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Replacement Value of Low Tannin Sorghum (*Sorghum bicolor*) for Maize in Broiler Chickens' Diets in the Semi-Arid Zone of Nigeria

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Abstract: The decrease in the production coupled with the numerous industrial uses make maize an expensive energy ingredient for poultry feeding, thus the need for research into cheaper alternatives. A 9-week experiment was conducted to assess the effects of feeding low tannin sorghum grain as a replacement for maize on the growth, haematology and carcass measurements of broiler chickens at the Poultry Unit of University of Maiduguri Livestock Research Farm, Maiduguri, Nigeria. A total of 300 day-old broiler chicks were randomly allotted to 5 dietary treatments containing 3 replications of 20 chicks each. The diets contained sorghum grains at 0.00, 25.00, 50.00, 75.00, and 100% respectively as a replacement for maize. The starter and finisher diets were formulated to contain 23% and 20% crude protein respectively. The results of growth performance showed no superiority of maize over sorghum grain in terms of weight gain and feed conversion ratio, during both phases of growth (starter and finisher). Feeding sorghum grain had no adverse effect on the haematological parameters analyzed. The yields of carcass and cut-up parts were not adversely affected by the level of sorghum grain in the diet. Similarly, there was no adverse effect of feeding sorghum grain on the weight of vital organs (heart, liver and spleen). It was concluded that low tannin sorghum can completely replace maize in broiler chickens diets without compromising the growth, meat yield or the health of the birds. The substitution is beneficial as it reduces competition between poultry and man for the already scarce maize grain.

Key words: Maize grain, low tannin sorghum, broiler performance

INTRODUCTION

Nigeria plays an important role in poultry feed production and supply in West Africa (Parthasarathy *et al.*, 2005; Issa *et al.*, 2007). Maize which forms the major energy source for poultry in Nigeria is however, becoming expensive as a result of the decline in its production due to the changing climate as well as its food and industrial uses. This calls for research into alternative energy sources which are readily available and have little industrial uses. Sorghum (*Sorghum bicolor*) is a drought tolerant crop able to withstand a wide range of environmental conditions and has limited industrial uses in Nigeria. Sorghum grain has proven to be a suitable feedstuff for use in animal diets (Hancock, 2000; Dowling *et al*., 2002; Cramer *et al*., 2003; Travis *et al*., 2006; Medugu *et al*., 2010). One major constraint to the use of sorghum in poultry feeding is its tannin content which exerts anti-nutritive effects on birds. The chakalare (white) cultivar of sorghum in northern Nigeria has however, been reported to have low tannin content (Medugu *et al.*, 2010; Kwari *et al.*, 2011). This study was designed to ascertain the inclusion level of the white variety of chakalare sorghum in the diet of broiler chickens in the semi-arid zone of Nigeria.

MATERIALS AND METHODS

Study area: The study was conducted at the Poultry Unit of the University of Maiduguri Livestock Research Farm between September and November, 2011. The area falls in the semi-arid zone with an annual rainfall of 500-600 mm (Ugherughe and Ekedolun, 1986). Sorghum is a well adapted crop to the area and several cultivars of sorghum (coloured and white grains) are produced in large quantities mainly for food. In addition to the use as human food, the coloured grains are used in local brewing.

Birds and management: A total of 300-day-old broiler chicks purchased from Obasanjo Farms, Otta, Nigeria, were randomly allotted to 5 treatments with 3

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Table 1: Ingredient composition and calculated analysis of broiler diets

	Replacement levels of chakalare sorghum grain for maize (%)									
	Starter diets					Finisher diets				
Ingredients	0	25	50	75	100	0	25	50	75	100
Maize	45.82	34.36	22.91	11.46	0.00	51.85	38.89	25.93	12.96	0.00
Chakalare	0.00	11.46	22.91	34.36	45.82	0.00	12.96	25.92	38.89	51.85
Wheat bran	9.17	10.37	9.95	10.16	11.33	25.92	25.00	25.71	26.44	27.15
Soybean	32.09	31.17	31.26	31.33	31.44	11.99	12.60	12.13	11.64	11.17
Fish meal	9.77	9.49	9.82	9.54	9.26	5.99	6.30	6.06	5.82	5.58
Bone meal	1.50	1.50	1.50	1.50	1.50	2.50	2.50	2.50	2.50	2.50
Limestone flour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis										
Crude protein (%)	23.36	23.09	23.36	23.34	23.45	20.10	20.12	20.12	20.06	20.08
Crude fibre (%)	4.00	4.12	4.17	4.26	4.34	4.444	4.46	4.77	4.75	4.88
ME (kcal/kg)	2871.47	2830.24	2808.04	2777.67	2759.17	3032.06	3001.32	2988.71	2983.83	2981.74

replications each. The birds in each replicate (20) were housed in a floor pen measuring 1.80 m^2. The birds were vaccinated against Gumboro disease weeks 2 and 4 and Newcastle disease at week 3.

Five isonitrogenous diets were formulated to provide 23% and 20% crude protein in the starter and finisher diets respectively (Table 1). The diets contained white chakalare (low tannin sorghum) at 0.00, 25.00, 50.00, 75.00 and 100.00% respectively as a replacement for maize. Soyabean meal and fish meal formed the protein supplements. The diets and clean drinking water were supplied *ad-libitum* during the period of the experiment (63 days). The starter diets were fed from 1 to 28 days and the finisher from 29 to 63 days.

Data collection: Data were collected on growth parameters (feed intake, weight gain and feed conversion), haematological indices and carcass measurements. Feed intake was monitored by feeding weighed quantities of feed daily and subtracting the left over from the quantity fed the previous day. The birds were weighed weekly and daily weight gain calculated as the difference between two (2) consecutive weighing divided by 7 (number of days in the week). Feed Conversion Ratio (FCR) was then deduced as the ratio of feed consumed to weight gain.

At the end of the experiment (9th week), 3 birds were randomly selected from each treatment for collection of blood samples for haematological analysis and carcass measurements. The birds were fasted overnight and blood samples collected early in the morning through the wing veins into sample tubes containing Ethylene Diethyl Tetra-acetic Acid (EDTA) as anticoagulant. The haematological analyses were carried using the methods described by Bush (1991). The birds were then weighed, slaughtered, plucked and eviscerated. The eviscerated weights (carcasses), the weights of carcass cut-up parts and organs (crop, gizzard, liver, spleen and caeca) and abdominal fat were expressed as percentages of the slaughter weights.

Data analyses: Growth, blood and carcass data were subjected to Analysis of Variance (ANOVA) in a completely randomized design (Steel and Torrie, 1980) using Statistix (2003).

RESULTS AND DISCUSSION

Growth performance: The results of growth performance during the two phases of growth are presented in Table 2. Daily feed intake was higher ($p<0.05$) on the sorghum-base diets compared to the control during both phases of growth (starter and finisher), although the increase was noticeable only above 25% replacement in the finisher phase. Daily weight gain in the starter was highest ($p<0.05$) on the 50 and 75% replacements, but the control, 25 and 100% replacement diets were similar ($p>0.05$). The best ($p<0.05$) values of FCR, during this phase, were observed on the 50 and 75% diets resulting in the lowest ($p<0.05$) feed cost per kg gain on these diets. With the exception of the 50% replacement diet which recorded higher ($p<0.05$) weight, there were no significant ($p>0.05$) differences between the control and the other sorghum-based diets in body weight at 28 days.

During the finisher phase (28-63 days), daily gain was depressed ($p<0.05$) on the 25% compared to the 75% sorghum diet, but did not differ statistically ($p>0.05$) between the control and the sorghum-based diets. Similarly, there were no significant ($p>0.05$) differences between the control and the sorghum based diets in the feed cost of meat production (Naira/kg gain). Final body weight was not statistically ($p>0.05$) affected by diet.

Table 2: Growth performance of broiler chickens fed graded levels of low tannin sorghum grain as replacement for maize

	Replacement level of chakalare sorghum grain for maize (%)					
Parameters	0	25	50	75	100	SEM
0-28 days (starter)						
Initial weight (g/bird)	43.61	45.40	43.31	44.46	44.38	0.85[NS]
Final weight (g/bird)	529.38[bc]	528.16[c]	578.51[a]	568.41[ab]	533.17[bc]	17.44*
Daily feed intake (g/bird)	41.61[c]	45.40[a]	42.31[bc]	44.46[ab]	44.38[ab]	1.20*
Daily weight gain (g/bird)	18.50[b]	17.86[b]	20.30[a]	20.12[a]	18.55[b]	0.47*
FCR (feed: gain)	2.25[bc]	2.55[a]	2.09[c]	2.21[c]	2.39[ab]	0.08*
Cost of feed (Naira/kg)	95.78	94.27	94.09	93.29	91.79	N.A
Feed cost (Naira/kg gain)	215.52[b]	240.07[a]	197.43[c]	206.17[bc]	219.69[b]	6.95*
28-63 days (finsher)						
Initial weight (g/bird)	529.38[bc]	528.16[c]	578.51[a]	568.41[ab]	533.17[bc]	17.44*
Final weight (g/bird)	2336.50	2304.10	2375.30	2298.40	2382.70	0.22[NS]
Daily feed intake (g/bird)	164.84[b]	175.30[ab]	179.19[a]	181.85[a]	183.62[a]	5.25*
Daily weight gain (g/bird)	51.60[ab]	50.08[b]	50.61[b]	59.67[a]	52.84[ab]	3.69*
FCR (feed: gain)	3.20	3.53	3.56	3.07	3.48	0.22[NS]
Cost of feed (Naira/kg)	81.21	81.31	80.10	78.81	77.61	N.A
Feed cost (Naira/kg gain)	260.14[ab]	286.75[a]	285.42[a]	241.95[b]	269.86[ab]	17.60*

[a,b,c,d]Means within the same row with different superscripts differ significantly ($p<0.05$).

NS: Not Significant ($p>0.05$), SEM: Standard Error of the Mean, *Significant ($p<0.05$).

NA: Not Analyzed, FCR: Feed Conversion Ratio, $1 = Naira154.00 at the time of the experiment

Table 3: Some haematological values of broiler chickens fed graded levels of low tannin sorghum grain as replacement for maize

	Replacement levels of chakalare sorghum grain for maize (%)					
Parameter	0	25	50	75	100	SEM
PCV (%)	28.67[ab]	31.00[a]	29.00[ab]	29.67[ab]	25.33[b]	2.31*
RBC ($10^6/mm^3$)	3.48[a]	3.31[ab]	3.07[c]	3.20[bc]	2.87[d]	0.08*
Hb (g/dl)	10.53	12.13	11.67	10.43	9.93	1.52[NS]
WBC ($10^3/mm^3$)	46.50[c]	46.33[c]	46.67[bc]	47.83[ab]	48.33[a]	0.52*
Heterophils (%)	35.67[a]	32.00[b]	35.33[a]	35.00[ab]	37.33[a]	1.40*
Monocytes (%)	7.33[b]	9.33[ab]	9.33[ab]	11.33[a]	11.67[a]	1.12*
Eosinophils (%)	7.33	5.33	6.33	6.67	7.67	1.21[NS]
Basophils (%)	0.33	0.33	0.33	1.33	1.00	0.61[NS]
Lymphocytes (%)	49.33[ab]	54.33[a]	48.67[b]	45.67[bc]	42.33[c]	2.27*
Heterophils: Lymphocytes	0.72[b]	0.54[c]	0.73[ab]	0.77[ab]	0.88[a]	0.05*

[a,b,c,d]Means within the same row with different superscripts differ significantly ($p<0.05$).

NS: Not Significant ($p<0.05$), SEM: Standard Error of the Mean, *Significant ($p<0.05$); PCV = Packed Cell Volume; Hb = Haemoglobin concentration; RBC = Red Blood Cells; WBC = White Blood Cells

The Metabolizable Energy (ME) of both the starter and finisher diets (calculated) decreased linearly as the inclusion of sorghum increased. This trend which was attributed to the lower ME of sorghum grain compared to maize (Olomu, 1995; Jadhav and Siddiqui, 2010) resulted in a higher intake in birds fed the sorghum-based diets probably, in an attempt to meet their energy requirement. The price difference between sorghum (Naira50:00) and maize (Naira80:00) at the time of the experiment was reflected in the cost of the finished feeds (starter and finisher) which reduced linearly as the level of sorghum grain increased. The growth parameters observed on all the diets were comparable to values reported for broiler chickens in the tropics (Oluyemi and Roberts, 2000), suggesting nutritional adequacy of the diets.

Haematology: The results of haematological analysis are presented in Table 3. The results showed no adverse effects ($p>0.05$) of feeding sorghum grain on PCV, heterophils, eosinophils and basophils compared to maize. The RBC count was depressed ($p<0.05$) above 25% and WBC count increased ($p<0.05$) above 50% replacement levels. Lymphocytes count was markedly ($p<0.05$) reduced and heterophils: lymphocytes ratio increased ($p<0.05$) on the 100% replacement diet compared to the maize- based diet (control).

All the haematological values observed were within normal ranges reported in literature (Dukes, 1975; Merck Veterinary Manual, 1986; Awoniyi *et al.*, 2000; Pampori, 2003) for broiler chickens. The count of WBC and the heterophils: lymphocytes ratio have been reported to increase with stressors applied on chickens (Gross and Siegel, 1983; McFarlane and Curtis, 1987). Although, neither the sorghum grain nor the diets were analyzed for tannin content, some dietary levels of this factor are expected when maize is replaced with sorghum grain (even low tannin). Another antinutrient of importance reported in sorghum grain is phytate phosphorus (Ravindran *et al.*, 1994; Selle, 2010). The higher WBC on

Table 4: Carcass measurements and organs weight of broiler chickens fed graded levels of low tannin sorghum as a replacement for maize

	Replacement levels of chakalare sorghum grain for maize (%)					
Parameter	0	25	50	75	100	SEM
Live weight (g)	1789.70	1965.70	2300.30	2075.70	2017.70	222.83[NS]
Dressed weight (g)	1230.30	1377.70	1638.30	1438.30	1431.00	200.41[NS]
Dressing (%)	68.74	70.09	71.22	69.29	70.92	0.42[NS]
Carcass cut up parts (% live weight)						
Breast	13.60	19.79	16.42	17.65	16.74	4.14[NS]
Thighs	12.14	11.53	11.62	11.19	12.36	1.81[NS]
Drumsticks	9.28	9.53	11.07[a]	9.97	9.74	1.12[NS]
Wings	8.83	8.31	8.36	8.06	8.13	1.19[NS]
Organs (% live weight)						
Liver	2.10	1.98	1.94	1.93	2.20	0.20[NS]
Spleen	0.13	0.19	0.15	0.13	0.13	0.05[NS]
Gizzard	3.09[ab]	2.87[ab]	2.29[b]	3.23[a]	2.40[b]	0.30*
Heart	0.50	0.51	0.54	0.55	0.55	0.06[NS]
Abdominal fat	1.55[b]	1.89[ab]	2.67[a]	1.88[ab]	2.40[ab]	0.65*

[a,b]Means within the same row with different superscripts differ significantly ($p<0.05$). NS = Not Significant ($p>0.05$),
SEM = Standard Error of the Mean, *Significant ($p<0.05$)

the 75 and 100% and heterophils: lymphocytes ratio on the 100% replacement diets could be a response to the levels of some of these factors which may however, not have exceeded the threshold levels to affect birds' performance.

Carcass measurements and organs weights: The results of carcass measurements in Table 4 showed no statistical differences (p>0.05) in carcass yield and the yield of carcass cut-up parts (breast, thighs, drumsticks and wings) amongst treatments. Similarly, there were no significant (p>0.05) treatment differences in the percent liver, spleen and heart. Percent gizzard was significantly (p<0.05) increased on the 75% compared to the 50 and 100% replacement diets while abdominal fat deposition was reduced (p<0.05) on the control diet compared to the 50% replacement diet. There were however, no significant (p>0.05) differences between the control maize-based and the sorghum-based diets in terms of percent gizzard and abdominal fat.

The yields of carcass and cut-up parts were all within ranges reported in literature (Jourdain, 1980; Oluyemi and Roberts, 2000; Jadhav and Siddiqui, 2010). The observed organs weights (liver, spleen, gizzard, heart) and the weight of the abdominal fat were also comparable to values reported by Oluyemi and Roberts (2000).

The liver detoxifies toxic substances while the spleen removes the waste materials from the blood for excretion by the liver. The similarities in the weight of these organs amongst treatments are a confirmation that the inclusion of sorghum grain did not result in any toxicity. The pattern of gizzard and abdominal fat weights could be linked to the slightly higher feed intake of the groups on sorghum-based diets.

From the foregoing results it was concluded that maize is not superior to low tannin sorghum grain with respect to the growth performance, health or meat yield of broiler chickens. Therefore, 100% substitution of maize with low tannin sorghum is beneficial as it will spare the already scarce maize grain for human use.

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