Performance, Nutrient Digestibility And Cost-Benefit Of Broiler Chickens Fed Four Local Varieties Of Sorghum As Replacement For Maize In Semi-Arid Zone Of Nigeria

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Abstract: A field study was carried out to investigate the effects of dietary replacement of maize with four local varieties of sorghum on the performance, nutrient digestibility and cost benefit of broiler chickens. Two hundred and twenty-five (225) day-old broiler chicks weighing averagely 341.22 g were randomly allotted to the five (5) experimental diets. The design of the experiment was Randomized Complete Block Design (RCBD) consisting of 45 chicks per treatment and three replicates with 15 chicks per replicate. Pen location served as the blocking factor. The experimental diets contained treatments 1 maize (control) and 2, 3, 4 and 5 contained yellow "Masakwa", white "Kafi-moro, yellow "Kamawanza" and white "Chakalere" sorghum varieties, respectively. The maize and sorghum were used as the major energy source in the diets. The results showed that there were no significant ($p<0.05$) difference in the final weight, total weight gain, mean daily weight gain, total feed intake, daily feed intake and feed conversion ratio among all the treatments. For the nutrient digestibility, the dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash were significantly ($p<0.05$) different in all the treatments with the exception of nitrogen-free extract (NFE) which showed no significant ($p>0.05$) difference. Higher DM was recorded in T4 ("Kamawanza'" sorghum). The cost benefit analyses revealed that feed cost (₦) were higher in diets 1 (maize) and 5 ("Chakalere") sorghum) and lower in diet 4 ("Kamawanza" sorghum). The total feed cost (14) followed the trend of the feed cost with higher cost in diet 1 (maize) with reduction in total feed cost in diet 3 ("Kafi-moro" sorghum). These results suggests that sorghum could replace maize without adverse effect on performance and nutrient digestibility of broiler chickens with reduced cost of production.

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Keywords: Performance, nutrient digestibility, cost benefit, broiler chickens, maize, sorghum.

Introduction

Maize has remained the premium source of energy in poultry diets. However, maize is relatively expensive due to drought and competition for human consumption. This has led to high cost of poultry diets. The search for alternative energy sources that can replace maize is a matter of concern in Nigeria. Viable alternative is sorghum. Sorghum is known to resist drought and require less rainfall than maize and it is cheaper and more readily available than maize (Ravindran and Blair, 1991; Douglas et al., 1993). The tannin content of sorghum limits its use in poultry diets but, low tannin sorghum varieties are comparable to maize in terms of nutrients and can be used in poultry diets without adverse effects (Medugu, et al. (2010). Olomu (2011) gave the metabolizable energy and crude protein values of sorghum as 3270 kcal/kg and 9.5%, respectively. The energy content of low-tannin sorghum (1.23% tannin) is 3214.00 kcal/kg (Medugu et al., 2014).

The protein contents of sorghum is 10.83 to 12.79%, ether extract 3.52 to 4.23% and crude fibre 2.16 to 3.02% as reported by Medugu et al. (2014). Medugu et al. (2010) and Kwari et al. (2014) reported that maize can be completely replaced by sorghum in broiler chicken diets without adverse effects on their performance. The objective of this study was to compare the performance, digestibility of nutrients and cost benefits of broiler chickens fed diets in which maize was replaced with four local varieties of sorghum in semi-arid zone of Nigeria.

Materials And Methods

Study Area

The study was carried out at the poultry unit of the Livestock Teaching and Research Farm, Department of Animal Science, University of Maiduguri, Borno state, Nigeria. Maiduguri is located between latitude 11°5' and 12° North and Longitude 13°05' and 14° East and at an altitude of 354m above

sea level (Encarta, 2007). Maiduguri falls within the Sahelian region which is noted for its great and harsh climate and seasonal rainfall variation. It has short period of rainfall (3 to 4 months) which varies from minimum of 478 to 500mm to a maximum of 600 mm to 621mm with a long dry season of 8 to 9 months (Afolayan et al., 2013). The ambient temperatures could be as low as 20°C during the dry cold season (October to January) and as high as 44°C during the dry hot (February to May) and relative humidity is about 5% in April and May and day length varies from 11 to 12 hours (Raji et al., 2009).

Experimental Stock and their Management/ Experimental design

Two hundred and twenty-five (225) broiler chicks were used for the study. The chicks were weighed individually and allotted to five (5) experimental diets. The chicks were assigned to the five dietary treatments in groups of 45 per treatment and replicated three (3) times with 15 chicks per replicate in a Randomized Complete Block Design (RCBD). Pen location served as the blocking factor. Five (5) experimental diets were formulated and designated as treatments 1 maize (control) and 2, 3, 4 and 5 which contained yellow "Masakwa", white "Kafi-moro", yellow "Kamawanza" and white "Chakalere" sorghum varieties respectively. The chicks were provided with the experimental diets with adequate drinking water *ad libitum* and other management practices including vaccination against Gumboro and Newcastle diseases. The study lasted for 49 days. The ingredients composition and calculated analyses of the experimental diets are presented in Table 1.

Table 1: Ingredient composition and calculated analyses of the experimental broiler finisher diets.

Ingredients (%)	**Diets / Treatment** T1 Maize	T_2 "Masakwa"	T_3 "Kafi-moro"	T_4 "Kamawan"|"za)	**T_5** "Chakalere"
■*j*					
Maize	48.92	-	-	-	-
Sorghum (masakwa)	-	48.92	-	-	-
Sorghum (kafi - moro)	-	-	48.92	-	-
Sorghum (kamawanza)	-	-	-	48.92	-
Sorghum (chakalere)	-	-	-	-	48.92
Wheat bran	15.46	15.46	15.46	15.46	15.46
Soyabean meal	26.48	26.48	26.48	26.48	26.48
Fish meal	5.29	5.29	5.29	5.29	5.29
Bone ash	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00
Methionine	0.30	0.30	0.30-	0.30	**0.30**
Salt (NaCl)	0.30	0.30	0.30	0.30	**0.30**
Premix*	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analyses (%)					
Crude Protein (CP)	19.69	20.66	20.66	20.66	20.66
Ether extract (BE)	3.37	2.59	2.59	2.59	2.59
Crude fibre (CF)	4.08	4.37	4.37	4.37	4.37
Calcium (Ca)	1.34	1.16	1.16	1.16	1.16
Phosphorus (P)	0.92	0.88	0.88	0.88	0.88
ME (kcal/kg)	3200.00	3100.00	3100.00	3100.00	3100.00

ME = Metabolizablc energy (kcal/kg)

** Premix supplying the following per kg of feed: Vitamin A = 12,000 1U, Vitamin E - 15000 mg, folic Acid = 1000 mg, Panthotenic acid = 15000 mg, Vitamin $B_{,2}$ = 15000 mg, Vitamin B_6 = 2,500 mg, Vitamin K = 2,000 mg, Choline = 50,000 mg, Manganese = 10,000 mg, Vitamin D_3 = 25,000 IU, Nicotinic acid = 40,000 mg, Vitamin B, = 2,000 mg, Vitamin B_2 = 6,000 mg. Biotin = 6,000 mg, Vitamin C = 3,000 mg, Copper - 15,000 mg, Cobalt = 250 mg and Selenium = 1,000 mg.*

Data Collection: Performance Data.

During the study, the following data were collected on: Feed intake, body weight gain and feed conversion ratio.

Chemical analyses.

All feed samples collected were analyzed using AOAC (2006) methods.

Digestibility of nutrients.

During the seventh week of the experiment, two

(2) chickens from each replicate were randomly selected and placed into metabolism cages for digestibility study. A measured quantity of feed was provided and faecal samples collected for 5 days, oven-dried and preserved for proximate analysis. The proximate composition of the diets and the faecal samples were determined. The digestibility (%) was calculated as follows:

$$\text{Digestibility } (\%) = \frac{(ND \times FI) - (NF \times FO)}{ND \times FI} \times 100$$

Where: FI = Feed intake; FO = Faecal Output; ND = Nutrient in diet; NF = Nutrient in Faeces.

Cost-Benefit Analyses.

The cost benefit analyses were calculated based on the cost price of ingredients during the study period. Feed cost (N/kg), total feed cost (N/kg/bird), feed cost/kg gain (N) and reduction in cost / kg gain (%) were calculated.

Statistical Analysis.

All data collected from the study were analyzed using statistical package, statistix 9.0 (Statistix, 2008).

Results And Discussions.

The proximate composition of the experimental diets are presented in Table 2. For the diets, the protein and energy levels were 19.00 to 20.30% and 3171.88 to 333.50 kcal/kg, respectively. All the diets in this study provided adequate nutrients to meet the requirements of broiler chickens in the tropics (Olomu, 2011).

Table 2: Proximate Composition of the experimental diets (%).

Nutrients (%)		T_1 Maize	T_2 "Masakwa"	T 3 "Kafi-moro"	T_4 "Kamawanza"	T_5 "Chakalere"
Dry matter (DM)		95.05	96.50	96.25	96.80	96.15
Moisture content		3.'00	3.50	3.75	3.20	3.85
Crude protein (CP)		19.00	20.25	20.30	20.00	20.20
Ether extract (BE)		3.50	3.00	3.15	3.25	3.00
Crude fibre (CF)		4.50	5.00	5.25	5.15	5.00
Ash		4.00	5.00	5.50	6.25	6.50
Nitrogen free extract	(NFE)	66.00	63.25	62.05	62.15	61.45
Metabolizable energy	(kcal/kg)	3335.50	3231.88	3209.00	3206.58	3171.88

ME (kcal/kg) - 37 x % CP + 81 x % EE + 35.5 x % NFE calculated according to the formula of Pauzenga (1985).

Growth Performance

Table 3: Performance of Broiler Chickens Fed Four Varieties of Sorghum as Replacement for Maize.

Ingredients (%)	Treatment / Diets					
	T_1 Maize	T_2 "Masakwa"	T_3 "Kafi-moro"	T_4 "Kamawanza"	T_5 "Chakalere"	SEM
Parameters						
Initial weight (g/bird)	347.80	341.30	333.44	350.86	332.71	36.06^{NS}
Final weight (g/bird)	1947.80	1842.00	1788.10	2064.10	2020.10	172.33^{NS}
Total weight gain (g/bird)	1600.00	1500.70	1454.70	1713.20	1707.30	153.14^{NS}
Mean daily weight gain (g/bird	38.09	35.73	34.64	40.79	40.65	3.65^{NS}
Total feed intake (g/bird)	5102.10)	4705.90	4204.20	5007.80	4746.20	411.46^{NS}
Mean daily feed intake (g/bird	121.48	112.04	100.10	119.23	113.01	9.80^{NS}
Feed conversion ratio (FCR)	3.21	3.14	2.88	2.95	2.79	0.26^{NS}
Mortality (%)	1.25	2.25	2.70	1.35	1.35	-

SEM = Standard Error of Means.
NS = Not significant difference (P>0.05).

The growth performance of the chickens are presented in Table 3. Weight gain, feed intake and feed conversion ratio showed no significant (p>0.05) difference among treatments. Although, there were no significant difference among treatment groups, chickens in treatments 4 ("Kamawanza") and 5 ("Chakalere" sorghum varieties) showed numerically, higher final live weight and total weight gain than the other treatments. The lower live weight noticed in treatment 3 ("Kafi-moro" sorghum) could be attributed to the high tannin (3.60%) and phytates (411.73 mg/l00g) in these varieties as reported by Medugu et al. (2014). These results agreed with the findings of Knox and MCNab (1995) who reported that replacement of maize with sorghum containing 2.0% tannin adversely affects performance and feed

efficiency of broiler chickens. However, these results agreed with the findings reported by other workers (Rama Rao et al., 1995; Jaynaik et al, 2008; Medugu et al, 2010) who reported that 75 to 100% replacement of maize with sorghum in broiler chicken diets did not affect body weight gain, feed intake and feed conversion ratio. In India, assays carried out using white, tannin-free sorghum varieties showed no significant differences in live weights such that the use of sorghum to replace maize completely was recommended (Subramanian and Metta, 2000). Similar observations were made by Karimian et al. (2004) that sorghum can replace up to 40% of the maize in the diet of layer quail without adverse effects on growth performance and nutrient utilization. There is therefore great potential for the use of sorghum as a substitute for maize in broiler chicken diets.

Nutrients Digestibility.

Results of the nutrients digestibility are presented in Table 4. The digestibility of cereals varies tremendously based on genetic background. The digestibility of sorghum starch across the whole digestive tract of poultry was 99% compared with 87% for cattle (Rowe et al., 1999). Within species, age differences also affect digestibility of feed stuff (Etuk et al., 2012). Nutrient digestibility of sorghum is also influenced by tannin concentration in the grain (Sibbald, 1977).

Mandal et al. (2006) reported that there was a negative correlation between tannin concentration and apparent metabolizable energy (AME). Mandal et al. (2006) reported that the AME digestibility value of high tannin red sorghum was lower (11.30 MJ/kg) than those of medium tannin brown (12.50 MJ/kg) sorghum and low tannin white (12.80 MJ/kg). The dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash digestibilities obtained in this study were significantly ($p<0.05$) different among treatment groups with the exception of nitrogen-free extract (NFE) which showed no significant ($p>0.05$) difference. Dowling et al. (2002) had earlier reported that the overall total digestibility of nutrients in sorghum are roughly 95% of those in maize, this is due to lower starch availability because sorghum starch content varies and is bound in a thicker protein matrix. The DM digestibility ranged from 68.07 to 96.64% were within the value (84.67%o) reported by Garcia et al. (2004) when sorghum diets were fed to broiler chickens to replace maize. Earlier, Lemme et al. (2004) reported that CP digestibility of sorghum was 86% and maize 90%, while the amino acid digestibility was only slightly, lower for sorghum compared to maize. Ajaja et al. (2002) reported an increase in nitrogen retention with increasing level of sorghum dust (1.40 to 1.75g/ chicken / day). Agbede et al. (2002) in their study reported a progressive increase in nitrogen retention of broiler chickens fed sorghum dust in replacement of maize up to 50%.

The values of CP (64.65 to 77.76%) and EE (71.58 to 82.61%) were superior than (77.19%) and (65.69 to 67.80%) respectively as reported by Garcia et al. (2004) and the CF (60.73 to 68.20%) were comparable to the values (65.69 to 67.80%) reported by Garcia et al. (2004). Nutrients digestibility were higher in chickens fed sorghum diets than maize. Sorghum therefore, compares favourably with maize in terms of nutritional quality.

Table 4: Apparent Nutrient Digestibility (%) of Broiler Chickens Fed Four Varieties of Sorghum Diets to Replace Maize.

Nutrients (%)	Treatments / Diets					
	T_1 (Maize)	T_2 ("Masakwa")	T_3 ("Kafi-moro")	T_4 ("Kamawanza")	T_5 ("Chakalere")	SEM
Dry matter (DM)	72.37^{d}	68.07^{c}	76.13^{c}	96.64^{a}	76.53^{b}	0.01*
Crude protein (CP)	68.89^{b}	68.90^{b}	77.62^{a}	64.65^{c}	77.76^{a}	0.06*
Ether extract (EE)	77.82^{ab}	71.58^{b}	82.44^{a}	80.66^{a}	82.61^{a}	2.66*
Crude fibre (CF)	60.73^{d}	62.43^{c}	68.20^{a}	61.18^{d}	64.35^{b}	1.95*
Nitrogen-free extract	62.19	59.42	62.63	59.79	65.45	2.65^{NS}
Available ash	62.00^{a}	49.23^{a}	49.92^{a}	23.79^{b}	65.24^{a}	0.17*

a - c = Means with a row with different superscripts arc significantly ($P<0.05$) different
* = Significant ($P<0.05$)
NS = Not significant ($P>0.05$)
SEM = Standard Error of Means

Cost Analysis

Cost benefit analysis is presented in Table 5. Feed cost (₦) were numerically higher in diets 1 (maize) and 5 ("Chakalere") sorghum and low in diet 4 ("Kamawanza") sorghum. Total feed cost was higher (₦486.29) than the ₦362.38, ₦406.38, ₦407.76 and ₦452.91 for "Kafi-moro" sorghum, "Masakwa" sorghum, "Kamawanza" sorghum and "Chakalere" sorghum respectively. The cost per kg feed followed similar trend as reported by Medugu et al. (2010) when

maize was replaced with sorghum or millet in the diets of broiler chickens with the exception of 'Kamawanza' sorghum which was inferior to maize, the birds receiving various sorghum varieties in their diets recoded better, feed cost per kg gain and reduction in cost than those on maize-based diets. A similar trend in cost reduction was reported by Ajaja et al. (2002) when they replaced maize with sorghum dust in broiler finisher diets.

Feed cost per unit weight gain (N) increased in diet 1 (maize) and 4 ("Kamawanza") sorghum than diet 2 ("Masakwa"), 3 ("Kafi-moro") and 5 ("Chakalere") sorghum varieties. There was drastic reduction in cost of production (N) in diet 4 ("Kamawanza") sorghum followed by diets 2 ("Masakwa"), 5 ("Chakalere") and 3 ("Kafi-moro") sorghum in that order. This decrease in cost is substantial enough to further enhance the profitability of broiler chicken enterprise. Cost benefit analyses revealed that replacement of maize with sorghum in diets for broiler chicken production was more economical and rewarding.

Table 5: Cost Benefit Analysis of Broiler Chickens Fed Four Varieties of Sorghum Diets as Replacement for Maize.

Parameters	Diets / Treatments					
	T1 Maize	T2 "Masakwa"	T_3 "Kafi-moro"	T_4 "Kamawanza"	T_5 "Chakalerc"	SEM
Initial weight (g/bird)	347.80	341.30	333.44	350.86	332.71	36.06*^{5}
Final weight (g/bird)	1947.80	1842.00	1788.10	2064.10	2040.10	172.33^{NS}
Total weight gain (kg/bird)	1.60	1.50	1.45	1.71	1.71	0.15^{NS}
Feed cost (₦ /kg)*	95.35	86.28	86.28	81.39	95.35	NSA
Reduction in feed cost (%)	0.00	9.51	9.51	14.64	0.00	NSA
Total feed intake (kg/bird)	5.10	4.71	4.20	5.01	4.75	0.41^{NS}
Total feed cost (₦/kg/bird)	486.29	406.38	362.38	407.76	452.91	NSA
Feed cost / kg gain (₦)	305.18	270.92	249.92	348.51	264.86	NSA
Reduction in cost / kg gain (%)	0.00	11.23	18.11	-14.20	13.21	NSA

NS = Not significant (P0.05), NSA = Not statistically Analyzed, SEM = Standard Error of Means, ₦= Naira
* Based on the market prices of the ingredients at the time of study.
* Feed cost/kg of various ingredients used in the experiment, maize, N80; wheat bran, N83.61; fish meal, ₦150,000; bone ash, ₦40.00; salt, ₦ 10.00; Premix, ₦150.00; Soyabean meal, ₦170.00; Limestone, ₦70.00; Sorghum, ₦70.00; Methionine, ₦300.00.

Conclusion

Considering the weight gain and feed cost per kilogram, it can therefore be concluded that, sorghum can replace maize in broiler chicken diets without adverse effects on performance and nutrient digestibility. An added incentive is the reduced cost of production arising from the replacement of maize with sorghum varieties. Further investigation is required in cockerel and layer chickens.

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