

## Carcass traits, nutrient composition and sensory properties of broiler chickens fed diets containing graded levels of fermented cassava (*Manihot esculenta* Crantz) tuber meal as replacement for maize meal

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### Abstract

The current situation in Nigeria has reduced the supply of maize, increase its price and raised an urgent need for a viable replacement. Cassava has high energy and fibre content but very low protein that needs valorization to replace maize in monogastric diets. Fermentation generates a large population of lactobacillus that contributes microbial protein thus increasing the protein content of cassava. Thus the objective of this 56-day study was to investigate the potential of aqueously fermented cassava tuber meal (FCTM) to improve in protein content and thus supplement maize without compromising carcass quality and sensory properties of broiler meat. Six treatments replicated thrice had 540 Arbor Acre day-old chicks. Diets were formulated with peeled and chopped tubers fermented aqueously for three days. The treatments were FCTM25, FCTM50, FCTM75 and FCTM100 that had maize replaced with FCTM at 25%, 50%, 75% and 100%, respectively. Treatments without FCTM coded CTRL and another with antibiotic growth promoter (AGP) with 5 g neocloxin/L in water served as control. On Day 56, breast meat samples were collected from three birds per replicate for analysis. Sensory evaluation was conducted by 20 untrained panelists with 200 g meat chops cooked under similar conditions. Data were analyzed with IBM SPSS version 20. Broilers fed with FCTM75 and FCTM50 had significantly ( $P < 0.05$ ) heavier live weight (1684 g) and dressed weight (1572 g). The FCTM50 improved meat protein while FCTM100 significantly ( $P < 0.05$ ) increased mineral and high density lipoprotein (HDL) contents. The FCTM50 and FCTM75 increased breast intramuscular fat accretion, with better aroma and juiciness than those fed with CTRL and AGP. Meat from birds fed with AGP had significantly ( $P < 0.05$ ) the highest overall acceptability while those fed with FCTM50 and FCTM75 significantly ( $P < 0.05$ ) higher acceptability among FCTM-fed birds. The replacement of maize meal with cassava tubers up to 50 and 75 % are recommended for best carcass traits and desirable sensory qualities.

**Keywords:** broilers, carcass traits, fermented cassava tuber meal, organoleptic properties, nutrient composition

**Caractéristiques de la carcasse, composition nutritionnelle et propriétés sensorielles des poulets à griller nourris avec des régimes contenant des niveaux gradués de farine de tubercules de manioc fermenté (*Manihotesculenta* Crantz) en remplacement de la farine de maïs**



**Résumé**

*La situation actuelle au Nigéria a réduit l'offre de maïs, augmenté son prix et soulevé un besoin urgent d'un remplacement viable. Le manioc a une teneur élevée en énergie et en fibres mais très peu de protéines qui doivent être valorisées pour remplacer le maïs dans les régimes monogastriques. La fermentation génère une grande population de lactobacilles qui contribuent aux protéines microbiennes, augmentant ainsi la teneur en protéines du manioc. Ainsi, l'objectif de cette étude de 56 jours était d'étudier le potentiel de la farine de tubercules de manioc à fermentation aqueuse (TMFA) pour améliorer la teneur en protéines et ainsi compléter le maïs sans compromettre la qualité de la carcasse et les propriétés sensorielles de la viande de poulet. Six traitements répétés trois fois ont porté sur 540 poussins d'un jour d'Arbor Acre. Les régimes ont été formulés avec des tubercules pelés et hachés fermentés en milieu aqueux pendant trois jours. Les traitements étaient TMFA25, TMFA50, TMFA75 et TMFA100 qui avaient remplacé le maïs par TMFA à 25 %, 50 %, 75 % et 100 %, respectivement. Des traitements sans CTRL codé TMFA et un autre avec un promoteur de croissance antibiotique (PCA) avec 5 g de néocloxacine/L dans l'eau ont servi de contrôle. Au jour 56, des échantillons de viande de poitrine ont été prélevés sur trois oiseaux par répétition pour analyse. L'évaluation sensorielle a été réalisée par 20 dégustateurs non formés avec 200 g de côtelettes de viande cuites dans des conditions similaires. Les données ont été analysées avec IBM SPSS version 20. Les poulets de chair nourris avec TMFA75 et TMFA50 avaient un poids vif significativement ( $P < 0,05$ ) plus lourd (1684 g) et un poids habillé (1572 g). Le FCTM50 a amélioré les protéines de viande tandis que le TMFA100 a augmenté de manière significative ( $P < 0,05$ ) la teneur en minéraux et en lipoprotéines de haute densité (HDL). Le TMFA50 et le TMFA75 ont augmenté l'accumulation de graisse intramusculaire dans le sein, avec un meilleur arôme et une meilleure jutosité que ceux nourris avec CTRL et PCA. La viande des oiseaux nourris avec de PCA avait significativement ( $P < 0,05$ ) l'acceptabilité globale la plus élevée tandis que celles nourries avec TMFA50 et TMFA75 significativement ( $P < 0,05$ ) une acceptabilité plus élevée parmi les oiseaux nourris au TMFA. Le remplacement de la farine de maïs par des tubercules de manioc jusqu'à 50 et 75 % est recommandé pour de meilleurs traits de carcasse et des qualités sensorielles souhaitables.*

**Mots-clés :** poulets de chair, caractéristiques de la carcasse, tourteau de manioc fermenté, propriétés organoleptiques, composition nutritionnelle

**Introduction**

Studies on livestock production seek to reduce production costs without compromising the welfare and hence the performance of livestock on one hand, and the quality of meat and meat products on the other hand. Thus, the need to search for alternative sources of energy and protein

ingredients that will replace or supplement maize and soybeans respectively in livestock feeds. Several alternatives to maize have been explored (Abu *et al.*, 2010; Medugu *et al.*, 2011) but none showed potential to replace maize in terms of cost effectiveness and nutrient composition. Cassava tuber on the other hand yields more

metabolizable energy than maize but is rather low in protein. However, aqueous fermentation of cassava tuber generates a microbial flora that is dominated by lactobacillus, which contributes to microbial protein that improves the crude protein value of the resulting fermented product (Aro, 2008). It has been reported that fermenting fresh cassava tuber increases the crude protein value by as much as 13.5% relative to control, i.e. fresh cassava tuber (Boonop *et al.*, 2009). Sugiharto *et al.* (2017) did not observe any significant difference among treatments groups in nitrogen retention, dry matter (DM) and organic matter digestibility among broilers fed fresh cassava tubers fermented with *Acremonium charticola*. Khempaka *et al.* (2014) reported a significant decrease in nutrient digestibility and retention when cassava pulp was fermented with *Aspergillus oryzae* but the decrease was not significant below 160 g/kg. (Okrathok *et al.* (2018) reported that layers could tolerate up to 320 g/kg of cassava pulp fermented with *Aspergillus oryzae* without showing any negative effects on nutrient digestibility and retention. Antibiotics are conventionally used for both prophylactic and therapeutic measures, and as a growth promoter in the Nigerian poultry industry. Lactobacillus and other probiotic organisms abundantly present in fermented cassava (Mokoena *et al.*, 2016) are also being evaluated for their potentials as natural alternatives to antibiotics and compared to conventional antibiotics, neocloxin. So the performance, with respect to carcass traits, of the birds fed fermented cassava will also be evaluated as a source of lactic acid producing bacteria (LAB) to replace antibiotics. The carcass characteristics of birds, which include dressed weight; and weights of cuts and internal organs recorded as a percentage of the live weight, are indicators of growth performance. The growth performance of

livestock is generally predicated upon two major factors namely nature and nurture, i.e., genetic potentials and the environment (Zhao *et al.*, 2004) of which feed is a part. Feed is a major environmental factor influencing the performance of broilers, and the type of ingredients used in feed formulation determines feed quality, feed intake and effect on meat quality; as well as what is imparted on the meat and other animal products (Corzo *et al.*, 2009; Haechang *et al.*, 2014; Sugiharto *et al.*, 2017). Feed ingredients also determine the capacity of the feed to furnish animals with their daily allowance of nutrients suitable for their physiological state or productivity level. Maize has been the ingredient of choice for livestock feed formulation in Nigeria because of its high nutrient content (9.8% crude protein, 2.60% crude fibre, 4.50% ether extract and 375 kcal/100 g ME) compared to other energy ingredients; as well as its relatively less anti-nutritional factors (Abiose and Ikujenola, 2014). As a result of increasing competition for maize between human consumption directly as food and indirectly in industrial processes on one hand, and its use as animal feedstuff on the other hand, it has become necessary to identify alternative energy ingredients to maize as livestock feedstuff. Several alternatives have been tested including agro-industrial by products and unconventional feed resources (Bistanji *et al.*, 2000; Choct 2012) but none quite has shown the potential and sustainability to fully replace maize. The cassava tuber is a rich source of dietary energy; and its energy yield per hectare is potentially much higher than those of cereals (FAO, 2013). The cassava plant gives the third-highest yield of carbohydrates per unit of cultivated area among crop plants, after sugar cane and sugar beets (Tanaka, 1983). However, cassava tuber contains cyanogenic glycosides, linamarin and lotaustralin, which on hydrolysis yield hydrogen

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cyanide. Hydrogen cyanide is highly toxic and can reduce feed intake and performance in broilers. The process of aqueous fermentation applied in this study to detoxify the cassava tuber has been shown to reduce the cyanide concentration to less than 100 mgkg<sup>-1</sup> recommended by Food and Agriculture Organization (FAO)/World Health Organization (WHO) (Akabanda *et al.*, 2010). Incidentally, the process imparts a characteristic smell on fermented cassava tuber that some people find unpleasant but is acceptable, and even desirable to others. Regardless of individual idiosyncrasies the smell of cassava imparted on poultry meat and other products is certainly undesirable. Thus, the objective of this study was to determine the potential of the characteristic smell of cassava to be imparted on the meat of broilers fed diets with graded levels of fermented cassava (*Manihot esculenta* Crantz) tuber meal as replacement for maize meal. Dietary effect on carcass characteristics as an indication of growth performance, proximate composition and cholesterolemic characteristics of the meat were also examined.

### **Materials and methods**

#### ***Location of the study and ethical approval***

This 56-day study was conducted at the Poultry Research Facility of the Teaching and Research Farm, Department of Animal Science, Ebonyi State University, Abakaliki, Nigeria. 540 day-old Arbor Acre chicks were procured from Obasanjo Farms, Ogun State, Nigeria, and randomly allotted to six dietary treatments replicated thrice with 30 birds per replicate in a completely randomized design. The study received the approval of the University Research Ethics Committee (UREC) of the Directorate of Research, Innovation and Commercialization (EBSU-DRIC) of Ebonyi State University, Abakaliki, Nigeria.

#### ***Sourcing and processing of cassava***

Cassava tubers (cultivar TMS 37767) were harvested at about 12 months post-planting. Within two hours of harvesting the tubers were peeled and washed before being chopped with kitchen knives into roughly 10 cm chunks. For aqueous fermentation, the chunks were steeped in water for three days for retting to be completed as is the traditional practice. The cassava chunks were removed from the steep liquor, mashed and incorporated into the liquid feed without sieving or drying.

#### ***Experimental design and diet formulation***

Six experimental diets were formulated as follows: Treatment 1 had 0% fermented cassava tuber meal (FCTM) and designated as CTRL. Treatment 2, AGP, contained antibiotic growth promoter (neocloxin) as currently used in the country. Both were used to benchmark the performance of the chickens fed with graded levels of FCTM. The FCTM diets were prepared by replacing 25, 50, 75 and 100% of the maize in the control diet with FCTM and thus designated as FCTM25, FCTM50, FCTM75 and FCTM100 respectively. Water was added to the dry formulated diets at the ratio of 1.5 L of water per kg of feeds to yield diets of circa 60% dry matter (DM) consistent with the moisture content (circa 40% moisture content) of the fermented cassava as determined by proximate analysis (AOAC, 2010). The compositions of the dietary treatments for starter and finisher diets are presented in Tables 1 and 2, respectively. The differences in FCTM caused varying energy and protein levels in the experimental diets, so the diets were neither isocaloric nor isonitrogenous.

#### ***Carcass evaluation***

Feeds were withdrawn from the birds at about 2200 hours on Day 55 but drinking water was provided *ad libitum*. At 0700 HRS on Day 56, three birds were randomly selected from each replicate for carcass analysis. Fresh feed and water were served

**Table 1: Composition (g/kg) of broiler starter diets containing graded levels of fermented cassava tuber meal as replacement for maize**

Ingredient (g/kg)	CTRL (Control)	AGP (Antibiotics)	FCTM25 (25% of maize replaced)	FCTM50 (50% of maize replaced)	FCTM75 (75% of maize replaced)	FCTM100 (100% of maize replaced)
Maize	500	500	375	250	125	0
Fermented cassava	0	0	125	250	375	500
Wheat offal	80	80	80	80	80	80
SBM*	120	120	120	120	120	120
GNC†	160	160	160	160	160	160
PKC‡	70	70	70	70	70	70
Fish meal	30	30	30	30	30	30
Bone meal	30	30	30	30	30	30
Salt	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin premix#	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	2.5	2.5	2.5	2.5	2.5	2.5
Methionine	2.5	2.5	2.5	2.5	2.5	2.5
TOTAL	1000	1000	1000	1000	1000	1000
Calculated nutrient composition						
%CP	22	22	22.5	23	23.34	23.8
%CF	4.47	4.47	4.5	4.53	4.6	4.56
ME (MJ/kg DM)	12.3	12.3	12.2	12.2	12.2	12.13

\*Soybean meal; †groundnut cake; ‡palm kernel cake; CP = crude protein; CF = crude fibre; ME = metabolizable energy

#Provided the following per kilogramme of diet:

Vitamin A –8,000 IU, Vitamins D3 –3,000 IU, Vitamins E –8 IU, Vitamin K –2mg, Vitamin B1 – 1 mg, Vitamin B2 – 0.2 mg, Vitamin B12 – 5 mg, Nicotinamide – 10 mg, Selenium – 0.1 mg, Ca Pantothenate – 5 mg, Folic acid – 0.5 mg, Choline Chloride – 150 mg, Iron – 20 mg, Manganese – 80 mg, Copper – 8 mg, Zinc – 50 mg, Cobalt – 0.225mg, Iodine –2 mg Antioxidant – 0.1ppm

to the rest while those selected for carcass evaluation were processed immediately. They were weighed and then humanely euthanatized by cervical dislocation. They were bled and scalded with hot water to remove the feathers, and then the dressed weight was taken. The dressing percentage was calculated from the dressed weight. The carcass was then eviscerated and the four major cuts, wing breast, thigh and back, as well as other internal organs of interest were also identified and cut off while their weights were recorded as a percentage of the live weight. The total

cholesterol, high density lipoprotein and low density lipoprotein were analyzed by spectrophotometric method using SFRI, Model No 3000 at U-Bonny Bio-Medical Diagnostic Laboratory, Mile 50, Abakaliki. The data collected were subjected to one-way analysis of variance (ANOVA) using IBM SPSS v.20.

#### **Sensory evaluation**

A panel of 20 untrained panelists who are regular consumers of chicken breast meat was used. Twenty cuts of 200 g breast meat of the slaughtered chickens were used for sensory evaluation. The cuts in each

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**Table 2: Composition of broiler finishers diets containing graded levels of fermented cassava tuber meal as replacement for maize**

Ingredient (g/kg)	CTRL (Control)	AGP Antibiotics	FCTM25 25% of maize replaced	FCTM 50 50% of maize replaced	FCTM 75 75% of maize replaced	FCTM 100 (100% of maize replaced)
Maize	550	550	412.50	275	137.50	0
FCTM	0	0	137.50	275	412.50	550
Wheat offal	70	70	70	70	70	70
SBM*	100	100	100	100	100	100
GNC†	150	150	150	15	150	150
PKC‡	60	60	60	60	60	60
Fish meal	30	30	30	30	30	30
Bone meal	30	30	30	30	30	30
Salt	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin premix#	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	2.5	2.5	2.5	2.5	2.5	2.5
Methionine	2.5	2.5	2.5	2.5	2.5	2.5
<b>Total</b>	<b>1000</b>	<b>1000</b>	<b>1000</b>	<b>1000</b>	<b>1000</b>	<b>1000</b>
Calculated nutrient composition						
%CP	20.8	20.8	21.3	21.7	22.2	22.6
%CF	4.2	4.2	4.3	4.3	4.31	4.37
ME (MJ/kg DM)	12.5	12.5	12.43	12.4	12.4	12.33

\*Soybean meal; †groundnut cake; ‡palm kernel cake; CP = crude protein; CF = crude fibre; ME = metabolizable energy

#Provided the following per kilogramme of diet:

Vitamin A–8,000 IU, Vitamins D3–3,000 IU, Vitamins E–8 IU, Vitamin K–2mg, Vitamin B1– 1 mg, Vitamin B2 – 0.2 mg, Vitamin B12 – 5 mg, Nicotinamide – 10 mg, Selenium – 0.1 mg, Ca Pantothenate – 5 mg, Folic acid – 0.5 mg, Choline chloride – 150 mg, Iron – 20 mg, Manganese – 80 mg, Copper – 8 mg, Zinc – 50 mg, Cobalt – 0.225mg, Iodine –2 mg Antioxidant – 0.1ppm

treatment were cooked without any spices or salt for approximately 30 min and kept warm in a food flask before serving. The panelists were informed that the birds were raised with food-grade feed additives while the antibiotics had been terminated as per manufacturer's directives prior to slaughter. They tasted the meat and noted their perceptions and overall acceptability on a 9-point Hedonic scale with rating expressed as follows: 1- extremely dislike, 2 – dislike very much, 3 – moderately dislike, 4 – slightly dislike, 5 – neither like nor dislike, 6 – slightly like, 7 – moderately like, 8 – like very much and 9 – extremely like.

## Results

### *Effect of cassava tuber meal on the carcass traits of broiler chickens*

The effect of diets containing graded levels

of fermented cassava tuber meal (FCTM) as replacement for maize meal on the carcass traits of broilers is presented in Table 3.

The live weight of the birds in treatment FCTM75 (1684 g) was significantly ( $P<0.05$ ) higher than the live weight of the birds in other treatment groups. Treatment FCTM25 recorded the least live weight (967.67 g) of the birds fed fermented cassava tuber meal. The dressed weight of the birds in treatment FCTM50 was significantly ( $P<0.05$ ) higher (1572 g) than the dressed weight in other treatments, while treatment AGP recorded the least dressed weight of 762.33 g. The birds in treatment FCTM25 has the best dressing percentage (93.56%), which was significantly ( $P<0.05$ ) higher than those of birds in other treatments, treatment

FCTM100 being the least was 72.04%. There was no significant ( $P>0.05$ ) difference between treatments CTRL and FCTM50 in dressing percentage. Birds in treatment AGP, FCTM75 and FCTM100 also had similar dressing percentage. The mean breast weight of the birds fed CTRL was significantly ( $P<0.05$ ) higher than those of other treatments. Birds fed FCTM75 diet had the heaviest mean breast weight (16.78%), which differs significantly from those of the birds in treatments AGP, FCTM25 and FCTM100. There was significant ( $P<0.05$ ) difference in the mean weight of the back (18.39%) for the CTRL birds compared to treatment AGP (15.72%), and FCTM75 and FCTM100 but there was no significant ( $P>0.05$ ) difference in the mean weights of the back of the CTRL birds compared to treatments FCTM25 and FCTM50, which have 17.64% and 17.0% respectively. The mean weight of the thighs of the CTRL birds (20.70%) were significantly ( $P<0.05$ ) higher than those of treatments FCTM25 (18.09%) and

FCTM100 (18.28%), both of which do not significantly ( $P>0.05$ ) differ.

There was no significant ( $P>0.05$ ) difference among other treatments except for treatment AGP (20.12%). The CTRL birds had significantly ( $P<0.05$ ) heavier (2.82%) gizzards than those of the birds in treatment AGP and the treatments FCTM25, FCTM50, FCTM75 and FCTM100. Among the birds fed fermented cassava, treatment FCTM100 had a mean gizzard weight of 2.55%, which is significantly ( $P<0.05$ ) higher than the other FCTM treatments. There was no significant ( $P<0.05$ ) difference among treatments in the weights of the wing and intestine.

**Proximate composition and cholesterol level of breast meat**

The effect of diets containing graded levels of fermented cassava tuber meal as replacement for maize on the proximate composition and cholesterol levels of breast meat of broilers is presented in Table 4.

**Table 3: Effect of diets containing fermented cassava tuber meal as replacement for maize meal on the carcass traits of broiler chickens**

Parameters	CTRL (Control)	AGP (Antibiotics)	FCTM25 (25% of maize replaced)	FCTM50 (50% of maize replaced)	FCTM75 (75% of maize replaced)	FCTM100 (100% of maize replaced)	±SEM
Live weight (g)	1676.33 <sup>b</sup>	985.67 <sup>d</sup>	967.67 <sup>c</sup>	1649 <sup>c</sup>	1684 <sup>a</sup>	1581 <sup>c</sup>	4.03
Dressed weight (g)	1386.33 <sup>b</sup>	762.33 <sup>f</sup>	905.33 <sup>c</sup>	1572 <sup>a</sup>	1217 <sup>c</sup>	1139 <sup>d</sup>	52.60
Dressing percentage	82.70 <sup>b</sup>	77.35 <sup>c</sup>	93.56 <sup>a</sup>	84.54 <sup>b</sup>	74.15 <sup>c</sup>	72.04 <sup>c</sup>	1.60
Wing	9.27	8.42	7.76	10.11	8.27	8.37	2.25 <sup>NS</sup>
Thigh	20.70 <sup>a</sup>	20.12 <sup>a,b</sup>	21.18 <sup>a</sup>	21.39 <sup>a</sup>	18.09 <sup>c</sup>	18.28 <sup>c</sup>	0.02
Breast	18.29 <sup>a</sup>	16.13 <sup>d</sup>	15.29 <sup>c</sup>	16.63 <sup>c</sup>	16.78 <sup>b</sup>	14.29 <sup>f</sup>	0.16
Back	18.39 <sup>a</sup>	15.72 <sup>b</sup>	17.64 <sup>a</sup>	17.0 <sup>a</sup>	13.22 <sup>c</sup>	13.66 <sup>c</sup>	0.38
Gizzard	2.82 <sup>a</sup>	2.43 <sup>b</sup>	2.34 <sup>b,c</sup>	2.36 <sup>b</sup>	2.14 <sup>d</sup>	2.55 <sup>b</sup>	0.21
Neck	6.30 <sup>b</sup>	5.14 <sup>c</sup>	5.14 <sup>c</sup>	7.12 <sup>a</sup>	5.07 <sup>c</sup>	4.22 <sup>c</sup>	0.22
Shank	3.78 <sup>c</sup>	4.29 <sup>b</sup>	7.23 <sup>a</sup>	3.76 <sup>c</sup>	3.22 <sup>d</sup>	3.71 <sup>c</sup>	0.01
Intestine	4.01	2.64	2.96	3.98	5.46	3.96	1.50 <sup>NS</sup>
Liver	1.91 <sup>b</sup>	2.43 <sup>b</sup>	4.27 <sup>a</sup>	2.18 <sup>b</sup>	1.88 <sup>b</sup>	2.23 <sup>b</sup>	0.14

a,b,c = Means in the same row with different superscripts differ significantly ( $P<0.05$ );

NS = not significant

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**Table 4: Proximate composition (%) and cholesterol levels (mg/dL) of breast meat of broilers fed graded levels of inclusion of fermented cassava tuber meal as replacement for maize**

Parameters	CTRL (Control)	AGP (Antibiotic growth promoter)	FCTM25 (25% of maize replaced)	FCTM50 (50% of maize replaced)	FCTM75 (75% of maize replaced)	FCTM100 (100% of maize replaced)	±SEM
Moisture	66.94 <sup>f</sup>	67.56 <sup>a</sup>	67.31 <sup>d</sup>	66.99 <sup>c</sup>	67.44 <sup>b</sup>	67.36 <sup>c</sup>	0.02
Fat	11.36 <sup>b</sup>	12.33 <sup>a</sup>	11.77 <sup>b</sup>	12.23 <sup>a</sup>	11.86 <sup>a,b</sup>	12.39 <sup>a</sup>	0.50
Ash	3.85 <sup>b</sup>	3.93 <sup>a,b</sup>	3.99 <sup>a</sup>	4.05 <sup>a</sup>	3.91 <sup>b</sup>	4.08 <sup>a</sup>	0.01
Crude protein	20.44 <sup>d</sup>	20.05 <sup>f</sup>	20.74 <sup>c</sup>	21.14 <sup>a</sup>	20.23 <sup>e</sup>	20.93 <sup>b</sup>	0.05
NFE	64.35 <sup>f</sup>	63.69 <sup>c</sup>	63.50 <sup>d</sup>	62.48 <sup>b</sup>	64.0 <sup>e</sup>	70.76 <sup>a</sup>	0.06
TC (mg/dL)	86.27 <sup>c</sup>	85.95 <sup>d</sup>	86.41 <sup>b</sup>	85.91 <sup>d</sup>	86.60 <sup>a</sup>	86.67 <sup>a</sup>	0.04
HDL (mg/dL)	38.68 <sup>d</sup>	33.26 <sup>e</sup>	39.61 <sup>b</sup>	34.68 <sup>d</sup>	39.43 <sup>c</sup>	39.65 <sup>a</sup>	0.14
LDL (mg/dL)	41.05 <sup>d</sup>	38.91 <sup>f</sup>	43.30 <sup>a</sup>	40.69 <sup>e</sup>	41.12 <sup>c</sup>	41.30 <sup>b</sup>	0.02

a,b,c = Means with differing superscripts within the same row differ significantly ( $P < 0.05$ ).

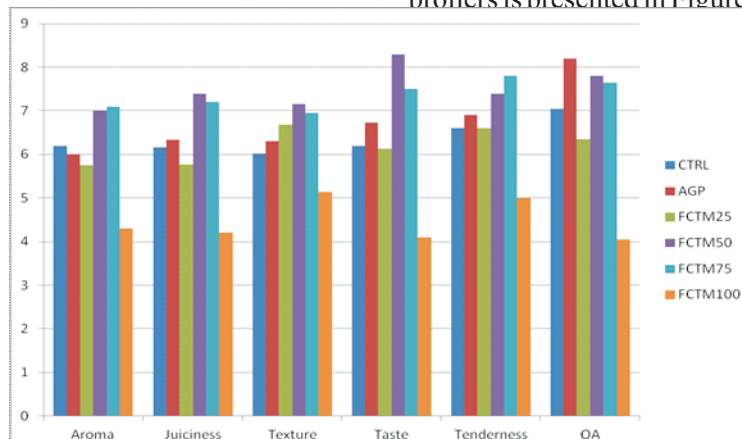
TC = Total cholesterol; HDL = High density lipoprotein; LDL = Low density lipoprotein.

All the parameters considered differed significantly ( $P < 0.05$ ) among treatments. The breast meat of broilers fed AGP contained significantly ( $P < 0.05$ ) more moisture than those of the birds in all the other treatments. Among birds fed treatments containing fermented cassava, the breast meat of the birds in treatment FCTM75 contained significantly ( $P < 0.05$ ) more moisture than those in treatment CTRL as well as FCTM25, FCTM50, FCTM75 and FCTM100. The breast meat of the birds in treatment FCTM50 had significantly ( $P < 0.05$ ) more crude protein (21.14%) than those of the birds in treatment CTRL, AGP, FCTM25 and

FCTM75 followed by FCTM100 at 20.93%. The fat content of the breast meat of the birds fed treatment FCTM100 was significantly higher than CTRL, AGP and FCTM 25, FCTM 50 and FCTM 75. This corresponds to a higher HDL content that is significantly ( $P < 0.05$ ) higher than other treatments including CTRL and AGP. LDL of the birds in treatment FCTM25 (41.05 mg/dL) was significantly ( $P < 0.05$ ) higher than other treatments while the birds in treatment AGP (38.91 mg/dL) had the least LDL mean value.

**Sensory evaluation**

The result of effect of experimental diets on the sensory evaluation of the breast meat of broilers is presented in Figure 1.



**Fig 1:** Effect of fermented cassava tuber meal (FCTM) as replacement for maize on the sensory properties of the breast meat of broilers

Key: OA= overall acceptability

The panelists did not observe any difference in the texture and tenderness of the breast meat among treatments. The aroma and juiciness of the birds fed FCTM50 and FCTM75 diets, which had 50% and 75% replacement of respectively were ranked higher than those of the birds fed CTRL, AGP, FCTM 25 and FCTM 100. It appears that complete replacement of maize with FCTM negatively affected all the sensory properties analyzed. The taste of the breast meat of the birds in treatment FCTM 50 was ranked over all other treatments. Similarly, the highest overall acceptability ranking was given for the breast meat of the birds in treatment AGP followed by those in treatment CTRL. The birds in treatment FCTM100 received the lowest overall acceptability ranking.

## Discussion

### *Feed composition and carcass traits*

The effects observed in this study were apparently created by differences in energy and protein levels as determined by inclusion levels of fermented cassava tuber meal since the treatments were neither isocaloric nor isonitrogenous. The apparent heavier live body weight of the birds in treatment FCTM75 was probably due to the 75:25 cassava: maize inclusion ratio for the treatment. This apparently provided a combination of nutrients, the synergy of which gave the birds in treatment FCTM75 an advantage in body weight gain over those in treatments CTRL and AGP. Besides, the high carbohydrate content of cassava and the potential increase in protein occasioned by microbial protein from aqueous fermentation may have increased the protein quality and amino acid profile of the protein far above that available to the birds fed control diet, CTRL and treatment AGP, which received neocloxin. In addition, lysine and methionine, which are limiting in maize, were probably complemented in the FCTM-based diets by

protein generated from fermentative microbial activity. This agrees with (Khempaka *et al.*, 2014; Sugiharto *et al.*, 2017) who reported that there was a rapid increase in protein content of cassava in the course of aqueous fermentation. However, the birds in treatment FCTM100 did not show superior weight gain over the birds in the other FCTM diets probably because the 9% crude protein content of maize, and maize oil gave the birds fed treatment with FCTM75 an advantage over those fed treatment with FCTM100 in which maize was completely replaced by fermented cassava. This is remarkable owing to the increased levels of energy and protein in treatment FCTM100 in which maize was completely replaced with fermented cassava. It could also have led to an energy-protein imbalance, resulting in reduced weight gain. Aro and Aletor (2012) also reported a significant increase in the crude protein content of fermented cassava from 1.12 g/100 g to 7.20 g/100 g, as well as a significant increase in the amino acid content particularly those of lysine and methionine due to microbial fermentation. This was even more evident in this study with fermented cassava in which spontaneous fermentation was applied. Aqueous fermentation of cassava increased microbial diversity and population that apparently created the same effect in this study as that was reported by (Aro and Aletor (2012). This probably accounts for the noticeable higher live body weight in birds fed treatment FCTM75 over other treatment groups. The difference observed could have been due to the disparity in energy and protein contents of the experimental feeds. On the other hand, the body weight was not proportional to the inclusion level of fermented cassava tuber meal. The mean gizzard weight of the birds fed the control treatment (CTRL) was heavier than those of the birds in all the other treatments. However, the crude fibre

### *Carcass traits, nutrient composition and sensory properties of broiler chickens*

content of the feeds increased progressively from treatment CTRL to FCTM100 (Table 2). Apparently fermenting the feeds containing cassava tuber meal improved ease of breakdown and so did not demand increased muscular activity arising from the high crude fibre content of fermented cassava that was reflected on the feeds. High crude fibre content has been shown to create muscular hypertrophy of the gizzard in broilers (Obianwuna *et al.*, 2013). Among the treatment groups fed fermented cassava, the increasingly higher crude fibre content did not corresponded to higher gizzard weight except for those of the birds in treatment FCTM100. Apparently, the higher the crude fibre, the more gizzard activity involved in feed break down. This is corroborated by (Obianwuna *et al.*, 2013) who demonstrated that birds fed goat manure with higher fibre content had significantly heavier gizzards than those fed goat manure with enzymes and probiotics as additives. The dietary enzymes and probiotics served to aid degradation of dietary fibre in the diets with correspondingly lower gizzard weight (Obianwuna *et al.*, 2013). Mateos *et al.* (2012) reported that moderate amounts of fiber might improve the development of organs, enzyme production, and nutrient digestibility in poultry. Some of these effects are a consequence of better gizzard function, with an increase in gastro-duodenal refluxes that facilitate contact between nutrients and digestive enzymes. In addition, increasing the insoluble fibre content of the diet resulted in a reduced length of the small intestine, a decreased proventricular weight, and increased gizzard weight and gizzard contents (Gonzalez-Alvarado *et al.*, 2007; Svihus, 2011) which, in general, are indicative of improved functioning of the gastrointestinal tract, GIT (Hetland and Svihus, 2001; Svihus 2011). Incidentally, Jørgensen *et al.*(1996) noted that these

changes often result in a reduction in carcass yield and the birds placed on treatment FCTM100 (72.04%), which had the highest gizzard weight had outstandingly less carcass yield than those fed with treatments FCTM50 (84.54%) and FCTM75 (74.15%). It is pertinent to note however, that though cassava fermentation, either for garri production (Oduah *et al.*, 2015) or in steep liquor for making *akpu*, as used in this study, invariably increased the crude fiber level of cassava from 0.9 for raw cassava to 1.30 and 1.40% for Days 3 and 4 respectively; and from 2.27 for raw cassava to levels ranging from 2.83 to 4.15% for *akpu* on Days 3 and 4 respectively (Oyetayo, 2006).

Treatment effect on relative liver weight showed no clear trend. The birds in treatment FCTM50 (4.27%) recorded much heavier liver weight among treatments while treatment FCTM75 (1.88%) being the least. Sugiharto *et al.*(2017) reported that fermenting cassava tuber pulp with *Acremonium charticola* or *Acremonium charticola* + AGP reduced relative liver weight. Treatment AGP-fed in this study did had a low relative liver weight (1.91%) which however was similar to other treatments apart from FCTM50. However, the reason for this observation was not clear but it appeared that the activity of probiotic organisms generated during aqueous fermentation of cassava and application of AGP seemed to reduce liver weight. This reduction in relative liver weight should have been more pronounced with the birds in treatment FCTM100 since it logically had more lactic acid bacteria than the other treatments. Mehr *et al.* (2007) suggested that probiotic organisms (such as lactobacillus generated in large populations during aqueous fermentation of cassava) may decrease the population of pathogenic microorganisms in the intestine. Consequently, less pathogens would mean less toxins will be produced and the liver

will have less work in detoxifying the system. Brooks (2008) also reported a decrease in enteropathogens due to certain properties of probiotic organisms mainly lactic acid bacteria by which they eliminate enteropathogens by competitive exclusion, production of biocin and bacteriocin amongst others. The use of neocloxin as an antibiotic growth promoter, AGP, tended to improve the moisture content of the meat compared to the control diet, treatment CTRL (Table 5). Apparently, antibiotics improve moisture retention in poultry breast meat; this should contribute to the juiciness of the meat. However, there is no available literature corroborating this effect. Among the treatment groups fed FCTM diets, treatment FCTM75 had more moisture. It was established that fermented liquid feed, as used in this study, reduces the water intake of broilers and pigs relative to those fed conventional (dry unfermented) feed as in treatments CTRL and AGP (Brooks, 2008). The mean protein content of the breast meat of the birds fed treatments FCTM50 (21.14%) and FCTM100 (20.93%) was higher than those of the other treatments, which corresponded to the protein content of the feeds. The protein content of the experimental diets tended to increase with increasing levels of inclusion of fermented cassava (Tables 1 and 2). So, possibly though not conclusively proven here, fermented cassava tuber meal influenced the accretion of protein in the breast muscle of broilers since protein content was highest in treatment FCTM50 in which 50% of the maize content of the diet was replaced with fermented cassava. Nasr and Kheiri (2012) reported that the interaction of digestible amino acid and lysine increased percentage weights of the carcass and breast in broilers. Apparently, such interactions occurred between the lysine in maize and digestible amino acids produced by microbial activity during the aqueous fermentation. The authors noted

that this interaction increased in protein, raising it by as much as 13.5% compared to control, and has been shown to occur when the nutritive value of cassava was enriched by yeast fermentation (Boonop *et al.*, 2009). In this present study however, the fermentation was not induced but the traditional spontaneous fermentation by steeping peeled cassava tubers in water (steep liquor) was applied. It has been reported that 91% of the microflora of cassava tubers is composed of *Lactobacillus plantarum* (Brauman *et al.*, 1996). Thus *Lactobacillus plantarum* may have contributed to increasing the protein content of the diets containing fermented cassava, and *ipso facto* contributed to increased protein retention in the breast tissue (Urdaneta-Rinco and Leeson, 2004). It was observed by eyeball estimation during carcass evisceration that the birds fed treatments containing fermented cassava had negligible abdominal fat deposits compared to those treated with the treatments CTRL or AGP so data were not collected on abdominal fat deposit as a carcass trait. On the contrary, birds fed with FCTM75 and FCTM100 had much higher total cholesterol content in the breast than the other treatment groups. It appears that, feed containing fermented cassava increased the accretion of fatty tissue in the breast muscle of broilers as intracellular fat and *ipso facto* boosted fat deposit in the intracellular fat depot as opposed to abdominal fat deposition as is the case with maize-based diets. In treatment FCTM25, 75% of the maize content was present and probably caused the increased LDL content in the breast of the birds that fed on it compared to those fed treatment FCTM100. An increase in LDL was observed as the inclusion level of fermented cassava tuber meal increased in the diet, but to a level that was still lower than that of the birds in treatment FCTM25 (43.30 mg/dL). The HDL also increased proportionately with

increasing level of inclusion of FCTM suggesting that FCTM increased muscular accretion of HDL in the breast of broilers. However, no supporting literature was found to compare the findings in this study.

### ***Sensory properties***

Fermented cassava tuber meal had no effect on the taste, tenderness and texture of the breast among all the treatment groups but affected the aroma, juiciness, taste and overall acceptability among treatments. Figure 1 showed that 75% replacement of maize (treatment FCTM75) had the best aroma followed by 50% replacement of maize (treatment FCTM50). Thus, a high total cholesterol and high HDL content probably influenced aroma in the breast meat of the broilers (Ponte *et al.*, 2004). Increasing levels of fermented cassava tuber meal appeared to influence positively the accretion of fatty tissue in the breast, mostly in the intramuscular fat depot (since there was little abdominal fat), thus the improvement in aroma and juiciness (Fig. 1). Cholesterol is an important molecule that has roles in membrane structure in addition to being a precursor for the synthesis of molecules such as steroid hormones, vitamin D, and bile acids. Treatment AGP had the best overall acceptability among the treatments groups while the birds fed treatment FCTM50 had the best overall acceptability among birds fed fermented cassava suggesting that a 50:50 mix of fermented cassava tuber meal and maize is most acceptable to consumers. On the other hand, 100% replacement of maize (FCTM100) with fermented cassava tuber meal ranked lowest in overall acceptability. It should be remarked that during the sensory evaluation, the panelists expressed strong disapproval of the meat and sauce from the birds fed treatment FCTM100, as the characteristic smell of fermented cassava was apparently elaborated on the meat of birds that fed on it. Generally, treatment FCTM100 ranked

poorest in all the sensory attributes evaluated. An earlier study on the effect of dietary composition on the sensory properties of eggs showed that trimethylamine (TMA) contained in rapeseed meal could be elaborated in the yolk where it accumulates, which then acquires a “fishy” smell. On a positive twist, the high content of omega-3 fatty acid is a nutritional advantage that gives it a “premium price” status in the market (Bolton *et al.*, 1976). The authors reported that TMA is produced by the bacterial fermentation of choline in the small intestine and caeca of the hen. More recently, Haechang *et al.* (2014) showed similar results in diets containing flaxseed oil, dried whitebait and fructo-oligosaccharides (FOS). The combination of flaxseed and dried whitebait tended to impart an off-flavour taste and reduced overall acceptability. However, there is no information in literature to suggest that fermented cassava meal could influence the taste and overall acceptability of broiler meat.

### **Conclusion**

Replacing maize with fermented cassava tuber meal improved the live weight and dressed weight; high density lipoprotein concentration, protein and mineral content of the breast meat of broilers. Replacement of 50% and 75% of maize with fermented cassava tuber meal increased accretion of fatty tissue in the breast as intramuscular fat and caused better aroma and taste of the meat. However, complete replacement of maize with fermented cassava tuber meal imparted the characteristic smell of fermented cassava to the meat thus imparting a rather obnoxious and unpleasant taste and aroma to the meat. This in turn led to very poor overall acceptability by panelists. Further research is required to corroborate these findings, and to possibly identify and eliminate the

particular microbial metabolites generated by aqueous fermentation of cassava that are responsible for its characteristic smell; or identify feed additives that can eliminate the smell. This will ensure that the nutritional potentials of fermented cassava can be fully harnessed as a supplement or substitute for maize in broiler diets without compromising their performance and organoleptic properties of the meat.

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#### Conflict of interest declaration

The authors declare that they have no competing interests.

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