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Sorghum is a Suitable Replacement of Maize in Broiler Feeds : Effect on Carcass Characteristics and Internal Organ Weights

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ABSTRACT

Maize is costly major source of energy in poultry feed. Sorghum usage promotion to reduce prices in feeds and effect of replacing maize as energy source on carcass and gut characteristics of broiler chickens demanded research. 648-day old broiler chicks of Arbo acre plus strain were assigned to nine experimental diets containing 72 birds per treatment with 24 birds per replicate in a completely randomized design of 4 × 2+1 factorial arrangement. Dietary treatments included : D_1 : 100% maize, D_2 : 50% *Farfara,* D_3 : 100% *Farfara,* D_4 : 50% *Kaura,* D_5 : 100% *Kaura,* D_6 : 50% *ICSV 400*, D_7 : 100% *ICSV 400*, D_8 : 50% *Red Sorghum* and D_9 : 100% *Red Sorghum* for two months. Three birds of the same sex per replicate were selected based on the average group weight and slaughtered for carcass and organ evaluation. Birds fed 100% *Farfara* and 100% *Red Sorghum* had the highest breast weight. In broiler diet, sorghum can replace maize with carcass quality. In broiler finisher diets *Farfara* and *Red Sorghum* varieties at 100% inclusion level were recommended.

Key words : Maize, sorghum varieties, broilers, carcass, gut, characteristics

INTRODUCTION

Sorghum (*Sorghum bicolor*) in terms of production and harvested area is the fifth most widely grown crop in the world. It is grown in 45 million hectares, with 75% of the area concentrated in 10 countries : Sudan, India, Nigeria, Niger, United States of America, Mexico, Ethiopia, Burkina Faso, Mali and Chad (Crop Diversity, 2020). In sub-Sahara Africa, Issa *et al.* (2015) reported sorghum covers the second largest area after maize. Maize import use as food, and high production cost are the main constraints to poultry production in Nigeria. According to Sheikh *et al.* (2016), feed is the major input in poultry production and the ever-increasing cost and scarcity of feedstuffs are the major constraints to poultry production. A strong increasing trend and a high variation of the prices of cereal grains have spurred interest in using other feed ingredients produced in large scale (Ravindran, 2014). Studies on alternatives for corn substitution by sorghum in poultry diet are researched in India, United States of America, Niger and West Africa (Bulus *et al.*, 2014; Yunus *et al.*, 2015; Issa *et al.*, 2016). Much information is lacking on the variety wise variations on location-specific assessment of sorghum varieties for substitution in poultry feed production in Kano, semi-arid Nigeria. Therefore, there is need for cheaper and more available alternative such as sorghum. To promote the use of sorghum in broiler feeds as a way of reducing cost, it is necessary to evaluate the effect of replacing maize with sorghum as energy source on carcass and gut characteristics of broiler chickens.

MATERIALS AND METHODS

This experiment was conducted in the pens of a commercial poultry farm in Imawa, Kura Local Government Area, Kano, Nigeria. A total of 675-day old broiler chicks (Arbor acre plus strain) of mixed sexes were purchased from Obasanjo Farms, Otta, Ogun State, Nigeria for the study for a period of eight weeks. The

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different sorghum varieties (*Farfara*, *Kaura, ICSV 400* and *Red Sorghum*) were procured from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kano Station, Nigeria for the study. The proximate composition of the experimental diets was carried out according to the methods of AOAC (2005) in the Animal Science Biochemical Laboratory, Faculty of Agriculture, Ahmadu Bello University, Zaria for dry matter (% DM), crude protein (% CP), crude fiber (% CF), ether extract (% EE) and nitrogen free extract (NFE). The anti-nutritional factors in the sorghum varieties were analyzed using the method described by AOAC (2005) at the Animal Science Biochemical Laboratory, of Faculty of Agriculture, Ahmadu Bello University, Zaria. The tannin acid content of the different sorghum varieties was determined using a slightly modified method described by AOAC (2005). The saponin content of the different sorghum varieties was determined using the method described by AOAC. The Munro and Bassir method was used to determine the total oxalic acid present in the different sorghum varieties. The Sutardi and Buckle method was used for determining the phytate content of the sorghum varieties. The Hurbone gravimetric method was used for alkaloids determination. Six hundred and seventy-five (675) Arbo acre plus strain chicks of mixed sexes were subsequently allotted to nine experimental diets in which four sorghum varieties (K*aura, Farfara, ICSV 400* and *Red Sorghum*) replaced maize at 50 and 100% level of inclusion, respectively, in a completely randomized design (CRD) in 4 × 2+1 factorial arrangement. The ingredients composition and proximate constituents of the diets for both starter and finisher phases are shown in Tables 1 and 2, respectively. Each treatment group had 72 birds which were sub-divided into

Table 1. Gross compositions of the finisher diets (5-9 wks) with sorghum varieties replacing maize

Ingredients (%)	Diets								
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
Maize	54.89	27.45	-	27.54	-	27.54	-	27.54	-
Farfara	-	27.45	54.89	-	-	-	-	-	-
Kaura	-	-	-	27.54	54.89	-	-	-	-
ICSV400	-	-	-	-	-	27.54	54.89	-	-
Red sorghum	-	-	-	-	-	-	-	27.54	54.89
Soybean	15.71	15.71	15.71	15.71	15.71	15.71	15.71	15.71	15.71
Groundnut cake	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Wheat offal	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Lysin	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100	100	100	100	100
Unit cost									

One kg of premix contained vitamins A (5,000,000 i. u.), vitamins D_3 (1,000,000 i. u.), vitamins E (16,000 mg), vitamins K_3 (800 mg), vitamins B_1 (1,200 mg), vitamins B_2 (22,000 mg), niacin (22,000 mg), calcium pantothenate (4,600 mg), vitamins B_6 (2,000 mg), vitamin B_{12} (10 mg), folic acid (400 mg), biotin (32 mg), choline chloride (200,000 mg), manganese (948,000 mg), iron (40,000 mg), cobalt (120 mg), zinc (32,000 mg), copper (3,400 mg), iodine (600 mg), selenium (48 mg) and anti-oxidant (48,000 mg).

Table 2. Proximate analysis of the experimental finisher diets

Parameters (%)	1	2	3	4	5	6	7	8	9
Dry matter	93.55	92.83	92.73	92.13	94.64	93.29	93.79	92.28	92.13
ME (kcal/kg)	2856.9	2849.0	2853.0	2859.45	2863.04	2844.99	2859.46	2850.8	2850.95
Crude protein	20.61	21.17	21.38	20.62	20.89	21.03	21.15	21.1	21.22
Crude fiber	5.65	6.14	5.5	5.88	6.35	6.5	5.98	5.83	6.08
Either extract	5.88	5.66	6.13	5.88	6.35	5.97	5.66	5.79	5.88
Ash	8.00	8.00	8.12	8.26	7.92	8	7.96	8.13	8.24
Nitrogen free extract	59.62	59.24	58.81	59.36	58.99	58.86	59.15	58.93	59.12

three replicates of 24 birds each. All routine management and recommended health practices were strictly adhered. The necessary vaccinations were given. Feed and water were provided *ad-libitum*. At the end of the experiment, three birds of the same sex per replicate were selected based on the average pen weight after fasting for 12 h before slaughtering to allow emptying of the gastrointestinal tract. The final live weights of the birds were taken before slaughter. The birds were slaughtered, weighed, immersed in hot water, defeathered, and eviscerated. Carcass weight and meat cut parts (back, drumstick, thigh, ribs cage, neck and wings) weighed. Similarly, the gut weights (proventriculus, gizzard, small intestine and large intestine weights) and weights of visceral organs weighed and expressed as percentage of live weights. Data obtained were subjected to one-way analysis of variance in a 4 × 2 factorial arrangement with a fixed control using SAS version 9. Significant (P > 0.05) differences among treatment means were separated using Duncan Multiple Range Test. Experimental Model used was :

$$\gamma_{ijk} = \mu + V_i + L_j + (VL)_{ij} + E_{ijk}$$

Where, γ_{ijk} = Observed value of the dependent variable; μ = Population mean; V_i = Effect of i^{th} varieties (*Red Sorghum*, *Kaura*, *ICSV 400* and *Farfara*); L_j = Effect of j^{th} level(s) of inclusion (50 and 100%); $(VL)_{ij}$ = Interaction of sorghum varieties and inclusion level(s) and E_{ijk} = Experimental error.

RESULTS AND DISCUSSION

Birds fed red sorghum had higher live weights and carcass weights compared to those on other diets. There were no variations in dressing per cent across dietary treatments, in drumstick and breast muscle (Table 3). This agreed with the finding of Issa *et al.* (2015) who reported similarities in the values of breast muscle and drumstick for birds fed low tannin sorghum-based diets. The dietary treatments showed significant effect on the abdominal fat. The similarities observed between maize and the other sorghum cultivar for carcass characteristics in this experiment were in line with the reports of Issa *et al.* (2015) who observed no differences (P>0.05) in carcass yield of broiler fed sorghum compared with maize.

The results of carcass obtained in this study were similar to the findings of Issa *et al.* (2015) who reported that feeding of sorghum in place of maize did not affect eviscerated yield. From the result of this study, broiler fed 100% sorghum recorded the highest value for breast weight followed by 50% level of inclusion, while the control had the least value though not statistically (P>0.05) different. This indicated that the four sorghum varieties used in this study can be well-utilized to produce broiler chickens with superior carcass quality compared to maize.

The interaction effect of the sorghum varieties and inclusion levels showed significant (P>0.05) effect on live weight, dressing percentage, breast and abdominal fat (Table

Table 3. Main effect of sorghum varieties and inclusion levels on carcass characteristics of broiler chickens

Parameters	Sorghum varieties						Inclusion levels		
	Maize	*Farfara*	*Kaura*	*ICSV 400*	*Red sorghum*	S. Em	50%	100%	S. Em
Live weight (g)	2479^{ab}	2573.83^{ab}	2452.17^{b}	2488.50^{ab}	2681.00^{a}	85.89	2573.25	2624.5	121.82
Dress weight (%)	86.13	88.32	86.74	85.11	86.74	1.5	86.7	86.81	2.12
Carcass weight (%)	71.67	74.27	72.31	72.91	75.18	2.16	72.79	74.54	3.06
Dressing (%)	75.67	74.42	75.52	74.92	76.42	1.06	75.46	74.67	1.5
Breast (%)	19.65	20.04	17.79	20.58	20.49	1.37	19.69	19.76	1.94
Drumstick (%)	9.88	9.72	10.09	10.24	10.22	0.42	9.53	10.11	0.59
Thigh (%)	14.45^{a}	14.31^{a}	14.04^{a}	14.33^{a}	11.30^{b}	0.18	12.17	11.91	1.15
Head (%)	2.48	2.31	2.7	2.36	2.73	1.28	2.42	2.63	0.39
Neck (%)	4.69^{b}	4.57^{c}	4.96^{b}	5.35^{ab}	5.93^{a}	0.27	5.3	5.11	0.38
Abdominal fat (%)	2.16^{b}	2.94^{ab}	2.34^{ab}	3.26^{a}	2.10^{b}	0.4	2.7	2.62	0.55
Wings (%)	8.36^{ab}	8.37^{ab}	8.93^{ab}	9.05^{a}	8.06^{b}	0.12	8.54	8.67	0.17
Back (%)	4.34^{c}	5.32^{bc}	5.97^{b}	7.10^{ab}	8.23^{a}	0.69	6.43	6.88	0.98

Means on the same row with different superscripts differ significantly (P<0.05). NS–Not Significant (P>0.05). S. Em : Standard error of means.

Table 4. Interaction effect of sorghum varieties and inclusion levels on carcass characteristics of broiler chickens

Parameters	Maize	*Farfara*		*Kaura*		*ICSV 400*		*Red Sorghum*		S. Em
	100%	50%	100%	50%	100%	50%	100%	50%	100%	
Live weight (g)	2479.00^{b}	2493.00^{b}	2654.67^{a}	2411.67^{b}	2492.67^{b}	2391.00^{c}	2586.00^{b}	2597.67^{b}	2764.67^{a}	60.7
Dressed weight (%)	86.13	88.29	88.34	87.44	86.03	83.78	86.43	87.3	86.45	2.06
Dressing (%)	79.67^{a}	75.76^{c}	73.61^{c}	79.16^{a}	77.87^{b}	78.64^{a}	74.07^{c}	75.27^{c}	74.39^{c}	1.52
Carcass weight (%)	71.67	73.68	74.86	72.01	72.6	70.65	75.17	74.82	75.54	2.75
Breast (%)	19.65^{b}	18.70^{b}	21.38^{a}	18.58^{b}	18.79^{b}	19.29^{b}	21.84^{a}	19.61^{b}	21.36^{a}	0.29
Drumstick (%)	9.88	9.91	9.53	9.39	10.79	8.94	9.55	9.86	10.57	1.1
Thigh (%)	14.45	16.04	12.58	13.03	15.05	14.66	13.99	11.74	10.87	4.57
Head (%)	2.48	2.3	2.32	2.45	2.95	2.4	2.31	2.51	2.94	1.19
Neck (%)	4.69	4.43	4.71	4.71	5.17	5.37	5.32	6.22	5.64	2.19
Abdominal fat (%)	2.42^{b}	3.22^{a}	2.66^{b}	2.66^{b}	2.52^{b}	3.22^{a}	3.30^{a}	2.13^{b}	2.07^{b}	0.28
Wing (%)	8.36	8.18	8.57	8.57	8.77	9.14	8.96	8.06	8.06	1.24
Back (%)	4.34	4.72	5.93	5.93	3.04	7.69	6.51	5.72	6.22	2.13

Means on the same row with different superscripts differ significantly (P<0.05). NS–Not Significant (P>0.05). S. Em : Standard error of means.

4). The higher value for abdominal fat in birds fed the sorghum varieties at both 50 and 100% level of inclusion was due to the slightly high either extract recorded in the sorghum varieties. Diaw *et al.* (2014) reported that broilers with better developed breast meat were considered superior, while heavy deposits of abdominal fat in finisher broiler indicated poor finishing. Birds fed 100% *Farfara* and 100% *Red Sorghum* had the highest breast weight which indicated that the *Farfara* and *Red Sorghum* varieties could replace maize in broiler diets completely with superior carcass quality.

The values obtained for the internal of fal such as the gizzard, heart, kidney and intestinal length were significantly (P>0.05) affected by dietary treatment, indicating that there were variations among these organs (Table 5). The expectation was that the birds fed *Red Sorghum* variety recorded the higher value for liver since it had higher value for most of the anti-nutritional factors tested but on the contrary, bird fed maize-based diet recorded the higher values, this requires further research. However, higher value recorded in the control group may not be related to the diet. The higher gizzard weight value (3.06%) observed in birds fed the control diet could be linked to the slightly higher feed intake. The higher value recorded in the 50 and 100% sorghum inclusion level compared to the control group for heart, caecum, intestinal length and intestinal weight may be due to the effect of the tannin, present in the sorghum varieties. According to Yunus *et al.* (2015), heavier weight of organs could be an indication of hyper trophy. The inclusion level showed a decrease in liver, kidney and intestinal weight with an increase in the level of inclusion which indicated that the trypsin inhibitor present in the sorghum varieties did not result in structural alteration of the kidney, liver and intestinal weight.

The interaction effect showed significant (P<0.05) effect in all the organs weight measured except lung, liver and heart (Table 6). The insignificant difference observed in the

Table 5. Main effect of sorghum varieties and inclusion levels on organs of broiler chickens

Parameters	Sorghum varieties						Inclusion levels		
	Maize	*Farfara*	*Kaura*	*ICSV 400*	*Red Sorghum*	S. Em	50%	100%	S. Em
Liver (%)	2.66^{a}	2.32^{a}	2.33^{a}	2.06^{ab}	1.93^{b}	0.12	2.28^{a}	2.04^{b}	0.17
Kidney (%)	0.64^{a}	0.55^{b}	0.79^{a}	0.70^{a}	0.43^{c}	0.05	0.68^{a}	0.55^{b}	0.06
Lungs (%)	0.63^{c}	0.74^{b}	0.71^{b}	1.09^{a}	0.62^{c}	0.09	0.82	0.76	0.12
Gizzard (%)	3.06^{a}	1.80^{b}	1.78^{b}	1.84^{b}	1.61^{b}	0.22	1.95	1.57	0.31
Heart (%)	0.41^{b}	0.46^{b}	0.46^{b}	0.55^{a}	0.51^{ab}	0.04	0.51	0.48	0.05
Spleen (%)	0.13	0.14	0.14	0.14	0.13	0.02	0.13	0.14	0.03
Intestinal weight (%)	6.66^{a}	5.02^{b}	5.57^{ab}	5.57^{ab}	5.51^{ab}	0.45	6.16^{a}	5.13^{b}	0.64
Intestinal length (cm)	235.83	203.33	234.33	228.17	219.33	2.5	232.33	226.5	3.43

Means on the same row with different superscripts differ significantly (P<0.05). NS–Not Significant (P>0.05). S. Em : Standard error of means.

Table 6. Effect of sorghum varieties and inclusion levels on organs weight of broiler chickens

Parameters	Maize	*Farfara*		*Kaura*		*ICSV 400*		*Red Sorghum*		S. Em
	100%	50%	100%	50%	100%	50%	100%	50%	100%	
Liver (%)	2.66	2.52	2.11	2.43	2.23	2.11	2.00	2.05	1.81	0.09
Kidney (%)	0.64^{b}	0.60^{b}	0.49^{c}	0.92^{a}	0.66^{b}	0.77^{b}	0.62^{b}	0.43^{c}	0.42^{c}	0.03
Lungs (%)	0.63	0.70	0.78	0.74	0.67	1.17	1.02	0.66	0.58	0.60
Gizzard (%)	3.06^{a}	1.97^{c}	1.62^{c}	2.24^{b}	1.32^{c}	2.02^{b}	1.66^{c}	1.56^{c}	1.66^{c}	0.16
Heart (%)	0.41	0.47	0.95	0.50	0.43	0.54	0.55	0.11^{c}	0.48	0.20
Spleen (%)	0.13^{c}	0.15^{a}	0.13^{c}	0.12^{c}	0.16^{a}	0.14^{b}	0.14^{b}	6.20^{ab}	0.15^{a}	0.01
Intestinal weight (%)	7.31^{a}	5.22^{ab}	4.81^{b}	6.66^{ab}	5.65^{ab}	5.92^{ab}	5.22^{ab}	217.00^{c}	4.81^{b}	0.32
Intestinal length (cm)	254.33^{a}	203.33^{c}	214.33^{c}	235.00^{b}	236.67^{b}	223.00^{b}	221.84^{b}	220.16^{b}	221.67^{b}	8.84

Means on the same row with different superscripts differ significantly (P<0.05).
NS–Not Significant (P>0.05). S. Em : Standard error of means.

treatment groups indicated that the anti-nutritional factors present in the diets did not adversely affect the health status of the birds. The higher value for gizzard weight was obtained in birds fed maize-based diet, which could be attributed to the high fed intake recorded in this group. Birds fed 50% *Farfara* had the highest value for spleen which was comparable to those on 100% *Kaura* and *Red Sorghum,* likely due to the high tannin and trypsin inhibitor recorded in the sorghum varieties.

Birds fed maize-based diet had the highest value for intestinal weight and intestinal length, which may be due to the high feed intake by the experimental birds fed this experimental diet. It could also be as a result of slightly high level of fibre found in maize-based diets.

CONCLUSION

From the result of this study, broilers fed 100% sorghum recorded the highest value for breast weight followed by 50% level of inclusion, while the control had the least value though not statistically (P>0.05) different. Therefore, it is concluded that the four sorghum varieties used in this study can be well-utilized to produce broiler chickens without negative effect on carcass quality.

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