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Physico-chemical Attributes of Meat from Broiler Chickens Fed Pelletised Cassava Chips-Based Diets Supplemented with Graded Levels of Crystalline DL-Methionine

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Authors' contributions

All authors contributed to the study, read and approved the final submission.

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ABSTRACT

Aims: This experiment was carried out to investigate the effect of cassava chips-based diets with methionine supplementation on performance and meat physico-chemical attributes of broiler chickens.
Methodology: 400 one-day old Arbor Acre broiler chicks were randomly allotted to twenty groups of two replicates each in a 4x5 factorial arrangement in a completely randomised design (4 levels of methionine (0, 0.5, 1.0, 2.0 g/kg) and 5 levels of cassava chips (0, 25, 50, 75, 100%)). Data on performance were collected weekly while at the end of the feeding trial, three birds were sacrificed from each replicate for meat quality evaluation.
Results: Performance results showed that there was significant difference ($P<0.05$) on methionine on final body weight and weight gain and on cassava on weight gain and FCR. The interactive effect of cassava and methionine on weight gain was significant ($P<0.05$). There were significant differences ($P<0.05$) on methionine, cassava and their interaction on shear force, water holding

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capacity and thermal shortening of the meat. Methionine showed significant difference (P<0.05) for aroma and tenderness while cassava was only significant (P<0.05) for juiciness. The main effect of methionine was significant (P<0.05) for TBARS. There was significant difference (P<0.05) on the main effect of methionine, cassava and their interactions on the proximate composition of meat.
Conclusion: Methionine inclusion in cassava chips-based diets had positive effects on performance and meat quality attributes of broiler chickens.

Keywords: Cassava chips; methionine; broiler chickens; performance; meat quality.

1. INTRODUCTION

Food scarcity is a plague in many developing countries of the world, including Nigeria where the per capita animal protein is below the normal as recommended by FAO [1]. The protein intake in Nigeria and a number of developing countries are grossly inadequate when compared with the developed countries [2]. The nutrition of humans particularly for protein is a real challenge to the economy of many developing countries including Nigeria. The need to improve animal production for more animal products has become more important with increasing human population and demand [3].

In West Africa, there is a general need for readily available, high quality, alternative vegetable protein and energy sources that are inexpensive and capable of reducing production costs of meat and other animal products. This would reduce protein-calorie malnutrition and also help alleviate poverty in the region [4]. Broiler production is the fastest and easiest route since they are prolific and possess a low feed conversion ratio. However, feed cost is presently very high and makes up to 60-80% of the total cost of production in developing countries [5]. This therefore underscores the importance of feed management to broiler producers. Thus, it is necessary to reduce the cost of feeds in order to have cheaper products without affecting profits.

The use of unconventional feed resources in poultry nutrition is one of the ways to overcome the feed crisis in the poultry industry. Alternative feed sources have proved valuable in supporting the performance of livestock and poultry at low cost of production [6]. Cassava which is available in large quantity has been investigated to serve as alternative main energy source in broiler feedstuffs [2]. Methionine is known to be involved in cassava detoxification [7]. Cyanide is detoxified to thiocyanate by the enzyme rhodanase making use of Methionine as the sulphur donor which makes this amino acid a limiting factor in cassava based-feeds. The use of high level of DL-Methionine could therefore be a way of improving the utilization of cassava based-diet by broiler chickens. Thus, this study was designed to investigate the performance and physico-chemical attributes of broiler chickens fed cassava chips-based diets supplemented with DL-methionine.

2. MATERIALS AND METHODS

A total of 400 one day-old unsexed Arbor Acre broiler chicks were sourced from a commercial hatchery in Ibadan, Nigeria and allotted into twenty treatments of two replicates with ten birds per replicates. The birds were brooded and fed common diet for the first week. The birds were fed *ad libitum* daily, also other routine vaccinations and necessary medications were administered. The experiment design was a 4x5 factorial arrangement in a completely randomized design and the experimental layout had 2 factors which comprised 4 levels of supplemental methionine (0, 0.5, 1.0, 2.0 g/kg) and 5 levels of cassava chips supplementations (0, 25, 50, 75, 100%). The experimental diet was formulated for the starters and the finishers (Table 1). The starter diet was fed for the first four weeks and the finisher diet the last four weeks. At week 8, three birds per treatment with an average weight closest to their group mean weight were purposively selected, tagged, starved of feed overnight and sacrificed by cutting their jugular vein, bled and defeathered. The carcasses were dressed, eviscerated and cut into parts.

Weekly body weight and feed intake measured were used to calculate feed conversion ratio (FCR) as stated below:

$$FCR= \frac{\text{Feed consumed (g)}}{\text{Body weight gain (g)}}$$

The Shear Force was determined by weighing 50 g of meat sample which was boiled in polythene nylon at 70℃ for 15 mins. The boiled meat sample was culled using the culling machine along meat fibres. The culled meat sample was then sheared across the meat fibres on the blade of the warner bratzler machine and the readings were recorded.

Table 1. Composition of the experimental diet (g/100 gDM)

Feed ingredients	Starter	Finisher
Maize	59.00	59.00
Cassava chips	0.00	0.00
Soyabean cake	36.00	30.00
Wheat bran	2.00	7.00
Calcium carbonate	1.00	1.00
Salt	0.25	0.25
Di-Calcium phosphate	1.50	1.50
Vitamin-mineral premix	0.25	0.25
Methionine	0.00	0.00
Toxin binder	1.00	1.00
Total (Kg)	100.00	100.00
Calculated values		
Crude protein %	22.44	20.59
Metabolic energy (Kcal/kg)	3032.06	2955.06

Premix composition: Vitamin A, 20000000 IU, Vit. D3 4000000 IU; Vitamin E 460 mg; Vitamin K3 40 mg; Vitamin ; Vitamin B1 60 mg; Vitamin B2 120 mg; Niacin 1000 mg; Calcium pantothenate 200 mg; Vitamin B6 100 mg; Vitamin B125 mg; Folic acid 20 mg; Biotin 1 mg; Chlorine chloride 8000 mg; Manganese 2400 mg; Iron 2000 mg; Zinc 1600 mg Copper 170 mg; Iodine 30 mg; Cobalt 6 mg; Selenium 24 mg; Anti-oxidant 2400 mg

Water holding capacity (WHC) was estimated by determining expressible juice using a modification of the filter paper press method described by Suzuki et al. [8] as follows. A meat sample weighing 1 g was placed on an 11 cm diameter filter paper between Plexiglas plates and pressed using a table vice for 1 min. The amount of expressible juices released from the samples was measured by measuring the area of the filter paper wetted relative to the area of the pressed sample and the two areas were determined using formula:

$$\text{Water holding capacity (WHC)} = \frac{\text{Meat area}}{\text{Water area}} \times 100$$

The thermal shortening was determined by measuring the length of the meat cut along the fibre of meat from the chest which was placed in a tray and put in an oven at 100℃ for 20 mins and then allowed to cool at room temperature. The percentage thermal shortening [9] was determined using the formula:

$$\%\ \text{thermal shortening} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

The sensory evaluation was determined by cutting a portion of meat from the chest part of the birds tied and labeled in polythene nylon and cooked for 20 mins with gas cooker, allowed to cool for 20 mins before serving it to the semi panelists. A total of 10 trained individuals were used to access the prepared meat samples according to the procedures of AMSA [10]. The meat samples were evaluated using a 9-point hedonic scale for aroma, flavour, tenderness, texture, juiciness, colour and overall acceptability. The samples were rated on a 9-point hedonic scale with maximum score of extremely high condition while the lowest score of 1 was assigned to the poorest condition. Each sample was evaluated independently of the other. The panelists were provided with crackers biscuit and water to rinse their mouths after evaluating each sample so as to give accurate evaluation of each sample. The rinsing of the mouth is done so that the mouth has a fresh perception.

The thiobarbituric acid reactive substances (TBARS) was determined by cutting 10 g of meat sample which was crushed and 25 mL of 20% TCA and also 20 mL of distilled water was added. The mixture was homogenised for 20 minutes and filtered through Whatman filter paper. The filtrate was mixed with equal quantity of 0.02 M TBA and inoculated at 100℃ for 35 mins. It was then cooled in tap water for 10 mins. The absorbance of the solution was measured using spectrophotometer at 532 nm [11].

The proximate analysis was carried out using AOAC [12] methods for protein, ether extract, moisture content, ash and crude fibre. Data were subjected to analysis of variance and the means were separated using Duncan's multiple range test at $P = \alpha_{0.05}$ with the statistical package SAS 9.3 [13].

3. RESULTS AND DISCUSSION

Figs. 1, 2, 3 and 4 show effect of varying levels of methionine on shear force of broiler meat, effect of graded levels of cassava on shear force of broiler meat, effect of varying levels of methionine on crude protein composition of broiler meat, effect of graded levels of cassava on crude protein composition of broiler meat respectively. Tables 2, 3 , 4, 5, 6, 7 and 8 show main effect of methionine and cassava on performance characteristics of broiler chickens at the finisher phase of production, interactive effect of methionine and cassava on performance characteristics of broiler chickens at finisher phase of production, main effect of methionine and cassava on meat physical characteristics, interactive effect of methionine and cassava on meat physical characteristics, main effect of methionine and cassava on sensory properties of broiler meat, main effect of methionine and cassava on chemical characteristics of broiler meat and interactive effect of methionine and cassava on chemical characteristics of broiler meat respectively.

There were significant differences (*P<0.05*) in the final weight and body weight gained by the finisher broilers. The highest final body weight (2139.01±76.77 g) and weight gain (1616.51±65.21 g) were observed with 2.0% level of methionine inclusion. Results showed that there were significant effects (*P<0.05*) of dietary cassava on the initial weight, final weight, weight gain and feed conversion ratio (FCR) of finishers broilers. The highest (*P<0.05*) value for the initial body weight (552.00±14.67 g), final weight (2121.75±30.10 g) and weight gain (1569.75±23.83 g) were observed in birds on 0% dietary cassava. The least (*P<0.05*) FCR value (1.72±0.03) was also obtained in broilers on 0% cassava. Results showed that the interaction of supplemental methionine and dietary cassava inclusion was significant (*P<0.05*) on final weight, weight gain and FCR of broilers. The highest (*P<0.05*) value of final weight (2384.88±29.86 g), weight gain (1831.13±3.61 g) was in 2.0% level of methionine and 25% dietary cassava combination and the least (*P<0.05*) value of FCR was in broilers on 2.0% level (1.47±0.00) of methionine and 25% of cassava treatment combination.

Birds fed on diet with 2.0% methionine inclusion level had the highest weight gain (1616.51±65.21) while those on 0% inclusion level of methionine was lowest (1169.08±60.28) in agreement with the report of Wyllie et al. [14] on linear increase in weight gain in broiler when fed diets which was supplemented with methionine. Birds fed cassava chips had lower weight gain (1325.17±104.85) while the ones with 0% level of cassava inclusion had the higher weight gain (1569.75±23.83).

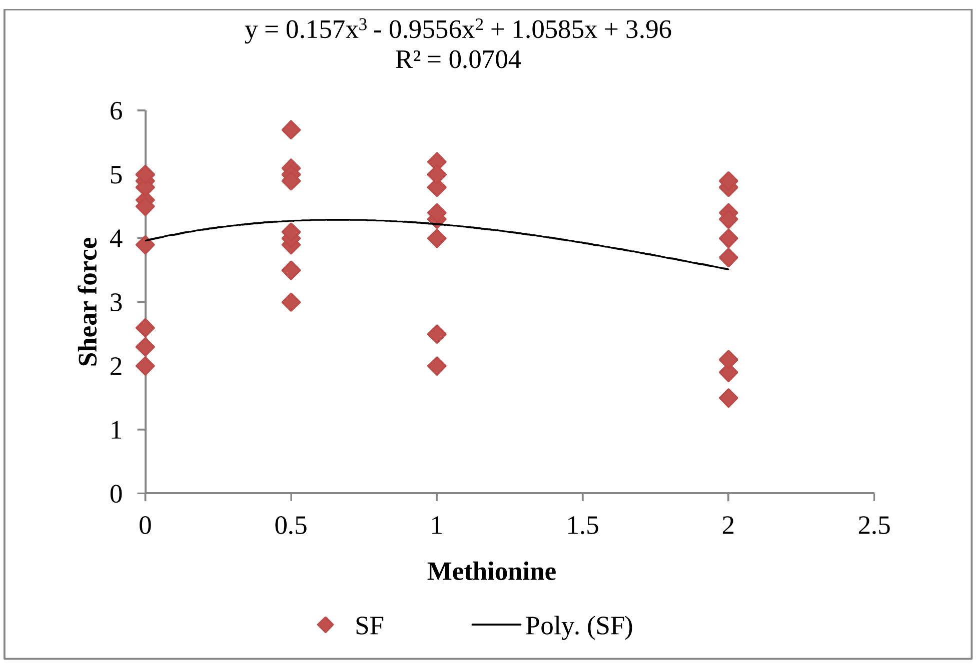

Fig. 1. Effect of varying levels of methionine on shear force of broiler meat

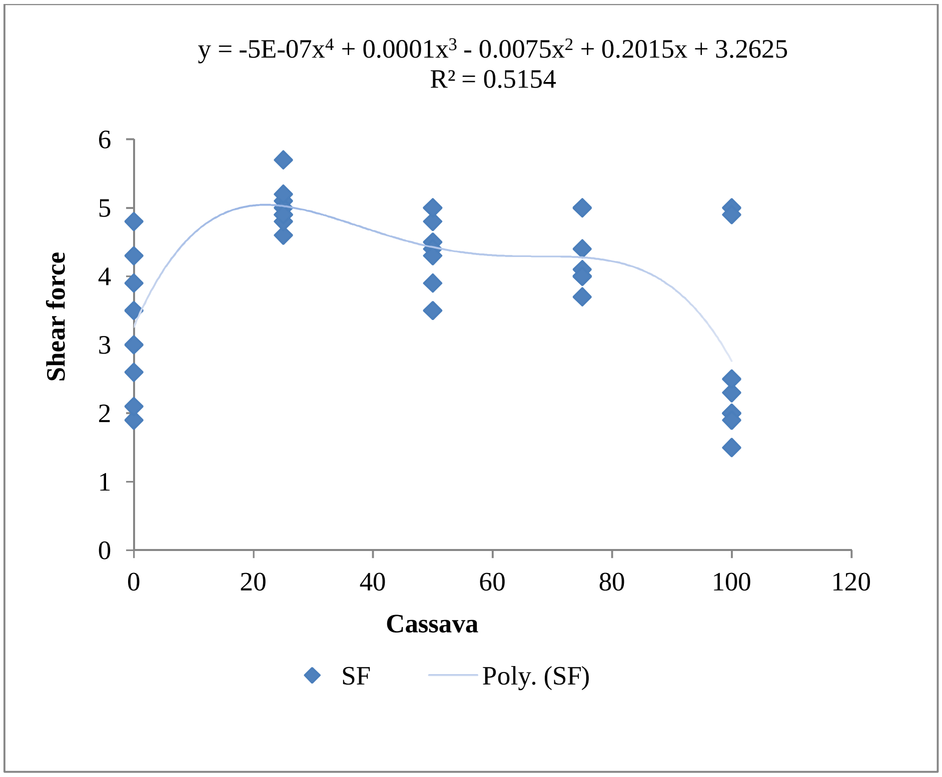

Fig. 2. Effect of graded levels of cassava on shear force of broiler meat

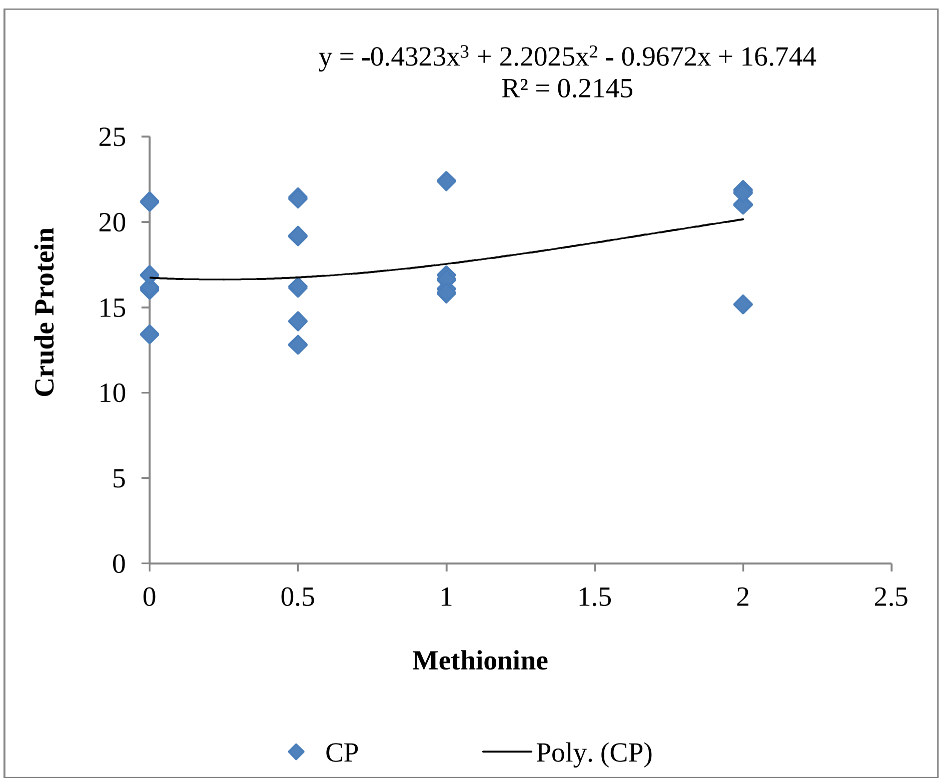

Fig. 3. Effect of varying levels of methionine on crude protein composition of broiler meat

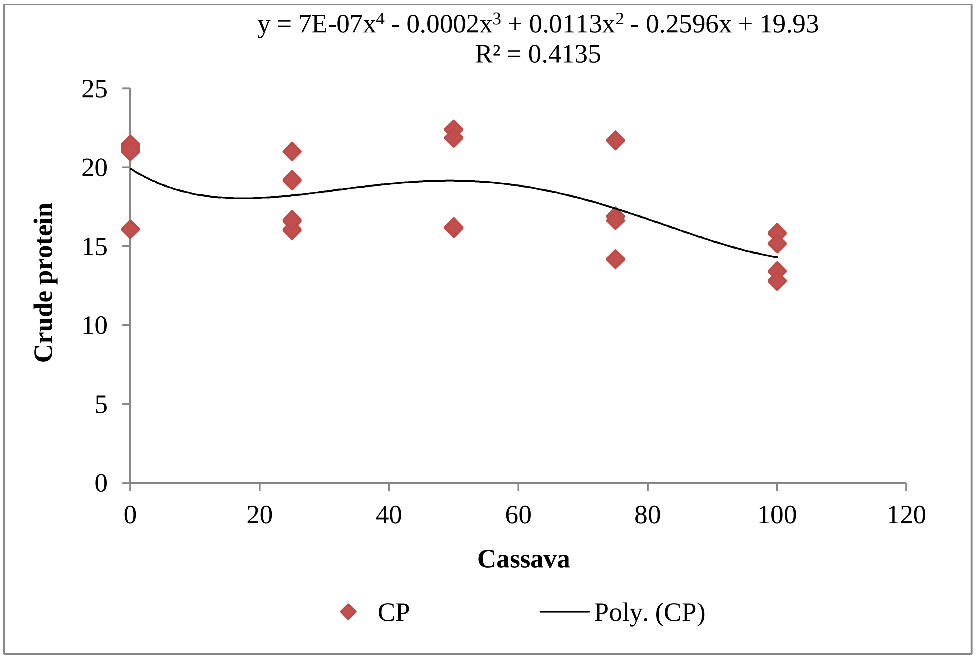

Fig. 4. Effect of graded levels of cassava on crude protein composition of broiler meat

Table 2. Main effect of methionine and cassava on performance characteristics of broiler chicks at the finishers phase of production

Methionine	Initial weight (g)	Final weight (g)	Weight gain (g)	FCR
0	503.80±15.82	1669.93±75.06^c	1169.08±60.28^d	2.37±0.11
0.5	522.75±18.69	1889.15±54.60^b	1366.40±43.49^c	1.99±0.06
1	525.00±9.01	2102.10±36.46^a	1577.10±30.59^b	1.72±0.03
2	522.50±20.63	2139.01±76.77^a	1616.51±65.21^a	1.70±0.07
Cassava				
0	552.00±14.67^a	2121.75±30.10^a	1569.75±23.83^a	1.72±0.03^d
25	541.88±16.30^a	2049.62±90.74^b	1507.75±83.74^b	1.83±0.10^c
50	514.06±12.91^{ab}	1948.59±106.33^c	1434.53±97.65^c	1.95±0.13^b
75	489.38±20.46^b	1809.80±72.53^d	1320.42±73.53^d	2.09±0.13^a
100	495.31±18.01^b	1820.48±118.86^d	1325.17±104.85^d	2.13±0.16^a

$^{a-d}$ Means along same column with different superscripts are significantly different (P<0.05)
FCR- Feed Conversion Ratio

As the level of cassava inclusion increased, the weight gained decreased. Similar result was recorded by Wyllie et al. [14]. Weight gain and conversion efficiency deteriorated linearly as the proportion of cassava in the diet increased. The reduction in weight gain in diets containing progressively larger amounts of cassava is similar to reports of other authors [15,16]. The reasons for the reduced performance may be due to several reasons like the presence of cyanoglucosidases in cassava; differences in energy content between cassava and maize; palatability differences and the presence of aflatoxins in the cassava meal. Effect of interaction of methionine and cassava shows a significantly higher weight gain (1831±3.61) with the highest value in chickens fed 2% levels of methionine and 25% cassava while the lowest value (985.37±37.36) was recorded in those fed 0% methionine and 100% cassava. Values obtained for the effect of methionine on FCR shows that there was no significant difference in all the inclusion levels. Chickens fed diets containing methionine could be said to have a lower FCR because as the inclusion level of methionine increased the FCR reduced. Similar result was obtained by Saki et al. [17] and Kidd et al. [18] who attributed the improvement of FCR to decreased supplemental methionine.

Results from the present study disagreed with those obtained by Mohamed et al. [19] that supplementation of methionine significantly improved FCR. Cassava based diets significantly affected FCR of birds. Birds fed 100% inclusion level of cassava had high value (2.13±0.16) while birds fed with 0% inclusion level of cassava had low value (1.72±0.03). The interaction effect of methionine and cassava diets on produced higher FCR value in birds fed 0% methionine and 100% cassava (2.74±0.10) while it was lower in birds fed with 2.0% methionine and 25% cassava (1.47±0.00).

Table 3. Interactive effect of methionine and cassava on performance characteristics of broiler chickens at the finisher phase of production

Methionine	Cassava	Initial weight (g)	Final weight (g)	Weight gain (g)	FCR
0	0	581.75±3.25	2071.30±27.30^{d}	1489.55±24.55^{d}	1.81±0.03^{e}
	25	503.75±6.25	1710.90±8.34^{gh}	1207.15±14.59^{f}	2.24±0.03^{c}
	50	501.25±18.75	1611.97±58.33^{hi}	1110.72±39.58^{g}	2.43±0.09^{b}
	75	481.25±13.75	1518.96±20.84^{ij}	1037.71±34.59^{gh}	2.60±0.09^{a}
	100	451.25±36.25	1436.52±73.61^{j}	985.37±37.36^{h}	2.74±0.10^{a}
0.5	0	518.75±58.75	2072.67±95.83^{d}	1553.92±37.08^{cd}	1.74±0.04^{ef}
	25	592.50±30.00	2068.98±20.84^{d}	1476.48±9.17^{d}	1.83±0.01^{e}
	50	495.00±37.50	1801.86±58.34^{fg}	1306.86±20.84^{e}	2.07±0.03^{d}
	75	545.00±5.00	1798.50±68.06^{fg}	1253.50±63.06^{ef}	2.16±0.11^{cd}
	100	462.50±12.50	1703.74±16.67^{gh}	1241.24±4.17^{ef}	2.18±0.01^{cd}
1	0	546.25±1.25	2137.95±1.39^{cd}	1591.70±0.14^{bc}	1.70±0.00^{ef}
	25	517.50±32.50	2033.74±37.50^{d}	1516.24±5.00^{cd}	1.78±0.01^{ef}
	50	505.00±15.00	2020.80±23.61^{de}	1515.80±8.61^{cd}	1.78±0.01^{ef}
	75	508.75±13.75	2020.80±23.61^{de}	1512.05±9.86^{cd}	1.79±0.11^{ef}
	100	547.50±22.50	2297.22±8.34^{ab}	1749.72±14.17^{a}	1.54±0.01^{gh}
2	0	561.25±21.25	2205.08±56.95^{bc}	1643.83±35.70^{b}	1.64±0.04^{fg}
	25	553.75±26.25	2384.88±29.86^{a}	1831.13±3.61^{a}	1.47±0.00^{h}
	50	555.00±20.00	2359.73±9.73^{a}	1804.73±10.28^{a}	1.50±0.01^{gh}
	75	422.50±57.50	1900.93±55.56^{ef}	1478.43±1.95^{d}	1.83±0.00^{e}
	100	520.00±27.50	1844.44±30.56^{f}	1324.44±58.06^{e}	2.04±0.09^{d}

$^{a-h}$ Means along same column with different superscripts are significantly different (P<0.05)
FCR- Feed Conversion Ratio

Table 4. Main effect of methionine and cassava on meat physical characteristics

Methionine	Shear force	WHC	Thermal shortening
0	3.96±0.38^{b}	51.98±2.70^{d}	12.11±1.60
0.5	4.27±0.27^{a}	57.84±2.37^{b}	13.38±2.00
1	4.22±0.35^{ab}	68.47±2.87^{a}	12.42±1.32
2	3.35±0.42^{c}	54.17±2.40^{c}	13.41±1.14
Cassava			
0	3.26±0.37^{c}	56.35±1.93^{bc}	8.25±1.47^{d}
25	5.03±0.11^{a}	63.86±5.34^{a}	17.64±0.67^{a}
50	4.43±0.19^{b}	54.94±2.26^{c}	13.95±1.72^{b}
75	4.28±0.17^{b}	57.01±2.83^{bc}	11.48±0.85^{c}
100	2.76±0.49^{d}	57.93±3.37^{b}	12.85±1.61^{bc}

$^{a-d}$ Means along same column with different superscripts are significantly different (P<0.05)
WHC= Water holding capacity

Table 5. Interactive effect of methionine and cassava on physical characteristics of broiler meat

Methionine	Cassava	Shear force	WHC	Thermal shortening
0	0	$3.25{\pm}0.65^{h}$	$51.77{\pm}1.31^{g}$	$5.76{\pm}0.36^{jk}$
	25	$4.75{\pm}0.15^{bcd}$	$39.73{\pm}0.71^{j}$	$16.98{\pm}1.02^{a-d}$
	50	$4.65{\pm}0.15^{b-e}$	$58.42{\pm}1.35^{de}$	$10.36{\pm}0.36^{ghi}$
	75	$5.00{\pm}0.00^{ab}$	$67.85{\pm}1.35^{c}$	$9.38{\pm}0.62^{hij}$
	100	$2.15{\pm}0.15^{i}$	$44.24{\pm}0.43^{hi}$	$18.06{\pm}1.94^{abc}$
0.5	0	$3.25{\pm}0.25^{h}$	$50.10{\pm}0.67^{g}$	$3.93{\pm}0.63^{k}$
	25	$5.40{\pm}0.30^{a}$	$58.30{\pm}1.30^{de}$	$18.95{\pm}1.06^{ab}$
	50	$3.70{\pm}0.20^{gh}$	$48.82{\pm}1.34^{gh}$	$19.71{\pm}3.63^{a}$
	75	$4.05{\pm}0.05^{efg}$	$58.28{\pm}0.52^{de}$	$11.97{\pm}1.08^{fgh}$
	100	$4.96{\pm}0.05^{abc}$	$73.28{\pm}2.63^{b}$	$12.38{\pm}0.67^{e-h}$
1	0	$4.55{\pm}0.25^{b-e}$	$67.68{\pm}2.31^{c}$	$9.33{\pm}0.58^{hij}$
	25	$5.10{\pm}0.10^{ab}$	$88.47{\pm}1.45^{a}$	$19.20{\pm}0.80^{ab}$
	50	$5.00{\pm}0.00^{ab}$	$62.82{\pm}0.81^{d}$	$9.71{\pm}1.18^{hi}$
	75	$4.20{\pm}0.20^{d-g}$	$59.54{\pm}0.78^{de}$	$9.93{\pm}0.08^{hi}$
	100	$2.25{\pm}0.25^{i}$	$62.21{\pm}1.92^{d}$	$13.94{\pm}2.18^{d-g}$
2	0	$2.00{\pm}0.10^{i}$	$55.85{\pm}1.95^{ef}$	$14.00{\pm}0.96^{d-g}$
	25	$4.85{\pm}0.05^{abc}$	$68.95{\pm}0.90^{c}$	$15.45{\pm}0.60^{b-f}$
	50	$4.35{\pm}0.05^{c-f}$	$49.70{\pm}0.40^{g}$	$16.04{\pm}0.08^{a-e}$
	75	$3.85{\pm}0.15^{fgh}$	$42.27{\pm}1.01^{ij}$	$14.56{\pm}1.52^{c-f}$
	100	$1.70{\pm}0.20^{i}$	$52.01{\pm}1.08^{fg}$	$7.02{\pm}0.98^{ijk}$

$^{a-k}$ Means along same column with different superscripts are significantly different (P<0.05)
WHC= Water holding capacity

The physical characteristics of meat are a measure of its shear force, water holding capacity (WHC) and thermal shortening. The effect of methionine on meat quality affected the shear force, WHC and thermal shortening. The highest value for shear force was recorded in birds fed with diet containing 0.5% methionine (4.27±0.27) while those fed with diets containing 2.0% methionine had the lowest value (3.35±0.42). Since shear force is a measure toughness of meat, birds fed with 0.5% methionine will give meat that will be tougher than those fed with 2.0% methionine which will give a relatively tender meat. Regression of shear force on methionine supplementation (Fig. 1) gave the regression equation $y = 0.157x^3 - 0.9556x^2 + 1.0585x + 3.96$ ($R^2 = 0.0704$). Texture differences may be due to varying protein turnover and connective tissue metabolism. There was significant difference in the WHC value for all the birds. Birds fed with diet containing 1.0% methionine had the highest value (68.47±2.87) while those fed with diet containing 0% methionine had the lowest (51.98±2.70). There was no significant difference in values obtained for thermal shortening. Birds fed with diet containing 25% cassava chips had shear force value that was significantly higher (5.03±0.11) than those fed with diets containing 100% cassava chips (2.76±0.49). Meat from birds with high shear force gives tough meat therefore, birds fed with 100% cassava chips gives a more tender meat than those fed with 25% cassava chips. Regression of shear force on cassava (Fig. 2) gave the regression equation $y = -5E\text{-}07x^4 + 0.0001x^3 - 0.0075x^2 + 0.2015x + 3.2625$ ($R^2 = 0.5154$). If the WHC of meat is low, whole meat and further processed product will lack juiciness. In this regard bird fed with diet containing 25% cassava chips (63.86±5.34) will give meat that will be juicier than those fed with diet containing 50% cassava chips (54.94±2.26).

There was significant difference in values obtained for thermal shortening; birds fed with 25% cassava chips had the highest value (17.64±0.67) while those fed with 0% cassava chips had the lowest (8.25±1.47). The value obtained shows that meat from birds fed with 0% cassava will give a better meat quality that will not shrink when subjected to heat treatment. Due to interaction effect, significant difference was obtained in shear force, WHC and thermal shortening. Tougher meat was gotten from birds fed with 0.5% methionine and 25% cassava which had the highest value (5.40±0.30) while tender meat was obtained from birds fed with 2.0% methionine and 0% cassava that the lowest value (2.00±0.10). There was significant difference in the values obtained for WHC. Birds fed with 1.0% methionine and 0% and 25% cassava had the highest value (88.47±1.45) while those fed 0% methionine and 25% cassava had the lowest which will result in more tough meat than the ones fed 1.0% methionine and 0% and 25% cassava. Thermal shortening was high in birds fed with 0.5% methionine and 50% cassava (19.71±3.63) resulting in a poor meat quality as the meat will shrink when subjected to heat treatment but low in birds fed with 0.5% methionine and 0% cassava (3.93±0.63) resulting in a better meat quality as the reduction in size was not much when subjected to heat treatment.

Sensory evaluation was measured using aroma, flavour, tenderness, texture, juiciness, colour and overall acceptability. There was significant difference in values obtained for Aroma (4.30±0.41) and tenderness (6.00±0.34) on the main effect of methionine. There was no significant difference in flavour, texture, juiciness, colour and overall acceptability, despite the non-significance Methionine had significant influence on them. Methionine at 2.0% level of inclusion had the highest value for all the sensory parameters measured except for colour where the highest value was recorded at the 1.0% inclusion level. There was no significant difference in the values obtained for the effect of cassava on the sensory parameters. Similar result was obtained by Abu et al. [20] who observed no significant difference in the organoleptic characteristic of meat as a result of the effect of different dietary treatment on the meat. Colour is mainly influenced by the myoglobin content and nature, the composition and physical state of muscle [21,22] and the meat structure. Juiciness was significantly difference with cassava at 100% level of inclusion had the highest value (5.58±0.44) while 25% inclusion level had the lowest value (4.42±0.34). Due to interaction effect, there was no significant difference in all sensory parameters evaluated. For Aroma, flavour, tenderness, texture and colour, birds fed diet containing 2.0% methionine and 100% cassava had the highest value.

The chemical characteristics of meat are a measure of its TBARS and proximate analysis. TBARS is a product of fat metabolism, over storage, fat is converted to some substances one of which is malonaldehyde. When malondialdehyde is high in meat, it means more fat is converted. For the effect of methionine on meat, there was significant difference in the TBARS value at 0 h and 24 h but no significant difference in the values obtained at 7 day. For 0 h, meat obtained from birds fed 0% methionine had the lowest value (0.43±0.13) while the highest was recorded for the meat obtained from birds fed 0.50% methionine inclusion (1.34±0.31). At 24 h the highest value was recorded for the meat obtained from birds fed with 1.00% methionine and the lowest was from meat obtained from birds fed with 0% methionine. The result of proximate analysis of the meat showed that there was significant difference ($P<0.05$) in ash, crude protein, ether extract, moisture content for the effect of methionine. The highest value for ash was (1.83±0.15) for meat obtained from birds fed diet containing 1.0% methionine inclusion. Crude protein was high (20.16±0.84) in meat obtained from birds fed diets containing 2.0% methionine inclusion. Regression of crude protein on methionine supplementation (Fig. 3) gave the regression equation $y = -0.4323x^3 + 2.2025x^2 - 0.9672x + 16.744$ ($R^2 = 0.2145$) which indicated a minimum of 16.74 methionine for crude protein. The highest value (10.94±0.17) for ether extract was in meat obtained from birds fed with 0.5% methionine inclusion. Moisture content of meat obtained from birds fed diet containing 1.0% methionine (72.90±0.30).

The effect of cassava on proximate analysis showed significant difference in ash, crude protein, ether extract and moisture content. The highest value for ash was (1.94±0.18) in meat obtained from bird fed with 25% cassava. Crude protein was high (19.93±0.84) in meat obtained from bird fed with 0% cassava. Regression of crude protein on cassava (Fig. 4) gave the regression equation $y = 7E\text{-}07x^4 - 0.0002x^3 + 0.0113x^2 - 0.2596x + 19.93$ ($R^2 = 0.4135$) which indicated a minimum of 19.93 cassava for crude protein. The highest value (10.50±0.25) for ether extract was in meat obtained from birds fed with 50% cassava. The highest value for moisture content was (72.80±0.20) in meat from bird fed with 75% cassava. The result obtained for the effect of the interaction of methionine and cassava shows that there was significant difference in all the combinations.

Table 6. Main effect of methionine and cassava on sensory properties of broiler meat

Met	Aroma	Flavour	Tenderness	Texture	Juiciness	Colour	O. accept
0	3.40±0.33[b]	3.93±0.26	4.93±0.40[b]	5.07±0.26	5.30±0.33	5.53±0.21	5.73±0.23
0.5	3.87±0.23[ab]	4.13±0.29	5.00±0.31[b]	5.30±0.25	4.60±0.31	5.50±0.23	5.90±0.23
1	3.57±0.36[ab]	3.63±0.34	4.37±0.40[b]	5.03±0.32	4.70±0.37	5.75±0.30	5.13±0.32
2	4.30±0.41[a]	4.46±0.37	6.00±0.34[a]	5.40±0.29	5.47±0.31	5.63±0.32	5.90±0.32
Cassava							
0	3.71±0.38	3.96±0.34	5.08±0.39	5.21±0.28	5.46±0.34[ab]	5.75±0.27	5.88±0.24
25	4.29±0.38	4.13±0.41	4.54±0.38	4.75±0.31	4.42±0.3 4[b]	5.00±0.26	5.33±0.23
50	3.63±0.40	4.04±0.35	5.29±0.43	5.29±0.31	4.88±0.4 0[ab]	5.46±0.31	6.00±0.32
75	3.21±0.32	4.00±0.31	4.71±0.46	5.21±0.32	4.75±0.3 3[ab]	5.79±0.34	5.71±0.31
100	4.08±0.41	4.33±0.40	5.75±0.42	5.54±0.35	5.58±0. 44[a]	5.79±0.30	5.42±0.43

[ab] Means along same column with different superscripts are significantly different (P<0.05)
Met- Methionine, O. Accept- Overall Acceptability

Table 7. Main effect of methionine and cassava on chemical characteristics of broiler meat

Methionine	TBARS 0 hr	TBARS 24 hrs	Ash	Crude protein	Ether extract	Moisture content
0	0.43±0.13[b]	0.41±0.08[b]	1.67±0.16[c]	16.74±0.84[c]	10.21±0.20[b]	72.26±0.31[b]
0.5	1.34±0.31[a]	0.81±0.19[ab]	1.48±0.05[d]	16.76±1.06[c]	10.94±0.17[a]	72.32±0.35[b]
1	1.03±0.22[ab]	0.98±0.15[a]	1.83±0.15[a]	17.55±0.82[b]	10.26±0.22[b]	72.90±0.30[a]
2	0.63±0.13[b]	0.67±0.14[ab]	1.72±0.09[b]	20.16±0.84[a]	10.03±0.11[c]	71.98±0.37[b]
Cassava						
0	1.30±0.43	0.68±0.23	1.65±0.05[c]	19.93±0.84[a]	10.29±0.22[b]	72.03±0.35[b]
25	0.92±0.26	0.82±0.24	1.94±0.18[a]	18.22±0.75[c]	10.44±0.20[a]	71.93±0.57[b]
50	0.76±0.18	0.64±0.14	1.86±0.10[b]	19.16±1.13[b]	10.50±0.25[a]	72.47±0.35[ab]
75	0.63±0.17	0.79±0.13	1.62±0.11[c]	17.39±1.03[d]	10.45±0.27[a]	72.80±0.20[a]
100	0.68±0.15	0.67±0.15	1.30±0.11[d]	14.31±0.47[e]	10.13±0.24[c]	72.60±0.32[a]

[a-d] Means along same column with different superscripts are significantly different (P<0.05)
TBARS-Thiobarbituric Acid Reactive Substances

Table 8. Interactive effect of methionine and cassava on chemical characteristics of broilers meat

Met	Cas	TBAR 0 hr	TBAR 24 hrs	Ash	Crude protein	Ether extract	Moisture content
0	0	0.19±0.18	0.28±0.00	1.83±0.04[e]	21.20±0.03[e]	9.83±0.20[jk]	73.00±0.41[a-d]
	25	0.76±0.00	0.48±0.05	2.06±0.03[c]	16.05±0.04[l]	11.34±0.04[b]	70.58±0.30[gh]
	50	0.23±0.09	0.36±0.07	2.19±0.01[b]	16.16±0.02[kl]	10.18±0.03[gh]	72.48±0.23[cde]
	75	0.66±0.59	0.68±0.38	1.42±0.03[h]	16.90±0.02[h]	9.86±0.05[jk]	72.19±0.05[def]
	100	0.32±0.29	0.25±0.13	0.85±0.04[j]	13.42±0.01[p]	9.84±0.01[jk]	73.08±0.09[a-d]
0.5	0	2.80±0.79	1.09±0.94	1.66±0.01[g]	21.42±0.56[d]	11.12±0.06[c]	71.39±0.85[fg]
	25	1.17±0.55	0.82±0.67	1.33±0.03[i]	19.19±0.04[g]	10.05±0.06[hi]	73.12±0.07[a-d]
	50	1.09±0.59	0.47±0.21	1.44±0.01[h]	16.19±0.05[k]	10.81±0.04[d]	71.08±0.29[gh]
	75	0.86±0.42	0.95±0.03	1.64±0.03[g]	14.19±0.02[o]	11.61±0.02[a]	72.60±0.52[bcd]
	100	0.76±0.38	0.77±0.10	1.35±0.03[i]	12.81±0.02[q]	11.14±0.06[c]	73.40±0.23[abc]
1	0	1.76±0.16	1.01±0.29	1.63±0.03[g]	16.09±0.02[kl]	10.52±0.02[e]	72.57±0.11[bcd]
	25	1.09±0.99	1.18±0.29	2.64±0.01[a]	16.64±0.04[j]	10.11±0.02[gh]	73.71±0.20[a]
	50	0.92±0.38	0.73±0.28	1.89±0.01[de]	22.41±0.03[a]	11.37±0.07[b]	73.53±0.35[ab]
	75	0.38±0.00	1.02±0.23	1.33±0.03[i]	16.77±0.13[i]	9.88±0.04[ij]	73.26±0.23[abc]
	100	1.01±0.25	0.98±0.31	1.65±0.02[g]	15.84±0.04[m]	9.43±0.03[m]	71.45±0.69[efg]
2	0	0.44±0.10	0.33±0.03	1.48±0.02[h]	21.03±0.03[f]	9.68±0.03[kl]	71.16±0.29[fgh]
	25	0.64±0.63	0.81±0.46	1.76±0.02[f]	21.01±0.01[f]	10.29±0.04[fg]	70.31±0.12[h]
	50	0.79±0.13	1.01±0.38	1.93±0.02[d]	21.88±0.03[b]	9.63±0.10[l]	72.80±0.13[a-d]
	75	0.63±0.36	0.49±0.22	2.11±0.01[c]	21.72±0.02[c]	10.45±0.05[ef]	73.16±0.29[a-d]
	100	0.62±0.33	0.69±0.44	1.35±0.01[i]	15.18±0.02[n]	10.11±0.03[gh]	72.48±0.44[b-e]

[a-q] *Means along same column with different superscripts are significantly different (P<0.05)*
Met- Methionine, Cas- Cassava, TBARS-Thiobarbituric Acid Reactive Substances

4. CONCLUSION

The result obtained from this research showed that the inclusion of methionine to cassava chips-based diets for broiler feeding was beneficial to the birds' performance and meat quality. The inclusion of methionine to cassava-based diet for broiler feeding proved better than diet without methionine. Birds fed with diet containing methionine had better performance than those fed with cassava. Meat from birds fed with methionine and cassava were also of better quality than those fed with cassava-based diet. It can be concluded from this study that the supplementation of varying levels of methionine to cassava in the diets of broilers was beneficial to the birds in terms of meat quality.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee".

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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