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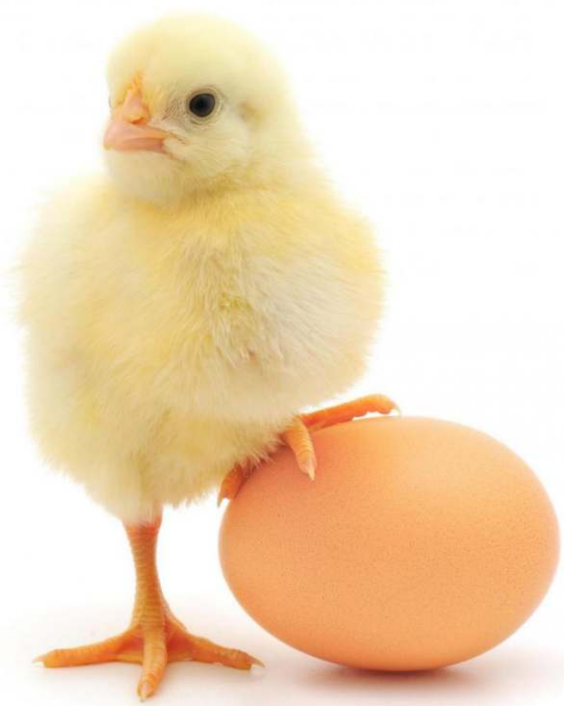

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Cassava Root Chips as an Alternative Energy Feed Ingredient in Broiler Ration

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Abstract: A total of 300 day-old Hubbard Classic broiler chicks with initial body weight (BW) of 43.6±1.33 (mean±SD) were randomly and equally distributed into 15 pens, representing five feeding treatments with three replication per treatment to evaluate the performance of chicks fed varying dietary levels of cassava root chips (CRC) replacing corn grain (CG). Treatments were replacement of CG with CRC at 0 (T_1), 25 (T_2), 50 (T_3), 75 (T_4) and 100% (T_5) levels. Isocaloric and isonitrogenous starter and finisher rations were used. Four birds 2 from each sex were randomly taken from each replication and slaughtered for carcass evaluation at the end of the study. The metabolizable energy content of CRC and CG were 3852 and 3753 kcal/kg dry matter (DM), respectively. Daily DM intake during the entire experimental period ranged 61 to 67 g/bird and was greater ($P<0.05$) for T_5 than T_3 and T_4, while values for T_1 was similar with other treatments. Change in BW, daily BW gain and DM conversion efficiency were similar ($P>0.05$) among treatments. Replacement of CRC for CG at higher levels (75 and 100%) lowered ($P<0.05$) yield of most carcass parameters such as slaughter weight, dressed weight, eviscerated weight, breast weight, thigh weight, drumstick weight and giblet weight. The same carcass parameters were greater ($P<0.05$) for male than female birds but abdominal fat percentage was higher for females. In conclusion, based on DM intake and growth performance of broilers obtained in this study, CRC could completely replace corn grain in broiler diets as energy feed ingredient. However, looking on the results of yields of major carcass parameters, CRC should substitute corn grain not more than 50%.

Key words: Broiler, carcass, cassava root chips, intake

INTRODUCTION

Cereal grains mainly corn are the conventional energy feed in poultry ration which constitutes over 50% of the diet for the different classes of poultry (Iyayi, 2009). The rapid growth of human population has intensified the competition between man and livestock for cereals, resulting to high cost of the cereal grains and consequently high prices of poultry products leading to low levels of per capita poultry meat and egg consumption. Therefore, it is necessary to look for alternative and cheaper sources of feeds that can replace cereals to reduce cost of production and contribute to increased supply of animal protein at an affordable price. One such economical substitute feed for maize is cassava meal (Anthony, 2009).

Cassava (*Manihot esculenta* Crantz) is a perennial woody herb which is grown as an annual. The name cassava is a collection name for many species belonging to the genus *Manihot* of the family Euphorbiaceae (Olsen and Schaal, 1999). Cassava is a high yielding starchy root crop of the tropics (Essers *et al.*, 1994). The high metabolizable energy content of Cassava Root Chips (CRC) (3870 kcal/kg) (Stevenson and Jackson, 1983; Tion and Adeka, 2000) and its' wide acceptability in the tropics makes it a possible alternative to cereals as feed for poultry. However, the usage of cassava is generally plagued by its high content of hydrocyanic acid (HCN) which is a chemical known to affect digestion, growth rate and other performance characteristics (Stephen, 2003) and certain haematological indices in broilers (Stephen and Ayanwale, 2003).

The surge to harness the potentials of cassava in poultry rations has brought about several investigations. Saentaweesuk *et al.* (2000a) studied effects of substitution of maize by cassava in broiler diets and found that cassava can be substituted for 50% of the maize without any adverse effect on performance. The authors also reported that broilers on cassava diets were stronger, required much less medication and had lower mortality rates and the meat on cassava diets had a better perception by consumers. Saentaweesuk *et al.* (2000b) studied the substitution of maize by cassava in diets for layers (22-37 weeks) and found that laying hens on 100% cassava diet had similar production performances to those on 100% maize diets. Stevenson and Jackson (1983) reported that a rate of up to 50% of cassava in the diet did not impair the growth performance of poultry, whereas Longe and Oluyemi (1977) as well as Wyllie and Kinabo (1980) observed a

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linear decrease in the weight of poultry with increasing quantity of cassava in the ration. Experiments conducted using CRC has thus given somewhat contradictory and inconclusive results. Therefore, this study was conducted to evaluate the performance of Hubbard classic broilers fed varying dietary levels of CRC replacing corn grain.

MATERIALS AND METHODS

Experimental ration and treatments: The experiment was conducted at Debre Zeit Agricultural Research Center (DZARC), located at an altitude of 1900 meters above sea level and at 8°44'N latitude and 38°38'E longitude. The average annual rainfall is 1100 mm and the average maximum and minimum temperature of the area are 28.3 and 8.9°C, respectively (DZARC, 2003). The feed ingredients used in the formulation of the different experimental rations were corn grain, CRC, wheat middling, noug seed cake, Soybean Meal (SBM), vitamin premix, salt, limestone and dicalcium phosphate (Table 2). Cassava tuber was purchased from southern part of the country (Gofa-Sawella district) from a model farmer who keeps Nigeria white cassava varieties. Whole fresh tuber was washed, cleaned and sifted, peeled and knife chopped into small manageable slices and then spread on a concrete level floor under direct sunlight to dry within 5 days. The slices were turned regularly to prevent uneven drying and possible decay. The dried cassava slices and all the ingredients except wheat middling, SBM, vitamin premix and dicalcium phosphate were then hammer milled to 5 mm sieve size and were stored until required for formulation of the experimental rations. Chemical composition of the major feed ingredients (Table 1) was determined from representative samples of corn, CRC, noug seed cake, wheat middling and SBM. Based on the chemical analysis result, five treatment rations containing CRC at levels of 0 (T_1), 25 (T_2), 50 (T_3), 75 (T_4) and 100% (T_5) of the total ration at the expense of corn were formulated. The rations were formulated to be nearly isocaloric and isonitrogenous (Table 2) with Metabolizable Energy (ME) content of 3000 kcal/kg Dry Matter (DM) and Crude Protein (CP) content of 22% during the starter phase of 1 to 28 days of age and ME content of 3200 kcal/kg DM and CP content of 20% for finisher phase of 29 to 56 days of age (Leeson and Summers, 2005).

Management of experimental birds: Three hundred unsexed day-old Hubbard Classic broiler chicks with initial body weight of 43.57±1.33 g (mean±SD) were randomly divided into five dietary treatments and three replications per treatment in a completely randomized design experiment, thus having 20 chicks per replicate or pen. The birds were vaccinated against Newcastle (HB1 at day 9 and Lasota a booster dose at day 21) and Infectious Bursal Disease (Gumboro) at the age of 7 and 19 days, all given through an eye drop. Other health precautions and sanitary measures were also taken throughout the study period. Before the commencement of the actual experiment, experimental pens, watering and feeding troughs were thoroughly cleaned, disinfected and sprayed against external parasites. The chicks were brooded using 250 watt infrared electric bulbs with gradual height adjustment as sources of heat and light in a deep litter house covered with *Teff* straw mixed with sawdust. Feed and clean tap water was offered *ad libitum* throughout the experimental period.

Measurements: The study lasted 56 days. The amount of feed offered and refused per pen was recorded daily. Feed intake was determined as the difference between the feed offered and refused. Samples of feed offered and refused were taken daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Birds were weighed weekly in a group per pen and pen average was calculated. Body Weight (BW) change was calculated as the difference between the final and initial BW. Average daily BW gain (ADG) was calculated as the ratio of BW change to the number of experimental days. Dry matter conversion efficiency was computed as the ratio of ADG to daily DM consumption. Mortality was registered as it occurred and general health status was monitored throughout the experiment. At the end of the experiment, 4 birds 2 males and 2 females were randomly selected from each replication for carcass evaluation. The birds were starved for 12 hours, weighed immediately before slaughter and exsanguinated by severing the neck. After slaughtering, the birds were dry de-feathered by hand plucking. Eviscerated and carcass cuts and non-edible offal components were determined according to the procedure described by Kubena *et al*. (1974). Dressed carcass weight was measured after removal of blood and feather. Dressing percentage was calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. Eviscerated carcass weight was determined after removing blood, feather, lower leg (shank), head, kidney, lungs, pancreas, crop, proventriculus, small intestine, large intestine, caeca and urogenital tracts from dressed carcass. Eviscerated percentage was determined as the proportion of the eviscerated weight to slaughter weight multiplied by 100. From eviscerated carcass weight drumstick-thigh and breast meat were separated and weighed and their weight were divided by slaughter weight and multiplied by 100 to determine percentage weights of each component. Fat around the proventriculus and gizzard and against the abdominal wall and the cloacae were collected and weighed. Fat percentage was calculated as the proportion of slaughter weight. The edible offal which includes the heart, gizzard and liver, were weighed and expressed in relation to slaughter weight.

From the same birds used for carcass evaluation, blood sample was taken for the determination of serum Total Cholesterol (TC) and Total Protein (TP). Blood samples were collected by inserting a sterile needle into the wing vein of the birds and extracting about 1 ml of blood. The samples were then placed inside plain vacutainers and centrifuged at 4000 rpm for 2 minutes in order to separate the serum. The collected sera were stored at -20°C pending analysis.

Laboratory analysis: Samples of feed ingredients and feed offered and refusal of the diets from the respective treatments were analyzed for DM, Crude Fiber (CF), Total Ash (TA), Ether Extract (EE) and Kjeldahl Nitrogen (N) (AOAC, 1998). The CP content was determined as N x 6.25. Calcium and total phosphorus content were determined by atomic absorption and vanado-molybdate method, respectively (AOAC, 1998). The ME content of the experimental diets was determined according to Wiseman (1987) as ME (kcal/ kg DM) = 3951+54.4 EE-88.7CF-40.80 Ash. The fresh samples of breast and thigh muscles were separately minced, dried and homogenized and analyzed for DM, CP, EE, ash, Ca and P (AOAC, 1998). Serum TC and TP assay were done using cholesterol and protein liquor commercial kit manufactured by Human Diagnostics Worldwide based on CHOD-PAP method (Liebermann, 1985).

Total HCN (mg/100g) in the ground cassava root sample was analyzed using the acid titration method (AOAC, 1998). One hundred ml of water was added to 20 g of the sample in a 500 ml Kjedahl flask for steam distillation. Hydrolyzed cyanide from solid sample was steam distilled into acidified silver nitrate ($AgNO_3$). The distillate was collected in 20 ml 0.01N $AgNO_3$ acidified with 1 ml concentrated HNO_3. The excess $AgNO_3$ was back titrated with 0.02 N potassium thiocyanate (KSCN) using ferric-alum indicator. The total HCN (mg/100g) content was then calculated as $HCN = [(V_{AgNO3}*0.27)]*100/W$; where V_{AgNO3} is Volume of silver nitrate = $[(20-(2*V_{KSCN}))]$, V_{KSCN} is Volume of potassium thiocyanate consumed in titration and W is weight of the sample.

Statistical analysis: Data were analyzed using the general linear model procedures of Statistical Analysis Systems software (SAS, 2002), with the model consisting of treatments for data other than carcass characteristics and serum parameters that were analyzed with a model consisting of treatments and sex. Differences between treatment means were separated using Tukey Kramer test.

RESULTS

The ME content of CRC is comparable to that of corn grain (Table 1). The CP, CF and EE content of CRC were relatively lower than the levels in the rest of the ingredients used in this study. Hydrogen cyanide content of CRC was low. The five treatment rations used in the study were nearly isonitrogenous and isocaloric (Table 2).

Average DM intake, BW changes, ADG, DM conversion efficiency and mortality rate of broiler birds are presented in Table 3. Compared to T_1, replacement of CRC for corn grain did not affect DM intake during the starter phase and the entire experimental period. Effect of CRC replacement to corn grain on DM intake during the finisher phase appears to lack an apparent trend, although the value for T_4 was lower than that for T_1 ($P<0.05$). Among treatments that received dietary CRC, T_5 had greater ($P<0.05$) DM intake than T_3 and T_4 during the starter and finisher phase, respectively. Average DM intake for the entire experimental period was greater ($P<0.05$) for T_5 than T_3 and T_4 and the value for T_2 was greater than T_4. Final BW, BW change, ADG and DM conversion efficiency during the starter phase, finisher phase and the entire experimental period were not affected ($P>0.05$) by CRC substitution to corn grain. Mortality rate was also similar among treatments.

The slaughter and dressed weights were lower ($P<0.05$) for T_4 and T_5 as compared to other treatments which appears to be consistent with numerical differences of final body weight recorded at the end of the experiment. Eviscerated weight was lower ($P<0.05$) for T_4 and T_5 as compared to T_2 and T_3, while values for T_1 was similar with other treatments except T_2 that has the highest

Table 1: Chemical composition of feed ingredients used to formulate experimental rations

Nutrients	CG	NSC	WM	SBM	CRC
DM (%)	92.1	94.9	92.9	96.0	92.3
CP (% DM)	8.4	34.6	19.2	42.2	2.3
CF (% DM)	3.3	21.2	14.4	6.5	0.3
EE (% DM)	4.4	7.1	5.4	6.8	0.8
Ash (% DM)	3.3	10.4	4.0	6.0	2.9
ME (kcal/kg DM)	3753	2034	2804	3496	3852
Calcium (% DM)	0.04	0.26	0.11	0.30	0.03
Phosphorus (% DM)	0.30	0.65	1.15	0.65	0.03
HCN (mg/100g)	-	-	-	-	2.41

CF: Crude fiber; CP: Crude protein; DM: Dry matter; EE: Ether extract; HCN: Hydrocyanic acid; ME: Metabolizable energy; CRC: Cassava root chips; SBM: Soybean meal; CG: Corn grain; NSC: Noug seed cake; WM: Wheat middling

Table 2: Proportion of ingredients used in formulating broiler starter and finisher rations and chemical composition of treatment rations

	Treatments									
	T_1		T_2		T_3		T_4		T_5	
Ingredients (%)	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
Corn grain	40.0	52.0	30.0	39.0	20.0	26.0	10.0	13.0	0.0	0.0
CRC	0.0	0.0	10.0	13.0	20.0	26.0	30.0	39.0	40.0	52.0
Wheat middling	14.8	7.8	12.8	4.8	10.8	2.8	8.8	1.8	5.8	0.8
Noug seed cake	21.0	13.0	21.0	18.0	23.0	20.0	24.0	22.0	24.0	23.0
SBM	21.0	24.0	23.0	22.0	23.0	22.0	24.0	21.0	27.0	21.0
Vitamin premix*	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nutrient Contents										
DM (%)	92.8	92.7	92.9	92.8	93.0	92.9	93.1	92.9	93.3	93.0
CP (% DM)	22.3	21.0	22.2	20.7	22.0	20.5	21.8	19.9	21.8	19.3
CF (% DM)	5.0	5.4	5.1	5.9	5.2	5.9	5.4	5.0	5.9	5.9
EE (% DM)	5.1	4.8	4.9	4.5	4.6	4.3	4.4	4.2	4.3	3.7
Ash (% DM)	8.4	10.5	8.7	10.7	9.3	10.9	9.4	11.0	9.9	11.1
ME (kcal/kg DM)	3088	3241	3097	3262	3105	3289	3129	3293	3138	3298
Ca (% DM)	1.1	1.09	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2
P (% DM)	0.7	0.58	0.6	0.5	0.6	0.5	0.5	0.4	0.5	0.4

CRC: Cassava root chips; SBM: Soybean meal. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain. Vitamin premix* = 50 kg contains, Vit A 1000000 IU, Vit D_3 200000 IU, Vit E 10000 mg, Vit K_3 225 mg, Vit B_1 125 mg, Vit B_2 500 mg, Vit B_3 1375 mg, Vit B_6 125 mg, Vit B_{12} 1 mg, Vit pp (Niacin) 4000000 mg, Folic acid, 100 mg, Choline chloride 37500 mg, Anti-oxidant (BTHT) 0.05%, Manganese 0.60%, Zinc 0.70%, Iron 0.45%, Copper 0.05%, Sodium 0.01%, Selenium, 0.004%, Calcium 2.7%; DM: Dry matter; CP: Crude protein; CF: Crude fiber; EE: Ether extract; ME: Metabolizable energy; Ca: Calcium; P: Phosphorous

Table 3: Dry matter intake, body weight change, feed conversion efficiency and mortality rate of broilers fed ration containing different levels of cassava root chips

	Treatments					
Parameters	T_1	T_2	T_3	T_4	T_5	SEM
DMI (g/bird)						
Starter	34.4^{ab}	36.2^{ab}	33.8^{b}	36.8^{ab}	37.1^{a}	0.64
Finisher	94.5^{a}	96.0^{a}	90.7^{ab}	85.8^{b}	96.6^{a}	2.05
Entire experiment	64.5^{abc}	66.1^{ab}	62.3^{bc}	61.3^{c}	66.8^{a}	1.22
IBW (g/bird)	43.3	43.8	43.1	43.7	44.0	0.79
FBW (g/bird)						
Starter	531	502	478	512	474	22.34
Finisher	1537	1441	1468	1316	1330	64.99
BW change (g/bird)						
Starter	487	458	435	468	430	22.51
Finisher	1006	939	990	805	857	49.72
Entire experiment	1494	1397	1425	1273	1286	64.95
ADG (g/day)						
Starter	17.0	16.6	15.7	16.8	15.6	0.67
Finisher	36.5	33.8	35.6	29.0	30.6	1.88
Entire experiment	26.8	25.2	25.6	22.9	23.1	1.16
DMCE (g ADG/g DMI)						
Starter	0.5	0.5	0.5	0.5	0.4	0.02
Finisher	0.4	0.4	0.4	0.3	0.3	0.02
Entire experiment	0.4	0.4	0.4	0.4	0.4	0.02
Mortality rate	0.1	0.0	0.1	0.1	0.0	0.03

$^{a-c}$Means within a row with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; ADG: Average daily body weight gain; BW: Body weight; IBW: Initial BW; FBW: Final BW; DMCE: Dry matter conversion efficiency; DMI: Dry matter intake; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

eviscerated weight. Breast weight was the lowest for T_5, while other treatment means follow a similar trend like that of eviscerated weight. The weight of thigh muscle varied among treatments (P<0.05) and was in the order of $T_2>T_1>T_4 = T_5$, while values for T_3 was similar with T_1 and T_2. Drumstick weight followed more or less a similar trend like that of thigh weight and was in the order of $T_2>T_1 = T_3>T_5>T_4$ (P<0.05). Giblet weight appeared to

Table 4: Carcass components of broilers fed ration containing different levels of cassava root chips

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Slaughter weight (g)	1507^a	1576^a	1487^a	1247^b	1330^b	27.3	1533^a	1326^b	39.4
Dressed weight (g)	1364^a	1435^a	1354^a	1156^b	1169^b	30.6	1397^a	1195^b	38.1
Dressing percentage	90.5^b	90.8^b	91.2^{ab}	92.7^a	87.9^c	0.5	91.1	90.2	0.4
Eviscerated weight (g)	989^{bc}	1133^a	1029^{ab}	875^c	886^c	23.7	1060^a	905^b	29.9
Eviscerated percentage	65.8^c	71.5^a	69.4^{ab}	70.3^a	66.6^{bc}	0.9	69.13	68.28	0.6
Breast weight (g)	372^{bc}	408^a	381^{ab}	343^c	306^d	6.4	383^a	341^b	13.8
Breast percentage	24.7^b	25.6^b	25.8^b	27.4^a	23.0^c	0.3	24.9	25.7	0.4
Thigh weight (g)	154^b	174^a	158^{ab}	128^c	134^c	3.7	169^a	130^b	5.6
Thigh percentage	10.2^b	10.8^a	10.6^{ab}	10.3^{ab}	10.0^b	0.1	10.9^a	9.8^b	0.1
Drumstick weight (g)	137^b	146^a	140^b	115^d	126^c	1.8	146^a	120^b	3.0
Drumstick percentage	9.1	9.3	9.5	9.2	9.4	0.2	9.5^a	9.0^b	0.1
Giblet weight (g)	77^a	73^{ab}	69^b	56^c	61^c	1.1	71^a	63^b	1.4
Abdominal fat (%)	0.6^b	1.0^a	1.3^a	1.3^a	1.0^a	0.1	0.9^b	1.2^a	0.1

$^{a-d}$Means within a row and within treatment or sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

Table 5: Weight and length of gut parts of broilers fed ration containing different levels of cassava root chips

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Esophagus weight (g)	3.00	2.58	2.32	2.18	2.17	0.22	2.81^a	2.09^b	0.14
Crop weight (g)	8.25^{ab}	9.28^a	7.48^{ab}	5.75^b	7.02^{ab}	0.60	8.53^a	6.59^b	0.38
Proventriculus weight (g)	7.18^{ab}	7.83^a	6.78^b	6.58^b	6.48^b	0.24	7.10	6.85	0.15
Gizzard weight (g)	38.78^a	36.38^a	36.06^{ab}	29.82^c	30.77^{bc}	1.29	35.20	33.53	0.82
Small intestine weight (g)	74.43^a	59.55^{ab}	55.43^b	48.72^b	52.20^b	3.67	59.43	56.70	2.32
Large intestine weight (g)	15.4^{ab}	16.8^a	13.3^b	10.5^c	13.1^{bc}	0.61	13.9	13.8	0.38
Caeca weight (g)	7.4^b	12.0^a	11.3^a	11.1^a	11.1^a	0.63	10.9	10.3	0.40
Esophagus length (cm)	6.37	6.42	5.62	6.75	5.25	0.45	5.87	6.29	0.29
Crop length (cm)	8.08	8.62	8.57	9.92	7.85	0.63	9.03	8.19	0.40
Proventriculus length (cm)	3.92^{ab}	4.05^a	3.76^b	3.85^{ab}	3.75^b	0.05	3.89	3.84	0.03
Small intestine length (cm)	198^a	180^b	170^{bc}	164^c	162^c	2.88	180^a	169^b	1.82
Large intestine length (cm)	25. 3	26.3	24.8	24.2	26.4	0.72	25.4	25.4	0.72
Caeca length (cm)	15.6	16.8	17.2	18.2	16. 7	1.26	16.7	17.1	0.80

$^{a-c}$Means within a row and within treatment or sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

decrease (P<0.05) with increase in dietary CRC inclusion, although the value for T_2 was similar with T_1 and T_3 and means for T_4 and T_5 were similar. Abdominal fat percentage was lowest for T_1 (P<0.05), while values for other treatments were similar (P>0.05). Comparison of carcass characteristics showed significant differences between the sexes for all the parameters measured except for dressing percentage, eviscerated percentage and breast percentage. The slaughter, dressed, eviscerated, breast, thigh, drumstick and giblet weights were all greater (P<0.05) for males than females. Conversely, female birds were greater (P<0.05) in fat percentage than male birds.

The weight and length of the different parts of the gastro intestinal tract of broilers is shown in Table 5. Esophagus weight was similar among treatments. Crop weight was greater for T_2 than T_4, while all other mean comparisons showed no significant difference (P>0.05). The weight of the proventriculus was similar between T_1 and T_2 but values for T_2 was greater than those for T_3, T_4 and T_5. Weights of the small and large intestine were also lower for T_3, T_4 and T_5 as compared to T_1 for small intestine and T_2 for large intestine. Caecal weight was lowest for T_1 but similar among other treatments. The length of esophagus, crop, large intestine and caeca were not affected by treatment. Proventriculus length was greater for T_2 than T_3 and T_5, while other means were similar. The length of small intestine appeared to decrease with increasing dietary level of CRC. Significant differences between sexes were noted only for crop and esophagus weight and small intestine length, with values for males being greater (P<0.05) than those for female birds.

Replacement of CRC for corn grain did not affect (P>0.05) the chemical composition of breast muscle (Table 6). The ash and Ca content of breast muscle was greater (P<0.05) for males than females, while the levels of moisture, CP, EE and P were similar between the

Table 6: Chemical composition of breast muscle of broilers fed ration containing different levels of cassava root chips

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Moisture (%)	74.10	74.37	74.37	74.10	74.37	0.27	74.25	74.28	0.17
Ash (%)	3.12	3.12	2.97	3.15	3.34	0.10	3.25^a	3.02^b	0.06
CP (%)	25.1	24.5	25.3	24.6	24.0	0.49	24.7	24.7	0.31
EE (%)	1.82	2.05	1.49	3.13	2.91	0.65	2.11	2.45	0.41
Ca (ppm)	16.9	13.1	11.0	17.8	16.6	2.59	16.5^a	12.7^b	1.64
P (ppm)	81	96	99	95	99	10.6	99	89	6.7

$^{a-b}$Means within a row and within sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; Ca: Xalcium; CP: Crude protein; DM: Dry matter; EE: Ether extract; P: Phosphorus; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

Table 7: Chemical composition of thigh muscle of broilers fed ration containing different levels of cassava root chips

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Moisture (%)	74.3	73.7	73.3	72.0	73.1	0.97	73.7	72.8	0.61
Ash (%)	3.04	3.03	3.09	3.29	3.22	0.10	3.09	3.18	0.06
CP (%)	21.4	21.1	20.3	22.1	21.9	0.60	21.5	21.2	0.38
EE (%)	8.14	7.18	7.64	9.03	8.33	1.18	7.05	9.08	0.75
Ca (ppm)	38.4^a	20.0^b	21.6^b	38.8^a	22.0^b	3.62	26.2	30.2	2.29
P (ppm)	77^b	108^a	110^a	112^a	106^a	7.0	97	108	4.4

$^{a-b}$Means within a row and within treatment with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; Ca: Calcium; CP: Crude protein; DM: Dry matter; EE: Ether extract; P: Phosphorus; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

sexes. The moisture, ash, CP and EE content of thigh muscle was similar among treatments and between sexes (Table 7). The Ca content of thigh muscle was greater (P<0.05) for T_1 and T_4 than the other treatments. The P content of thigh muscle was lowest for T_1, while values for other treatments were similar. The Ca and P contents were similar between male and female birds.

The level of serum cholesterol and total protein differed (P<0.05) among treatments but was similar (P>0.05) between sexes (Table 8). Serum cholesterol was greater for T_4 as compared to T_1, T_2 and T_5 but was similar with T_3. Serum total protein concentration was also higher for T_4 than T_1 and T_5 but was similar with T_2 and T_3.

DISCUSSION

Cassava root chips appeared to be rich source of energy and low in fiber, protein, ash and ether extract. The high ME content of CRC noted in this study is indicative of its potential as a substitute to energy rich cereals in the diet of broilers. In agreement with results of the present study, high levels of ME in CRC have been reported previously (Stevenson and Jackson, 1983; Tion and Adeka, 2000). The CF content of CRC from cassava species used in this study (*Manihot esculenta* Crantz) was quite low (0.3%) as compared to the 1.80-2.40% reported by Enidiok *et al.* (2008) for the cassava species *Manihot utilissima*. The HCN content of CRC in the present study was within the range of 1.51-2.81 mg HCN/100 g reported by Enidiok *et al.* (2008) and was at a level that will not negatively impact the utilization of the feed by broilers. Report of IITA (IITA, 1989) noted a range of HCN within 2-3 mg/100 g to be regarded as acceptable level of cyanide in cassava to be used as feed. Higher level of HCN in the diet of broilers was shown to negatively impact digestion, growth rate and performance (Stephen, 2003). Moreover, Egena and Ocheme (2008) stated that intake of HCN to have a negative effect on sensory properties of broiler meat which was felt in birds fed above 124 mg/100 g HCN. The low level of HCN in CRC obtained in the present study might be partly due to the type of cassava variety used in this study and the method of processing or the sun drying employed (O'Hair, 1990; Massaquoi *et al.*, 1990; Garcia and Dale, 1999).

Although DM intake was lower in T_4 in the finisher phase as compared to the treatment with no dietary CRC, differences between T_1 and other CRC containing dietary treatments in the starter phase and the entire experiment was not significant. Generally, effect of replacing corn grain with CRC on DM intake did not show an apparent trend, indicating a possible lack of effect of CRC substitution to corn grain on intake. The lack of variation among treatment means on broiler performance parameters such as BW changes, ADG and DM conversion efficiency in this study indicates the comparable feeding value of CRC and corn grain as an energy source. The intake and performance results of this study thus suggest that CRC can fully substitute corn grain. This was in agreement with different previous findings (Saentaweesuk *et al.*, 2000a; Ojewola *et al.*, 2006; Ngandjou *et al.*, 2011). However, in a study using

Table 8: Serum total cholesterol and serum total protein levels of broilers fed ration containing different levels of cassava root chips

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Cholesterol (mg/dl)	249^{c}	294^{bc}	360^{ab}	424^{a}	300^{bc}	0.7	325	326	0.5
Protein (g/dl)	10.00^{b}	11.17^{ab}	11.17^{ab}	13.17^{a}	9.83^{b}	25.19	11.13	11.00	15.93

$^{a-c}$Means within a row and within treatment with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; CRC: Cassava root chips. T_1 = No CRC inclusion. T_2 = 25% CRC replacing corn grain. T_3 = 50% CRC replacing corn grain. T_4 = 75% CRC replacing corn grain. T_5 = 100% CRC replacing corn grain.

Cobb 500 broiler chicks and dietary cassava flour substitution to maize at levels of 25, 50, 75 and 100%, Tada *et al*. (2004) noted a decrease in weight gain and feed conversion efficiency of broilers with increasing level of dietary cassava flour which disagrees with the results of the current study. The difference in performance of chicks of the present study and that of Tada *et al*. (2004) might be related to differences in the breed of broilers used and variation in the variety and HCN content of the cassava used in the two studies.

Weights of most carcass parameters were reduced with CRC inclusion beyond 50% level, despite the similar DM intake, ADG and DM conversion efficiency among treatments, making the reason for such differences unapparent. It is however, possible that the numerical decreases in BW change and ADG with CRC inclusion beyond 50% level could have been reflected in reduced weights of most carcass parameters. Although treatment rations were formulated to be isocalaric and isonitrogenous, the profile of amino acids and certain key minerals and vitamins associated with the substitution of CRC to corn might have differed and impacted carcass yield. According to Garcia and Dale (1999), cassava must be supplemented with amino acids, minerals and vitamins at greater levels than are needed in cereal-based diets. Yeoh and Truong (1996) noted that sulfur-containing amino acids (methionine and cysteine) and leucine and lysine to be the limiting amino acids in different cultivars of cassava roots which could have been the reason for the observed differences in this study. Adequate dietary level of methionine is needed to support optimum growth and carcass yield of fast-growing commercial broilers (Ojano-Dirain and Waldroup, 2002). The sensitivity of breast meat yield in broilers to dietary methionine has been demonstrated as well (Schutte and Pack, 1995; Elamin and Talha, 2011). The present finding was in line with the lower carcass yield of broilers fed beyond 25 and 50% raw and boiled sun dried taro (*Colocasia esculenta*) meal, respectively, as substitute for maize (Abdulrashid and Agwunobi, 2009).

The higher abdominal fat percentage observed in CRC treated groups in this study might probably be due to the lower methionine content of cassava roots (Yeoh and Truong, 1996). Broiler chicks consuming diets with methionine lower than requirements showed an increased weight of abdominal fat (Elamin and Talha, 2011). Methionine may interact with the lipid metabolism by stimulating the oxidative catabolism of fatty acids *via* its role in carnithine synthesis, thus offering a potential for reduced carcass fatness in commercial broiler production (Schutte *et al*., 1997). Similar effects on abdominal fat with increased level of cassava root chips replacing maize in broiler diets was not observed when additional methionine was included in the formulated rations (Eruvbetine *et al*., 2003; Adeyemi *et al*., 2008).

In the current study, proventriculus weight of broilers was unaffected up to CRC inclusion rate of 25% and decreased at higher levels of dietary CRC inclusion. Adeyemi *et al*. (2008) noted increasing weight of proventriculus with increasing levels (0-25%) of unpeeled cassava root meal fermented with rumen filtrate as a substitute to maize, in contrast to the results of this study possibly due to differences in the processing method of cassava employed. The decrease in weight of proventriculus beyond 25% CRC replacement for corn in this study was in contrast to the report of Promthong *et al*. (2004) that noted no difference among treatments of broilers fed 100% of either cassava chips or cassava pellets in comparison to corn. Gizzard weight was reduced beyond 50% replacement of CRC to corn in this study. Adeyemi *et al*. (2008) noted no difference in gizzard weight up to 25% inclusion level of cassava and Tada *et al*. (2004) noted reduction of gizzard weight only when cassava flour entirely replaces maize. Generally, cassava starch is more digestible than corn starch (Promthong *et al*., 2004) requiring less enzymatic and mechanical action of the muscle wall, thus less muscle enlargement than corn based diets which could be the reason for reduced weights of such organs at higher levels of cassava substitution to corn.

The chemical composition parameters considered in breast and thigh muscles were for most part similar among the treatments employed in this study. This was not in agreement with the decrease in muscle DM, ash, EE and CP and increased in CF contents when cassava flour substituted maize beyond 25% (Tada *et al*., 2004). Such differences could be attributed to differences in energy, protein and other nutrient contents of the experimental rations. The rations in the current study was formulated to be nearly isocaloric and isonitrogenous and had a quit similar CF content, while in the study of Tada *et al.* (2004) the ranges of gross energy and CF contents of treatment rations were 15.9-18.3 MJ/kg and a CF 2.7-3.2 g/kg DM, respectively and as such vary widely and may be the reason for the differences observed in the two studies.

Oladunjoye *et al.* (2010) noted cassava peel to lower cholesterol in layers probably due to its fibre content. In the current study an apparent trend of serum cholesterol was not observed with increasing levels of cassava in the diet of broilers, although cholesterol levels were increased in rations containing cassava which appears to be consistent with higher fat deposition in birds that received cassava containing diets (Tewe and Bokanga, 2001). Serum TP has been reported as an indication of the protein retained in the animal body (Akinola and Abiola, 1991; Esonu *et al.*, 2001). Serum TP was higher with dietary CRC levels of 25-75% in this study, in contrast to Adeyemi *et al.* (2008) who obtained a depressed serum TP of broilers fed with increased level of whole cassava root meal fermented with rumen filtrate to replace maize.

Conclusion: Based on DM intake and growth performance of broilers obtained in this study, CRC could completely replace corn grain in broiler diets as energy feed ingredient. However, looking on the results of yields of major carcass parameters, CRC should substitute corn grain not more than 50%.

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