SUPPLEMENTAL DL-METHIONINE IMPROVED PERFORMANCE AND NUTRIENT RETENTION IN BROILER CHICKENS FED CASSAVA CHIPS-BASED DIETS

[1]Ogunwole, O. A., [2]Etop, S. C. and [1]Adedeji, B. S.

[1]Agricultural Biochemistry and Nutrition Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria
[2]Nutrition, Research and Development Department, Grand Cereals Limited, Jos, Nigeria

Corresponding author's e-mail: **oluogunwole@yahoo.com**

ABSTRACT

This study was aimed at investigating the effects of DL-methionine in cassava chips-based diets on performance and nutrients retention in broiler chickens. One-day old Arbor Acres broiler chicks (n-450) were allotted to cassava chips-based diets with cassava chips used to replace 0, 25, 50, 75 and 100% maize alongside DL-methionine at 0, 0.1 and 0.2% in a 3x5 factorial arrangement of a completely randomized design. Each treatment was in triplicate of 10 chicks per replicate. Feed intake (FI) of starter chickens on different dietary levels of cassava chips were similar (p>0.05). The final body weight (FBW) of chicks on 50% replacement of maize with cassava chips (757.6g) was significantly lower (p < 0.05) to those on 0% (855.3g) and 25% (809.8g) replaced maize diets, but higher than 75% (688.2g) and 100% (701.4g) replacement of maize with dietary cassava chip levels. The feed conversion ratio (FCR) of broiler chicks on 0 (1.68), 25 (1.78) and 50% (1.94) replacement levels of maize with dietary cassava chips were similar (p > 0.05) but differed significantly (p < 0.05) from 2.14 and 2.09 obtained for diets with 75 and 100% replacement of maize with cassava chips. Supplemental methionine significantly improved (p < 0.05) feed intake (FI), FBW and FCR. At the finisher phase, FI was only lowered in chicks fed diet with 75% of maize replaced with cassava while WG and FCR did not improve with increasing levels of dietary cassava chips. The relationships among FCR (R^2=0.56), FW (R^2 =0.57) and supplemental methionine in cassava-based diets were cubic. Crude protein retention reduced (p < 0.05) with increased cassava-chips inclusion while CF and ash increased. Supplemental methionine increased CP and ash retention but lowered crude fibre and ether extracts. Effect of interaction of cassava and methionine on all monitored parameters was significant (p<0.05). Thus, performance and nutrient retention by broiler chickens fed cassava chip-based diets improved with dietary supplementation of 0.1 and 0.2% DL methionine.

Keywords: Methionine, Hydrogen cyanide, Cassava chips, Broiler chicks, Performance, Nutrient retention.
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INTRODUCTION

Energy is the primary need of poultry which is often met through dietary corn-soy based formulations in poultry. In the formulation of feed for chickens, cereal usually constitutes the most prominent proportion. Hence, a shortfall in the supply of cereal is often traumatic and unjustifiable in economic terms for poultry production in sub-Saharan Africa (Kana *et al.,* 2014). This observation has heightened the search for alternative locally cheap and available feed stuffs with emphasis on those that do not attract severe competition between humans and the livestock. Efforts have been made to replace cereals with cassava in poultry feeds (Tewe, 1997; Aina and Fanimo, 1997; Nwokoro and Ekhosuehi, 2005; Ojewola *et al*., 2006; Adeyemi *et al*., 2008; Mafouo *et al*., 2011; Kreman *et al*., 2012; Kana *et al*., 2012; 2013, 2014) and the results in terms of production performance and economics have showcased extended variability (Khajerern and

Khajerern, 2007). However, circumstance of variable reports is not a sufficient reason to ignore the thought of feeding cassava to monogastric animals, especially poultry. Despite overwhelming evidence of satisfactory performance of animals fed cassava chips-based diets, arguments persisted in scientific circles as to the safety of cassava for sustainable livestock production even in European communities (Tewe, 1994).

Earlier studies on the optimum inclusion levels of cassava in diets to concisely meet the nutritional requirements of different types of poultry at the least cost (Onibi *et al*., 2008; Adeyemi *et al*., 2008) have been documented. Nearly all reports concluded that cassava root products and by-products could be successfully used to substitute cereals in nutritionally balanced rations for the different classes of poultry. However, the challenge with cassava as feed ingredients for poultry manifests usually in the form of growth rate retardation, high feed consumption, poor feed conversion and low egg production due to the presence of cyanide in cassava (Adeyemo *et al.,* 2013). Reported methods of ameliorating the effect of hydrocyanic acid in cassava products by processing ranged from sun drying, fermentation, cooking, addition of palm oil and feeding of high protein supplements and/or amino acids like methionine and lysine (Oke, 1980; Adeyemo *et al.,* 2013).

The response of animals to a limiting nutrient generally follows the law of diminishing returns (Brugallia, 2003). Hence, adequate dietary levels of limiting amino acid is needed to support optimum growth and carcass yield of fast-growing commercial broilers (Ojano-Dirain and Waldroup, 2002; Ahmed and Abbas, 2011).

Methionine is the limiting amino acid in cassava-based feeds for poultry and has been reported to be involved in cassava detoxification (Rosling, 1994). Cyanide is detoxified to thiocyanate by the enzyme rhodanase making use of methionine as the sulphur donor. DL-Methionine does more than detoxification of prussic compounds especially in alternative feedstuff. It makes up for the deficient sulfur containing amino acid in the complementary plant protein feedstuff which always contribute the largest portion of crude protein in the feed compared to animal sources (Garcia and Dale, 1999). DL-Methionine is essential for muscle growth because it is the only amino acid that can be at the head of a growing protein strand. Leveraging on this may give a leeway to providing lasting solution to the use of cassava in poultry production.

Improvement in the performance of pigs have been reported (Du *et al.,* 2009) when diet containing 20% fresh cassava leaves (DM basis) was supplemented with 0.2% synthetic DL-methionine. Other studies have reported response of chickens to cassava-based diets with DL-methionine supplementation (Hickling *et al*., 1999; Hang *et al.,* 2009; Ahmed and Abbas, 2011; Mohammed and Talha, 2011; Ebrahimzadeh *et al*., 2013) though with inconsistency in their level of supplementation. Also, most works on cassava have been focused on the influence of cyanide on performance attributes of poultry (McDonald and Evans, 1977; Gonzalez-Alcorta *et al.,* 1994; Lee *et al.,* 2003, 2004; Khojasteh and Shivazad, 2006) with little attention on utilization of nutrients in cassava-based diets for poultry. Also, information on the influence of supplemental DL-methionine on nutrients retention in cassava chip-based diets for poultry have been scanty. This study was therefore aimed at assessing the performance and nutrient retention in broiler chickens when fed cassava chip-based diets supplemented with DL-methionine.

MATERIALS AND METHODS

Experimental Site: The experiment was carried out at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. The study area lies between longitude 7°27.05 north and 3°53.74 of the Greenwich Meridian east at an altitude 200m above sea level. Average temperature and relative humidity of the location is between 23-42 °C and 60-80%, respectively.

Experimental Animals and Management: One-day old Arbor Acres broiler strain (n=450) were purchased from CHI Farms Limited, Ibadan. Brooding was at a temperature of 32 ºC and relative humidity of 66.50% for the first week. Subsequent weeks witnessed a gradual decrease in temperature by 2.4 °C. The chicks were weighed at the inception of the trial and subsequently on weekly basis. Routine management practices in line with the Breeder Farm recommendations, including vaccination and drug administration were adhered to.

Experimental Design: The broiler chicks (n=450) were allotted to 15 treatments each replicated three times and with 10 chicks per replicate in a 3x5 factorial arrangement and a completely randomized design.

Experimental Diets: Cassava chips and DL methionine were included in the basal diet in different combinations to produce fifteen dietary treatments. Treatments 1 to 5 had maize replaced with cassava chips at 0, 25, 50, 75 and 100% levels representing 0, 14.75, 29.5, 44.25 and 59.0g levels of cassava chips inclusion, respectively in the diets without (0%) DL-Methionine supplementation. Treatments 6 to 10 had 0, 14.75, 29.5, 44.25 and 59.0g cassava chips, respectively which replaced 0, 25, 50, 75 and 100% maize (59.0g). with 0.1% supplemental DL-Methionine while Treatments 11 to 15 had 0, 25, 50, 75 and 100% maize replaced with cassava chips (0, 14.75, 29.5, 44.25 and 59.0g cassava chips, respectively with 0.2% supplemental DL-Methionine. The experimental layout is shown below in Table 1, with the gross compositions of the starter and finisher diets shown in Table 2 while calculated nutrients of the basal diets are presented in Table 3.

Data Collection

Chemical Analysis: The proximate composition of the cassava chips was determined (AOAC, 2000) while the HCN was analyzed according to Chhay-Ty *et al*. (2007).

Performance: Feed intake was calculated weekly by subtracting the left over from the total feed offered. The weight gain was calculated by deducting the initial weight from the final weight at the starter and finisher phases while the feed conversion ratio was the ratio of feed intake and weight gain.

Digestibility trial: At day 28, three chickens in each treatment were selected and housed in metabolic cages. They were fed respective diets for 72 hours and allowed to adjust to the cage before the commencement of faecal collection. Excrements were collected from trays laden with dilute HCL placed below the metabolic cages daily for four days. The daily collection was weighed, bulked, and stored in the refrigerator until the end of the trial. The bulked samples were oven dried at 80 ^{o}C for 24 hours until constant weight was attained and thereafter assayed for proximate composition according to AOAC (2000). Nutrient retention was calculated by subtracting nutrient in excreta from nutrient in feed divided by nutrient in feed multiplied by 100.

Statistical Analysis: Data were subjected to analysis of variance using statistical package of SAS (1999) and means separated using Bonferroni option of the software at $\alpha_{0.05}$

Table 1: Dietary layout of cassava chips-based diet with supplemental DL-methionine fed to chicks

		Methionine (%)		
	Cassava chips levels (%)	0	0.1	0.2
1.	0	T1	T6	T11
2.	25	T2	T7	T12
3.	50	T3	T8	T13
4.	75	T4	T9	T14
5.	100	T5	T10	T15

Table 2: Composition (g/100gDM) of the experimental diets fed to chicks

Feed ingredients	**Starter**	**Finisher**
Maize	59.00	59.00
Cassava Chips	0.00	0.00
Soya bean Cake	36.00	30.00
Wheat Bran	2.00	8.00
Calcium carbonate	1.00	1.00
Table Salt	0.25	0.25
Di-Calcium Phosphate	1.50	1.50
*Vitamin-Mineral Premix	0.25	0.25
DL-Methionine	0.00	0.00
Total (kg)	100	100
Calculated Nutrients		
Lysine (%)	1.21	0.98
Methionine (%)	0.41	0.35
Calcium (%)	1.20	1.00
Available Phosphorus (%)	0.50	0.40
Crude Protein (%)	22.44	20.59
ME (kcal/kg)	3224.06	3000.06

*Premix composition (2.5kg/tonne): Vitamin A, 20000000IU, Vitamin D3 4000000IU; Vitamin E 460mg; Vitamin K3 40mg; Vitamin; Vitamin B1 60mg; Vitamin B2 120mg; Niacin 1000mg; Calcium pantothenate 200mg; Vitamin B6 100mg; Vitamin B125mg; Folic acid 20mg; Biotin 1mg; Chlorine chloride 8000mg; Manganese 2400mg; Iron 2000mg; Zinc 1600mgCopper 170mg; Iodine 30mg; Cobalt 6mg; Selenium 24mg; Anti-oxidant 2400mg.

Table 3: Calculated nutrient composition of the experimental diets fed to broiler chicken

	Maize replacement levels with cassava chips				
	Diet 1 (0%)	Diet 2 (25%)	Diet 3 (50%)	Diet 4 (75%)	Diet 5 (100%)
Starter diets					
ME (kcal/kg)	3224.06	3187.91	3128.77	3069.62	3010.47
Crude protein (%)	22.44	22.10	21.97	21.83	21.69
Crude fibre (%)	4.23	4.19	4.16	4.14	4.11
Methionine (%)	0.42	0.41	0.39	0.37	0.35
Lysine (%)	1.21	1.20	1.18	1.15	1.13
Available P (%)	0.55	0.54	0.53	0.52	0.52
Calcium (%)	1.18	1.00	1.03	1.06	1.08
Finisher diet					
ME (kcal/kg)	3000.06	3011.27	2997.14	2973.00	2959.17
Crude Protein (%)	20.59	20.37	19.99	19.71	19.48
Crude Fibre (%)	4.26	4.20	4.17	4.15	4.12
Methionine (%)	0.35	0.35	0.33	0.31	0.23
Lysine (%)	0.98	1.03	1.02	0.99	0.96
Available P (%)	0.40	0.41	0.40	0.39	0.38
Calcium (%)	1.00	1.00	1.03	1.05	1.08

RESULTS

Chemical composition of cassava chips: The chemical composition of cassava chips used in this study is shown in Table 4. Cassava chips contained 8.77±0.17 % moisture, 1.10±0.02% crude protein, crude fat content of 0.70±0.02, 2.21±0.05% ash, 1.81±0.04% crude fibre, 3033.00 ±32.85 kcal/kg metabolizable energy with 20.20±0.12 mg/kg cyanide and 5.50±0.10 ppb aflatoxin levels.

Table 4: Chemical Composition of Cassava Chips

Parameters	Composition
Moisture (%)	8.77±0.17
Crude protein (%)	1.10±0.02
Crude fat (%)	0.70±0.02
Ash (%)	2.21±0.05
Crude fibre (%)	1.81±0.04
ME (Kcal/kg)	3033.00 ±32.85
Hydrogen Cyanide (mg/kg)	20.20±0.12
Aflatoxin (ppb)	5.50±0.10

ME = Metabolizable Energy; ppb = parts per billion

Performance of broiler starter chickens

The effect of varying dietary cassava chips inclusion and supplemental DL-methionine on performance of broiler starter chickens is shown in Table 5. Feed intake was similar ($p < 0.05$) for all chickens fed cassava chips-based diets. The final body weights (FBW) of broiler chickens fed 50% cassava chips in replacement of maize (757.64g) was significantly lower ($p < 0.05$) to those on 0% (855.33g), 25% (809.84g), 75% (688.19g) and 100% (701.39g) cassava chips levels. The highest FBW of 855.33g (0%) and 809.84g (25%) cassava chips-based diets were similar ($p>0.05$).

The average body weight gain (ABWG) of broiler chickens on 50% cassava replacement level (707.64g) was significantly lower ($p < 0.05$) to those on 0% (805.33g), 25% (759.84g), but significantly higher than obtained for chickens on 75% (638.19g) and 100% (651.39g) cassava levels. The highest ABWG of 805.33g and 759.84g were obtained for broiler chickens on 0 and 25% cassava chips-based diets, respectively and were similar ($p>0.05$). Daily body weight gain of broiler chickens fed 0% (28.76g) and 25% (27.14g) cassava chips in replacement of maize were higher than those on diets with 50 (25.27), 75 (22.79) and 100% (23.26) maize replacement.

The FCR of broiler chickens fed 0 and 25% cassava chips in replacement for maize were similar ($p > 0.05$) but significantly lower ($p < 0.05$) to those on 75 and 100% maize replacement levels in the diet. The FCR of chickens fed 50 and 100% cassava chips-based diets were, however, similar ($p>0.05$). The FI of broiler chickens on 0.1 and 0.2% supplemental DL-methionine were similar ($p> 0.05$) but higher ($p < 0.05$) than those on 0% inclusion. The ABWG of 760.19 and 749.72g obtained for broiler chickens fed 0.1 and 0.2% DL-methionine levels, respectively were similar ($p > 0.05$) but significantly higher ($p < 0.05$) than 648.89g obtained for chicks fed diets without supplemental DL-methionine. The DWG of chicks on 0.1 and 0.2% DL-methionine levels were also similar ($p > 0.05$) but significantly higher ($p < 0.05$) than those on diets without DL-methionine. The FCR of chicks on 0.1% DL-methionine (1.77) was similar ($p > 0.05$) to those on 0.2% DL methionine (1.86) supplemental level but significantly lower ($p < 0.05$) than 2.09 obtained for chicks on diet without (0%) DL-methionine supplementation.

The effect of interaction of supplemental DL-methionine and varying dietary cassava-chips inclusion on performance of broiler chickens is shown in Table 6. The interaction of DL methionine with graded cassava chips in the diets showed a similar trend of improvement in the utilization of cassava chips for broiler chickens. The effect of interaction of 0% cassava chips with 0 (862.9), 0.1 (850.9) and 0.2% (912.9) supplemental DL-methionine on FBW (g) was not significantly different ($p>0.05$). So also, were the respective AWG, DWG and FCR. These values were however not different from those obtained for the interaction of 100% cassava chips and 0.2% supplemental DL-methionine supplementation for the various parameters. The FCR was lowest (1.55) when 0% cassava chips was combined 0.2% DL-methionine but was highest (1.72) with 100% cassava chips with 0.2% DL-methionine.

Table 6: Effect of interaction of varying dietary cassava chips inclusion and supplemental DL-methionine on performance of broiler starter chicken

Cassava	Methionine	FBW (g)	AWG(g)	DWG (g)	FCR
0	0	862.04^{ab}	812.04^{ab}	29.00^{ab}	1.66^{d}
	0.1	850.92^{ab}	800.92^{ab}	28.60^{ab}	1.67^{d}
	0.2	912.96^{a}	862.96^{a}	30.82^{a}	1.55^{d}
25	0	716.66^{c}	666.66^{c}	23.81^{c}	2.00^{c}
	0.1	814.82^{b}	764.82^{b}	27.31^{b}	1.76^{cd}
	0.2	842.13^{ab}	792.13^{ab}	28.29^{ab}	1.70^{cd}
50	0	643.52^{cd}	593.52^{cd}	21.20^{cd}	2.26^{b}
	0.1	769.45^{abc}	719.45^{abc}	25.69^{abc}	1.87^{cd}
	0.2	911.11^{a}	861.11^{a}	30.75^{a}	1.57^{d}
75	0	637.96^{cd}	587.96^{cd}	21.00^{cd}	2.24^{bc}
	0.1	835.18^{ab}	785.18^{ab}	28.04^{ab}	1.72^{cd}
	0.2	554.63^{d}	504.63^{d}	18.02^{d}	2.61^{a}
100	0	634.26^{cd}	584.26^{cd}	20.87^{cd}	2.27^{b}
	0.1	780.56^{abc}	730.56^{abc}	26.09^{abc}	1.82^{cd}
	0.2	777.78^{abc}	727.78^{abc}	25.99^{abc}	1.86^{cd}

$^{a-f}$Means with different superscripts in the same column are significantly different ($p < 0.05$)
FBW= Final Body weight, AWG= Average Weight Gain, DWG = Daily weight Gain, FCR= Feed Conversion ratio; SEM: Standard Error of Mean

Table 5: Effect of cassava chips based-diets and supplemental DL-methionine on performance of broiler starter chicken

	FI (g)	FBW (g)	ABWG (g)	DWG (g)	FCR
Cassava chips (%)					
0	1352.95	855.33^{a}	805.33^{a}	28.76^{a}	1.68^{c}
25	1352.52	809.84^{a}	759.84^{a}	27.14^{a}	1.78^{c}
50	1372.82	757.64^{b}	707.64^{b}	25.27^{b}	1.94^{bc}
75	1365.72	688.19^{c}	638.19^{c}	22.79^{c}	2.14^{a}
100	1361.20	701.39^{c}	651.39^{c}	23.26^{c}	2.09^{b}
SEM	11.00	16.81	16.81	0.60	0.05
Methionine (%)					
0	1326.77^{b}	698.89^{b}	648.89^{b}	23.17^{b}	2.09^{a}
0.1	1339.90^{a}	810.19^{a}	760.19^{a}	27.15^{a}	1.77^{c}
0.2	1337.50^{a}	799.72^{a}	749.72^{a}	26.78^{a}	1.86^{bc}
SEM	3.00	15.04	15.04	0.54	0.05
P-Value					
Cassava	<0.05	<0.0001	<0.0001	<0.0001	<0.0001
Methionine	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cassava* Methionine	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

^{abcd} Means with the same superscripts in the same row are not significantly different (P<0.05); FBW= Final Body weight, AWG= Average Weight Gain, DWG = Daily weight Gain, FCR= Feed Conversion ratio SEM: Standard Error of Mean.

Performance of finisher broiler chickens

Effects of varying dietary cassava chips inclusion and supplemental DL-methionine on performance of broiler finisher chickens are shown in Table 7. Broiler chickens on 100% cassava chips had the least FI of 4987.87g which was lower ($p < 0.05$) to those on other dietary cassava chips inclusions. The WG of 2059.06g in chickens on 0% cassava chips was significantly higher ($p < 0.05$) than those on 25 (1985.73g) 50 (1895.04g) 75 (1827.06g) and 100% (1790.97g) cassava chips replacement for maize. The WG of chickens on 75 (1827.06g) and 100% (1790.97g) cassava chips were however similar ($p>0.05$). The FCR of broiler chickens on 0 (2.60), 25 (2.68), 50 (2.70) and 75% (2.73) maize replacement with cassava chips were similar but significantly lower ($p < 0.05$) than 2.94 in chicks on 100% cassava chips diets in replacement of maize.

The FI of broiler chickens on 0% supplemental DL-methionine (5396.16g) was similar ($p > 0.05$) to those on 0.1% DL-methionine (5170.89g) but higher ($p < 0.05$) than 4899.65g in chickens fed 0.2% DL-methionine. The WG of broiler chickens on 0.1% supplemental DL-methionine (2119.22g) was significantly higher ($p < 0.05$) than 1606.92g in chickens on 0% supplemental DL-methionine but similar ($p > 0.05$) to 2093.87g in those on 0.2% supplemental DL-methionine level. However, chickens on 0% DL-methionine supplementation had FCR of 3.36 which was significantly higher (p < 0.05) than 2.44 (0.1) and 2.34 (0.2%) supplemental DL-methionine levels.

Table 7: Effect of cassava chips-based diets and supplemental DL-methionine on performance of broiler finisher chicken

	FI (g)	WG (g)	FCR
Cassava (%)			
0	5353.55[a]	2059.06[a]	2.60[b]
25	5321.76[a]	1985.73[b]	2.68[b]
50	5361.47[a]	1895.04[c]	2.70[b]
75	4987.87[b]	1827.06[d]	2.73[b]
100	5265.25[a]	1790.97[d]	2.94[a]
SEM	279.18	16.18	0.46
Methionine (%)			
0	5396.16[a]	1606.92[c]	3.36[a]
0.1	5170.89[ab]	2119.22[a]	2.44[c]
0.2	4899.65[b]	2093.87[a]	2.34[c]
SEM	284.48	14.48	0.41
P-Value			
Cassava	<0.0001	<0.0001	<0.0001
Methionine	<0.0001	<0.0001	<0.0001
Cassava* Methionine	<0.05	<0.0001	<0.0001

[abc]Means with the same superscripts in the same column are not significantly different (P>0.05)
FBW= Final Body weight, WG= Weight Gained, FCR= Feed Conversion Ratio

Effects of interaction of cassava chips-based diets and DL-methionine supplementation on performance of finisher broiler chicken are presented in Table 8. Effects of interaction of cassava chips-based diets and DL-methionine supplementation were only significant (p < 0.05) for WG and FCR. Performance parameters observed were significantly different (p < 0.05) across treatments. The WG of chickens on 25% cassava inclusion with 0.2% DL-methionine (2319.37) was the highest but similar (p > 0.05) to those on 0 cassava x 0.2 DL-methionine, 50 cassava x 0.2 DL-methionine, 75 cassava x 0.1 DL-methionine and 100 cassava x 0.1 DL-methionine inclusion in their diets. The lowest FCR (2.00) was recorded in broilers on 25% cassava x 0.2% methionine supplementation though similar to FCR of chickens on 50% cassava x 0.2% DL-methionine, 75% cassava x 0.1% DL-methionine, and 100% cassava x 0.1% DL-methionine supplementations but was different from other cassava x DL-methionine combinations.

Table 8: Effect of interaction of cassava chips-based diets and DL-methionine on performance of finisher broiler chickens

Cassava	DL-Methionine	ABWG(g)	FCR
0	0	2003.08[bc]	2.68[bc]
	0.1	2093.04[b]	2.77[b]
	0.2	2152.76[ab]	2.48[c]
25	0	1648.93[d]	3.17[ab]
	0.1	1980.50[bc]	2.84[b]
	0.2	2319.37[a]	2.00[e]
50	0	1538.54[de]	3.42[ab]
	0.1	1974.97[bc]	2.46[cd]
	0.2	2316.67[a]	2.11[de]
75	0	1458.01[de]	3.61[a]
	0.1	2278.14[a]	2.06[de]
	0.2	1861.11[c]	2.27[d]
100	0	1386.06[e]	3.92[a]
	0.1	2269.44[a]	2.06[de]
	0.2	1819.44[cd]	2.84[b]
	SEM	32.37	0.09

[a-f]Means with the same superscripts in the same column are not significantly different (P>0.05). FBW: Final body weight; ABWG: Average body weight gain; FCR: Feed conversion ratio; SEM: Standard error of mean

The relationships of FCR and FBW of broiler chickens on dietary supplement of methionine are, respectively illustrated in Figures 1 and 2. Both relationships were cubic and are represented by the equations 1 and 2 below as follows:

$Y=6.554x^3 + 39.73x^2 – 13.24x + 3.360$ ($R^2=0.572$) ……………equation 1.

$Y=-27732x^3 + 56315x^2 + 2264x + 1606$ ($R^2=0.561$) …..………equation 2.

Where X=independent variable (supplemental methionine) and Y=dependent variable (FCR and FBW).

From the equations, DL methionine inclusion which elicited optimal FCR and FBW of 1.99 and 2217.39g, respectively was 0.16%. Beyond 2% inclusion of methionine in the diets there were observed marginal increase in FCR and decrease in FBW.

The effect of varying dietary cassava chips inclusion with supplemental DL-methionine on nutrient retention in broiler chickens is shown in Table 9. Retention of crude protein by chickens was similar ($p > 0.05$) with 0 (71.67%) and 50% (71.67) maize replacement with cassava chips compared to replacement levels of 25 (48.07) 75% (62.17) and 100% (64.61). Crude fibre retention in chickens fed maize replaced with cassava chips at 75 (43.33) and 100% (45.37%) were significantly higher ($p < 0.05$) than those on 0 (29.3), 25 (23.34) and 50% (18.34%) levels.

Table 9: Effect of varying dietary cassava chips inclusion with supplemental DL-methionine on nutrient retention in broiler chickens

	Crude Protein (%)	Crude Fibre (%)	Ether Extract (%)	Ash (%)
Cassava chips (%)				
0	71.67[a]	29.30[b]	59.72	41.85[c]
25	48.07[c]	23.34[b]	55.46	41.28[c]
50	71.67[a]	18.34[b]	66.33	41.10[c]
75	62.17[b]	43.33[a]	51.79	47.85[b]
100	64.61[b]	45.37[a]	57.96	60.09[a]
SEM	1.60	1.36	3.19	2.68
Methionine (%)				
0	59.84[c]	32.80[a]	65.56[a]	23.90[b]
0.1	61.64[b]	19.78[b]	56.65[a]	54.06[a]
0.2	64.60[a]	18.48[c]	47.08[b]	49.38[a]
SEM	1.43	1.22	2.85	2.40
P-Value				
Cassava	<0.0001	<0.0001	0.05	0.002
Methionine	0.0021	<0.0001	0.0007	<0.0001
Cassava* Methionine	<0.0001	<0.0001	0.0023	<0.0001

[a-f]Means with the same superscripts in the same column are not significantly different (P>0.05).
SEM = Standard error of means.

Effect of cassava chips-based diets on retention of ether extract ranged from 55.46 at 25% to 66.33% at 50% replacement levels. Although, the values were not significantly different (P>0.05). Retention of ash by the chickens at 100% cassava chips replacement of maize (60.09) was significantly higher ($p < 0.05$) than 47.85% at 75% inclusion of cassava chips. Ash retention at these inclusion levels, however, were higher ($p < 0.05$) than similar ($p > 0.05$) values obtained at 0, 25 and 50% cassava chips inclusion levels.

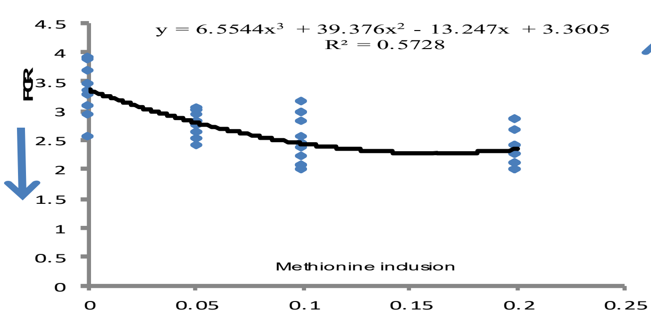

Fig 1 Relationships between methionine supplementation and FCR of broiler chickens

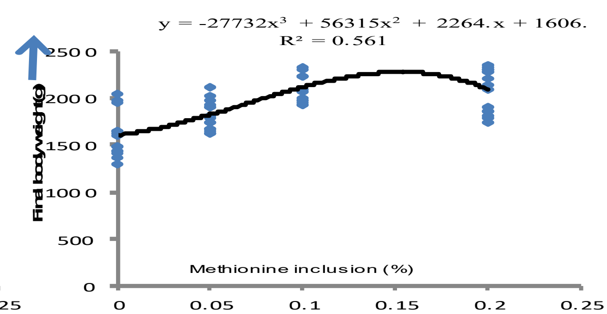

Fig 2 Relationships between methionine supplementation and final weights of broiler chickens

Crude protein retention was higher at 0.2% methionine inclusion (64.60%) compared to 59.84 and 61.60% at 0 and 0.1% inclusions of methionine, respectively. Crude fibre and ether extract at 0 % DL-methionine supplementation was higher than at 0.1 and 0.2%, respectively while supplemental DL methionine at 0% significantly lowered ($p < 0.05$) ash retention to 23.9% compared with 34.06 and 49.38% when supplemented with 0.1 and 0.2% DL methionine, respectively.

Nutrient retention in broiler chickens

Effect of interaction of varying dietary cassava chips inclusion and supplemental DL-methionine on nutrient retention in broiler chickens is shown in Table 10. Higher ($p < 0.05$) crude protein retention (82.05%) was obtained for chicks on 100% dietary cassava chips inclusion with 0.2% supplemental DL methionine. This was similar ($p > 0.05$) to the respective CP retentions of 74.32, 71.08 and 75.87% for respective chicks on dietary cassava chips inclusion with supplemental DL methionine of 75% with 0.2%, 50% with 0.1% and 50% with 0%, respectively as well as 79.31% in those on the control (0% cassava with 0% methionine).

Crude fibre retention of broiler chickens (52.42 and 55.30%) on 0% with 75% cassava chips x0% DL-methionine supplementation was significantly higher ($p < 0.05$) than in chickens on other treatment combinations while the least CF retention of 22.24% was recorded with 25% cassava chips inclusion and 0.1% methionine supplementation.

Ether extract (EE) retention of chicks on 0 (76.98) and 50% (70.05%) cassava chips inclusion with 0% methionine were similar ($p > 0.05$) to 66.49 and 68.75% for the cassava inclusions at 50 and 100% with 0.2% and 0% methionine, respectively. Least ether extract retention of 29.54% was recorded at 0% cassava inclusion with 0.2% methionine which was not different ($p > 0.05$) from 32.94 at 75% dietary cassava chips with 0.2% supplemental DL methionine. Ash % was higher ($p < 0.05$) with 75% inclusion of cassava chips with 0.1% supplemental DL methionine while least retention of ash (3.93%) was at 50% cassava chips inclusion with 0% methionine supplementation.

Table 10: Effect of interaction of cassava chips-based diets and supplemental DL-methionine on nutrient retention in broiler chickens

Cassava (%)	Maize (%)	Crude Protein (%)	Crude Fibre (%)	Ether Extract (%)	Ash (%)
0	0	79.31^{a}	52.42^{a}	76.98^{a}	16.17^{f}
	0.1	67.93^{b}	37.68^{c}	58.47^{b}	19.54^{f}
	0.2	67.31^{b}	5.04^{f}	29.54^{d}	53.45^{bc}
25	0	33.87^{e}	18.70^{e}	58.17^{b}	44.79^{d}
	0.1	54.12^{c}	-22.24^{i}	57.04^{b}	48.55^{cd}
	0.2	36.20^{e}	47.37^{b}	64.68^{b}	34.94^{de}
50	0	75.87^{ab}	36.52^{c}	70.05^{a}	3.93^{h}
	0.1	71.08^{ab}	23.55^{d}	48.70^{bc}	56.78^{bc}
	0.2	63.10^{b}	19.42^{e}	66.49^{ab}	50.66^{c}
75	0	52.98^{c}	55.30^{a}	53.84^{b}	30.14^{de}
	0.1	66.16^{b}	34.40^{c}	57.38^{b}	80.16^{a}
	0.2	74.32^{ab}	36.37^{c}	32.94^{cd}	42.86^{d}
100	0	57.16^{c}	1.08^{g}	68.75^{ab}	25.48^{e}
	0.1	48.90^{d}	25.48^{d}	61.68^{b}	65.25^{b}
	0.2	82.05^{a}	-15.82^{h}	41.73^{c}	65.07^{b}
	SEM	3.19	2.72	6.38	5.36

[abcd] Means with the same superscripts in the same row are not significantly different ($p < 0.05$)
SEM: Standard Error of Mean

DISCUSSION

The crude protein of cassava chips used in this trial was within the range of 0.7% to 1.3% reported by Ngiki *et al*. (2014). Crude fat (0.43±0.2 %) however, was higher than 0.3 % reported by Khajarern and Khajarern (2007) though lower than 2.18 reported in dried cassava chips (Akinwande *et al*., 2013). The metabolizable energy of 3033.00±32.85 kcal/kg was within the range in literature (Tion and Adeka, 2000; Buitrago *et al*., 2002; Khajarern and Khajarern, 2007). Ash content of 2.21±0.05 reported in this study was similar to 2.18 in dried cassava chips (Akinwande *et al*., 2013) but lower than 3.2, 5.1, 3.8 and 6.1 earlier reported (Buitrago *et al*., 2002; Egena, 2006; Khajarern and Khajarern, 2007; Olugbemi *et al*., 2010) for cassava chips. Crude fibre (1.81±0.04) however, was within the range of values reported by these researchers and were within 5% fibre specification for export cassava chips (Balagopalan *et al*., 1998).

Cassava tubers vary widely in their cyanogen content, although most varieties contain 15 to 400 mg HCN per kg fresh weight (Padmaja, 1995). Cyanide doses of 50 to 100 mg are reportedly lethal to adults (Halstrom and Moller, 1945). Aflatoxin affects virtually all species of livestock, though it takes relatively high levels to cause mortality in poultry, continuous feeding at low level, however, may be detrimental (Salwa, and Anwer, 2009). Tolerable levels of aflatoxin in poultry have been reported and as a rule of thumb, growing chickens should not be fed more than 20 ppb aflatoxin in their diets. The HCN and aflatoxin levels in this study were within the tolerable limits for poultry, thus cassava used could be described as safe for poultry diets.

Performance characteristics of starter broiler chickens fed varying inclusion levels of cassava chips-based diets in Table 5 indicated that FBW, AWG and DWG reduced with increasing levels of cassava in the diets while improvement was recorded for these parameters when diets were supplemented with methionine. Interactions of dietary cassava and supplemental methionine (Table 6) however resulted in improvement of chickens diets up to 59.0% (100% replacement of maize) was acceptable to the chicks and did not affect these parameters at the different levels. A similar trend noted earlier in the starter chicks was also observed for the finisher broiler chickens (Table 7). The similarity in feed intake among chickens on different dietary cassava chips treatments implied acceptability of cassava chips-based diets by the chickens therefore high FI. The acceptability of the diets as reflected in the FI could be due to pelleting of diets (Ravindran *et al*., 1986) which reduced bulkiness, dustiness and palatability limitation often associated with cassava-based diets (Khajarern *et al*., 1980). This therefore may explain the noted improvement in its acceptability by the broiler chickens.

Despite similarity in FI of chickens fed diets with higher than 25% maize replacement with cassava chips, there were reduction in FBW, AWG and DWG with consequential effect on FCR which increased at levels beyond 50% replacement level. This observation conforms to reports by Müller and Chou (1974) as well as those of Stevenson and Jackson (1983) that a rate of up to 50 percent cassava in the diet did not impair the growth performance of poultry. However, the rather poor FCR among broilers on cassava diets despite similarity in feed intake could be that the chicks were unable to convert the feed effectively due to residual HCN toxicity coupled with amino-acid imbalance associated with cassava based diets and the non-starch polysaccharides embedded in it (Wyllie and Kinabo, 1980; Stephen, 2003; Etalem *et al*., 2013). Also, the poor FCR observed with increasing dietary cassava level could be that more of the available methionine in the feed was used in HCN detoxification rather than for muscle accretion. However, increased dietary supplement of DL-methionine resulted in increased feed intake which was reflected in the improved FBW, AWG, and DWG with an overall lowered FCR. The improvement in FCR could be attributed to the role of supplemental amino acid in protein metabolism and development of muscle (Shimomura, 2012) as protein metabolism is regulated by amino acids, with major consequences on tissue development (Tesseraud, 2011).

Effect of interaction of dietary cassava chips and supplemental DL-methionine (Table 8) on FBW, AWG and DWG of finisher broiler chickens on the control (0 cassava and 0 methionine supplementation) were similar ($p > 0.05$) to those from other treatments except for treatments with cassava inclusions without methionine supplementations. This affirmed the role of methionine in body building processes as these improved parameters would only be the result of a more balanced amino acid profile of the diets which agreed with the remarks of Beski (2015). Earlier observations of increased FCR with higher dietary levels of cassava were however obviated with methionine supplementation. This reflected in the lower FCR recorded for broilers on the different levels of dietary cassava at 0.1 and 0.2% supplemental DL methionine, respectively.

The methionine supplemented cassava diets favourably competed with the conventional maize-based diets (0 cassava) with or without methionine supplementation. These observations contradicted earlier reports (Longe and Oluyemi, 1977; Willie and Kinabo, 1980) on linear decrease in the final weight of chickens when fed cassava-based rations. Observations from this study therefore implied that utilization of cassava by chickens could be enhanced by supplemental DL-methionine in the diets as reflected in the lowered FCR of chicks on cassava-based diets.

Though the FCR of broiler chicken reduced with supplemental methionine, the regression curve showed cubic relationship of supplemental DL methionine with FCR (Figure 1). Optimum FCR however was attained with 0.16% supplemental DL methionine (R^2=0.573). A cubic relationship was observed between final weight of chickens and supplemental dietary DL methionine (R^2=0.561). (Figure 2).

The retention of dietary crude protein by the chickens was reduced with increasing cassava chips inclusion in the diets as shown in Table 9 with concomitant increment in crude fibre digestibility. This observation was akin to reports by Oladunjoye *et al*. (2014) on reduction in CP with cassava inclusion in broiler diets. This could be due to low crude protein content of cassava which reflected in its utilization by broiler chickens. The increasing level of digestible crude fibre as cassava inclusion increased in the diet could be due to the high level of crude fibre which was reportedly high in cassava. Khajarern and Khajarern (2007) opined that the low digestibility of CP in cassava-based diets was due to the high crude fibre content in cassava which formed slurry in the intestine thus reducing digestion and absorption of nutrients. Similarly, Stephen (2003), adduced poor digestibility of CP in cassava-based diets to HCN which impedes protein absorption.

Also, digestibility of ash was increased with higher inclusion of cassava chips in the diets. Supplemental DL methionine in the diets however, improved CP and ash, while crude fibre and ether extract retentions were lowered by methionine supplementation. The observed increased CP and ash retentions could be linked to the cardinal roles of amino acid-methionine in protein utilization, absorption as well as its key roles in the metabolism of certain minerals as posited (Vieira *et al*., 2004). The noted reduction in ether extract retention could be linked to the established roles of methionine in the rapid mobilization of fats *in vivo in swine* (Castellano *et al*., 2015). The observed reduction in crude fibre retention may be due to impedance of some fibre degrading microbes or activities of some fibre degrading enzymes with the inclusion of methionine in the diets. Also, cassava is high in non-soluble polysaccharides that chickens could not digest (Iyayi *et al*., 2002). Interaction of cassava and methionine showed a reduction in CP, crude fibre and ether extract retentions while ash retention of the feed increased with supplementation of the diets with methionine.

CONCLUSION

- Supplementation of cassava chips-based diets with 0.1 and 0.2% DL-methionine improved performance and nutrient retention in broiler chickens.

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