices and carry out domestic and social activities from day to day.

The University of Ilorin, a fast growing public university in North Central Nigeria has a unique residential environment setting as a result of the involvement of private developers in the provision of on-campus accommodation unlike other public universities where private developers only provide off-campus accommodation for students. This has led to an increase in the population of students accommodated on campus in recent time. The food behaviour of these students is important in maintaining good health and wellbeing all through their stay on campus and this is dependent on what is easily accessible by them in their residential environment (Chen & Yang, 2014).

Few studies have examined students' residential environments as they relate to dietary habits. For instance, Jaworowska and Bazylak (2007) estimated the nutrient intake as well as nutritional status of female pharmacy students in Bydgoszcz, and the relationship of these factors with the type of residence during an academic year. The result of the study revealed that the dietary intake of students residing with parents was poorer than students living away from family home. Brunt and Rhee, (2008); El Ansari, Stock, and Mikolajczyk, (2012); Laska, Larson, Neumark-sztainer, and Story, (2009), in their cross-sectional studies revealed the effects of on-campus, off-campus, and family home residential environment on students' food choices and consumption. The result of their studies revealed that nutrition habits of students differed according to their residential environment. Family, home and on-campus residents displayed healthier nutrition habits than those off-campus. On the contrary, Gonzales (2013) in his study on the impact of residence on dietary intake, food insecurity, and eating behavior among university undergraduate students revealed that residence type (on-campus, off-campus, and family home) did not have any impact on the dietary behaviour of students. Furthermore, issues related to living arrangements and eating behaviour among students seem exaggerated according to Mann and Blotnicky (2017) as healthy eating is only slightly influenced by type of residence (with parents, in apartments, or on-campus).

The residential environment in which students live have been observed to influence dietary habit in a measure. Students, especially those who live independently i.e. away from parent and family home have been reported to practice negative dietary habits which can have health implications especially as they grow older (Macino, Todd & Lin, 2009; Abdull-Hakim, Muniandy & Danish, 2012; Otemuyiwa & Adewusi, 2013). Several factors including a higher perception of stress, low self-esteem, lack of discipline and time, self-control, social support, product prices (costs), limited budgets, availability of and access to (healthy) food options and type of residence (i.e. with parents or away from family) were reported as important

influencing factors of students' dietary behaviours (Cartwright *et al,* 2003; Huntsinger & Luecken, 2004; Cluskey & Grobe, 2009; Greaney *et al,* 2009; Nelson, Kocos, Lytle, & Perry, 2009). However, it remains unknown whether the physical characteristics of students' residential environment affect their dietary habits. Knowledge of the influence of the physical attributes of students' residential environment in relation to dietary habits may be important in influencing students housing policy and making recommendations that can improve students' dietary behaviour. This cross-sectional study is therefore aimed at describing the physical characteristics of students' residential environment that are important for cooking and eating in University of Ilorin, Nigeria so that recommendations can be made to enhance student housing policy. The specific objectives were to: describe the socio-economic characteristics of students on campus residence halls (ii) determine the design of residence halls on campus with respect to kitchen arrangement and identify the additional facilities available that could aid students' eating habits, and to: (iii) examine the type and number of food outlets available within the students' residential environment.

METHODOLOGY

The Study Area

University of Ilorin is situated in the ancient city of Ilorin on latitude 8° 30'N and longitude 4° 32'E. Ilorin, the capital of Kwara State, is geographically positioned in the "middle belt" region of Nigeria where there is a cultural confluence of the North and South.

The University of Ilorin was established in 1975 as a University College affiliated to the University of Ibadan. The University took off as a mini campus on its temporary site at the Kwara State Polytechnic with three faculties, namely: Faculties of Arts, Science and Education. The faculties later evolved into six and incorporated Faculties of Engineering & Technology, Business and Social Sciences, and Basic Clinical Sciences.

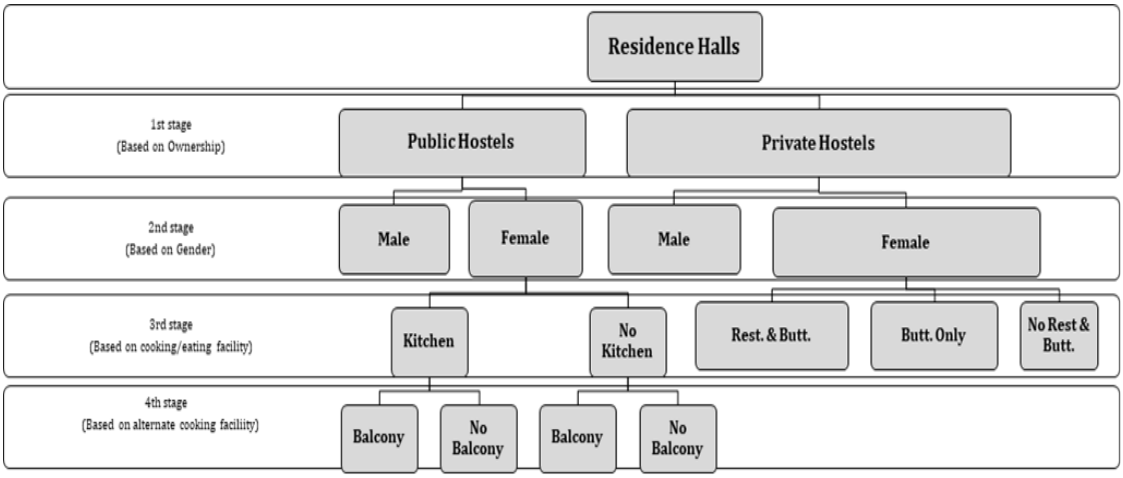
In January 1982, the University moved to its permanent site after the completion of new Faculty blocks and residences for Natural Sciences and Engineering with a record of more than 1000 students studying in sciences. The permanent site of the institution has a land mass of about 15,000 hectares and this makes it the largest university in Nigeria in terms of land mass. The University now has fifteen Faculties and over sixty Academic Departments. Since 2002 to date, there has been an upsurge in the physical development of the main campus which is on the permanent site in terms of academic, administrative and students' residential facilities. At the time of this research, there are a total of twenty (20) residence halls on campus which consist of six (6) public hostels and fourteen (14) private residence halls. The public residence halls are owned and managed by the institution while the private residence halls are owned and managed by private individuals in partnership with the

university. They public and private residence halls are situated on the university campus. The staff and student populations are now about 3,500 and 40,000 respectively. However, due to the shortage of hostel facilities, the university has only been able to accommodate about 15% of the student population on campus leaving the other 75% to seek for accommodation off campus (University of Ilorin, n.d).

Sampling Procedure and Sample Size

The research design employed was a descriptive survey. Questionnaire and structured observation schedule were used as the instrument for data collection. The study focused on the on-campus residential environment of undergraduate students in the University of Ilorin. This includes the residence halls, their environs, and the facilities within the residence hall environment. The study population comprised all the students residing on the campus residence halls in the University of Ilorin. This included both private and public residence halls on the University campus. A multi-stage sampling technique was adopted to select samples. In the first stage, twelve (12) residence halls were purposively selected out of the twenty (20) residence halls on campus based on three criteria, namely: ownership (institution owned or owned by private individuals), gender (male or female), and design type (with or without kitchen facility, restaurant, buttery, balcony and backyard) as shown in figure 1. The second stage was the systematic selection of 12% of students in each of the twelve (12) residence halls. The first student in each of the residence halls was selected randomly. Four hundred and thirty (430) copies of questionnaire were administered on the students and 416 were retrieved representing a response rate of 97%. Information obtained through the use of questionnaire included the socioeconomic/demographic characteristics of students and the perceived distance of students' residence halls to restaurants in the residential environment. The schedule was prepared and filled objectively by the researcher. The data collected included the residence hall design, availability of kitchen, washing sinks, and worktops, storage and availability of shopping and restaurant facilities in the residence halls.

Fig. 1: Analysis of the sampling technique used for the study



The 12 residence halls purposively selected out of all the 20 residence halls consisted of:

- 5 public and 7 private residence halls;
- 2 male and 10 female residence halls;
- 3 with kitchen facility, 2 without kitchen facility, 3 with Restaurant & Buttery, 3 with Buttery only and 1 without Restaurant & Buttery;
- 2 with balconies, 1 without balcony, 1 with backyard, 1 without backyard, 7 without balconies nor backyard.

Data Analysis

Statistical analysis was performed using the Statistical Package for Social Scientists (SPSS) software version 16. Analytical tools used for the study were mainly descriptive statistics such as frequency tables and percentages.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Students

The results of the socioeconomic characteristics of the students in Table 1 showed that majority (72.4%) were females while only a few (27.6%) were males. This indicates that more females resided on campus than males. The results also revealed that 17.5% of the students were less than 18 years of age, 54.3% were between the ages of 18 and 20 years, 24.8% were between the ages of 21-24 years; while 22.2% were more than 24 years of age. This indicates that most of the students (79%) were between the ages of 18 and 24 years and were fairly distributed among 100 to 300 levels. In addition, most (62.5%) of the students had lived in their residence halls for a period of at least one session. This implies that they would

be familiar enough with the residential environment to enable them supply sufficient information about it.

Table 1: Distribution of students based on socio-economic characteristics (N = 416)

Variables	Frequency	Percentage (%)
Gender:		
Male	115	27.6
Female	301	72.4
Age (in years):		
<18	73	17.5
18 – 20	226	54.3
21 – 24	103	24.8
> 25	9	2.2
Level:		
100	111	26.7
200	116	27.9
300	106	25.5
400	72	17.3
>400	10	2.4
Length of stay (in the residence hall):		
< One semester	12	2.9
One semester	22	5.3
<One session	120	28.8
One session	260	62.5

Source: Field Survey, 2018

Residence Hall Design

Table 2 shows the design of the residence halls with respect to room-kitchen design and arrangements. The table shows that 67% of the residence halls selected were the suite type (a room with kitchen en suite); 8% shared kitchen (two rooms sharing a kitchen space); 8% had kitchen per floor design (a number of rooms sharing a kitchen space per floor or level) while 17% had no kitchen space provided in the residence hall. The results also showed that 83% of the residence halls surveyed had kitchens within them while 17% had no kitchens. It is worthy of note that the commonest residence hall design among the halls selected was the suite type. The suite type design is however common with the private residence halls while the kitchen per floor design is common with the public residence halls. The result suggests that most of the students would find it easy to access the cooking area since the kitchens are located in the rooms. It also suggests that the culinary habits of the students would be enhanced since most of the residence halls had kitchens within them.

Table 2: Distribution of residence halls by design

Variables	Frequency	Percentage (%)
Residence hall design:		
Suite type	8 hostels	67
Shared kitchen	1 hostel	8
Kitchen per floor	1 hostel	8
No kitchen	2 hostels	17

Source: Field Survey, 2018

Additional Facilities in the Residence Hall

Table 3 shows the additional facilities for shopping and eating within the residence halls. It shows that 42% of the residence halls had restaurants and butteries within them, 50% had butteries only while 8% had no restaurant and no buttery. The result reveals that most of the residence halls had restaurants and buttery spaces in them to aid the eating and shopping activities of students. This result suggests that most of the students would find eating and shopping activities easy within the residence halls because of close proximity.

Table 3: Distribution of additional facilities in the students' residence halls

Variables	Frequency	Percentage (%)
Additional facility:		
Restaurant and buttery	5 hostels	42
Restaurant only	0	0
Buttery only	6 hostels	50
No restaurant and no buttery	1 hostels	8

Source: Field Survey, 2018

Type and Number of Food Outlets within the Residential Environment on Campus

The results on the various types, number and locations of food outlets within the University campus are presented in Table 4. Findings reveal that 35% of the food outlets were snacks shops; 38% were butteries; 19% were restaurants; 6% were ready-to-eat food vendors; 1% mainly sell vegetables and raw foods while 2% sell frozen foods, vegetables and raw foods. The results depict that 73% of all available food outlets were snack shops and butteries. This may suggest a high consumption of snacks and junk foods among students because of the availability of many snacks shops and butteries on campus.

Table 4: Distribution of type of food outlets in the students' residence halls

S/N	Types	Frequency	Percentage
1	Snack shops (Snacks & drinks)	62	35%
2	Butteries (Provisions, snacks & drinks)	68	38%
3	Restaurants	32	18%
4	Ready-to-eat food vendors	10	6%
5	Frozen foods only	0	0
6	Vegetables (tomatoes, pepper & vegetables) only	0	0
7	Raw foods store (raw rice, beans, yams, etc.) only	0	0
8	Vegetables and raw foods	2	1%
9	Frozen foods, vegetables and raw foods	4	2%

Source: Field Survey, 2018

Perceived Distance of Residence Halls to Restaurants

Table 5 shows the subjective distances from the residence halls to the restaurants. The table reveals that 17.1% of the students reported that the restaurants were very close to their residence halls; 46.9% reported that they were close; 24.3% reported that they were far; 4.6% reported that they were very far; while 7.2% reported that the information was not

applicable to them because they do not patronize restaurants. It can be deduced that for most of the students, the restaurants often patronized were close to their residence halls. The result suggests frequent restaurant patronage among students due to close proximity.

Table 5: Perceived distance of residence hall to restaurants

Distance of residence hall to restaurant	Frequency	Percentage (%)
Very close	71	17.1
Close	195	46.9
Far	101	24.3
Very far	19	4.6
Not applicable	30	7.2

Source: Field Survey, 2018

CONCLUSION AND RECOMMENDATIONS

The study revealed the physical attributes of students' residential environment in relation to dietary habits in University of Ilorin, Nigeria. The suite type (kitchen en suite) residence hall was the commonest residence hall design observed on campus. Also, most of the residence halls had restaurants and buttery spaces in them to aid the cooking and eating habits of students. Furthermore, the study revealed that majority of the food outlets available on campus were snack shops and butteries, which may suggest a high consumption of snacks and junk foods among students.

Based on these findings, the following recommendations were made:

1. More restaurants should be provided on campus to enable students to access healthier food options than the snacks and sugary drinks that are mainly available at the snack shop and butteries which were found to be dominant.

2. The built environment professionals, developers, stakeholders and polices on student housing should pay more attention to the provision of facilities such as kitchens and restaurants within students' residential environment so that the cooking and eating habits of students would be enhanced. These facilities should be provided in the residence halls from the building design stage.

3. The kitchen facilities should be provided within the students' rooms or at close proximity to the students' room for easy accessibility and to encourage use.

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