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Growth Performance and Energy Metabolisability of Finisher Broiler Chickens Fed Red and White Sorghum-Based Diets Supplemented with Methionine

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ABSTRACT

The study evaluated the growth performance and energy metabolisability of finisher broiler chickens fed red and white sorghum-based diets supplemented with methionine. One hundred and forty-four broiler chickens were randomly allotted to six dietary treatment groups of red and white sorghum as well as control diets based on maize, each at two inclusion levels of methionine (0.2% and 0.6%). At the 8th week of the study, six birds per treatment were selected for energy metabolisability study. Results showed comparable performance in feed conversion ratio among birds fed dietary treatments, though birds fed the control diets had significantly ($p<0.05$) higher daily gain and final body weight while those fed the red sorghum-based diets recorded the poorest performance. Also, birds fed the sorghum-based diets had lower feed intake compared to those on control. All the birds fed experimental diets had higher apparent and true metabolisable energy values that were superior ($p<0.05$) to those of the control. It can be concluded that, finisher broiler chickens fed red and white sorghum-based diets produced inferior growth performance compared with those on maize diets, and methionine supplementation improved the apparent and true metabolisable energy values of sorghum-based diets fed to the broiler chickens.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is an inexpensive energy dense (3633 – 3944 Kcal kg-^{1} DM) cereal grain that can suitably replace maize in diets of broiler chickens (Garcia *et al.,* 2013; Saleh *et al.*, 2019). Also, its high tolerance for hot and dry climates especially at this era of global warming and declining global grain inventory has projected sorghum as a reliable alternative. However, emerging evidence from previous studies provided contrasting reports on performance of broiler chickens fed different varieties of sorghum-based diets.

Previous studies suggested that feeding broiler chickens with graded levels of sorghum-based diets had depressed performance (Ahmed *et al.,* 2000; Robertson and Perez-Maldonado, 2006; Bryden *et al.,* 2009; Torres *et al.,* 2013; Hughes *et al.,* 2014). Whereas in recent time, studies by Farahat *et al.* (2020), Puntigam *et al.* (2020), Moses *et al.* (2022) and Moritz *et al.* (2022) on the performance of broiler chickens fed graded levels of sorghum in replacement of maize gave similar performance at 50% inclusion level, beyond which performance declines on all evaluated growth indices.

The inferior performance in whole replacement of maize with sorghum could be attributed to varietal differences with varied contents of anti-nutrients especially the tannins, causing reduction in feed intake, nutrient digestibility and growth (Batonon-Alavo *et al.,* 2015; Bedford *et al.,* 2016). Also, significant negative relationships had been established between the performance of broilers fed red and white sorghum-based diets and apparent metabolisable energy (AME) values (Rodrigues *et al.,* 2007).

Similarly, Mandal *et al.* (2006) obtained lower values for the nitrogen-corrected AME (AMEn) in red grain sorghum varieties than in white grain sorghum due to increased tannin. Dykes and Rooney (2006) indicated that, of the tannin-free grain sorghum varieties, red grain sorghum had greater total phenol compounds than white grain sorghum, causing adverse effects on performance due to reduction in available energy in birds fed diet. These inconsistencies have invoked a negative perception of using sorghum grain as an alternative to maize in diets of broiler chickens.

Meanwhile, performance of birds fed sorghum-based diets can be improved by methionine supplementation with the tannin hydrolysed to gallic acid, methylated to a larger extent and excreted in urine as 4-o-methyl gallic acids (Farahat *et al.*, 2020). Also, the feeding value of an ingredient depends on availability and utilisation of its energy and protein (Ebadi *et al.,* 2018). Gross energy of feed ingredients is not entirely representative of the extent to which it can be utilized by the animal, however, estimation of apparent and true metabolisable energy are more reliable predictors of energy use (Khodami *et al*., 2015).

Therefore, it is crucial to evaluate the feeding values of methionine supplementation in sorghum-based diets for finisher broiler chickens. The objective of this study was to evaluate the performance, nitrogen corrected apparent and true metabolisable energy of red and white sorghum-based diets on two levels of methionine supplementation for finisher broiler chickens.

MATERIALS AND METHODS

Experimental animals and management

One hundred and forty-four 1-day old Marshal Breed broiler chickens were purchased from Nu-breed farm in Abeokuta, Ogun State, Nigeria. The experimental birds were brooded for two weeks. Feeders, drinkers and the pens were cleaned and disinfected, wood shavings were spread on the floor at a depth of 3 cm. The experimental birds were raised on deep litter from d 27 to 56 of the experimental duration. All management protocols, vaccinations routine, medications and good hygiene were properly observed throughout the experimental duration. Feed intake was measured on daily basis while weight gain was evaluated as the differences in weight between the previous and current weeks. The feed conversion ratio was determined from weight gain and feed intake throughout the experimental duration.

Experimental diets

Six experimental diets comprising of three different energy sources (maize, red and white sorghum) at 54% were supplemented with two inclusion levels (0.2% and 0.6%) of methionine. Diets 1 and 2 comprised of maize at two levels (0.2% and 0.6%) of methionine supplementation, while diets 3 and 4 as well as 5 and 6 contained red and white sorghum, as replacement of all the maize in diets 1 and 2, at 0.2% and 0.6% levels of methionine supplementation. All the diets were formulated according to NRC (1994) recommendations for finisher broiler chickens reared from day 27 to 56 (Table 1). The experimental diets were formulated to contain similar proportion of metabolisable energy and crude protein contents. Also, other nutrients and elements such as fat, calcium, phosphorus, lysine and methionine were similar for all diets. There were three replicates per treatment, each replicate comprising of eight experimental birds to make a total of 24 experimental broiler chickens per treatment. Each experimental pen measures 0.85 m^2 equipped with drinking and feeding facilities.

Table 1: Composition of experimental diets fed finisher broilers

Ingredients	$MZ_{(0.2)}$	$MZ_{(0.6)}$	$RS_{(0.2)}$	$RS_{(0.6)}$	$WS_{(0.2)}$	$WS_{(0.6)}$
Maize	540	540	-	-	-	-
White Sorghum	-	-	540	540		
Red sorghum	-	-	-	-	540	540
Soybean	160	160	160	160	160	160
Groundnut cake	115	115	115	115	115	115
Fish meal	20	20	20	20	20	20
Wheat offal	100	96	100	96	100	96
Vegetable oil	10	10	10	10	10	10
Bone meal	30	30	30	30	30	30
Oyster shell	15	15	15	15	15	15
*Vitamin premix	2.5	2.5	2.5	2.5	2.5	2.5
Salt	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	2.5	2.5	2.5	2.5	2.5	2.5
Methionine	2	6	2	6	2	6
Total	1000	1000	1000	1000	1000	1000
Determined composition						
ME	2907.45	2898.17	2919.69	2834.35	2981.65	2987.81
Protein (%)	20.08	20.11	20.17	20.19	20.05	20.13
Fat (%)	3.34	3.33	3.34	3.33	3.34	3.33
Fibre (%)	4.43	4.37	3.76	3.80	3.68	3.75
Ca (%)	1.81	1.83	1.81	1.94	1.78	1.84
P (%)	0.80	0.88	0.67	0.72	0.74	0.77
Lysine	1.20	1.17	1.22	1.24	1.24	1.25
Methionine	0.51	0.60	0.48	0.56	0.50	0.54

MZ: Maize; RS: Red sorghum; WS: White sorghum.

*Vitamin A: 10 000 IU, vitamin D3: 2 000 IU, vitamin E: 30 IU vitamin K3: 3 mg vitamin B1: 2 mg vitamin B2: 6 mg. vitamin B3: 20 mg, vitamin B5: 13.5 mg, vitamin B6: 3 mg, vitamin B7: 0.06 mg, vitamin B9: 0.8 mg, vitamin B12: 0.05 mg, vitamin C: 10 mg, manganese 30 mg, iron: 110 mg, copper: 25 mg, zinc: 100 mg, iodine: 0.38 mg, selenium: 0.36 mg, cobalt: 0.3 mg, antioxidant: 60 mg per kg of complete diet

Excreta collection and measurements

Excreta collection and other measurements for nitrogen corrected apparent and true metabolisable energy (AMEn and TMEn) determination of grain sorghum were determined in finisher-diet phase for broiler chickens at the 8th week of age. Two birds were randomly selected from each replicate and transferred into a metabolic cage. Weighed quantity of feed was given to each bird. A 3-d adaptation period was provided, while fecal collection was taken in the last 3 d. At the end of each collection period, total excreta weight was measured. A 30 g sample of feed and excreta was analyzed, on a DM basis, for GE with a bomb calorimeter and nitrogen content with a combustion N analyzer at the Federal University of Agriculture Abeokuta Nutrition Laboratory. Feed intake, excreta weight, GE, and nitrogen content results were used to calculate the AMEn and TMEn of sorghum grains using the difference method developed by MacLeod *et al.* (2008):

Diet AMEn ={(GEI - GEE) – {8.73 x (NI – NE)]} / FI

where GEI = GE intake; GEE = GE output in excreta; NI = Nitrogen intake from the diet; NE = Nitrogen output from excreta.

N contents of diets and excreta were determined using a nitrogen determinator (Leco Corporation, St Joseph, MI) and N retentions calculated from the following equation:

Retention (%) = <u>(Feed intake × Nutrient in diet) - (Excreta output × Nutrient in excreta)</u> × 100 (Feed intake × Nutrient in diet)

N-corrected AME (AMEn MJ/kg DM) values were calculated by correcting N retention to zero using the factor of 36.54 kJ/g N retained in the body (Hill and Anderson, 1958).

Experimental design and statistical analysis

The experimental design was 2 x 2 + 1 factorial arrangement of two sorghum varieties (red and white sorghum) at two (0.2% and 0.6%) levels of methionine supplementation while the maize-based diets served as control. Data were analysed using the PROC GLM Procedure of Factorial Analysis of Variance (ANOVA) of SAS (2009) package. The class were the treatments (red and white sorghum varieties) and methionine inclusion of 0.2% and 0.6%. The response variables were the weight gain, feed intake and feed efficiency. Means were separated using Duncan Multiple Range Test at 95 % significant level.

RESULTS AND DISCUSSION

The results in Table 2 show the performance of broiler chickens fed the red and white sorghum varieties at two levels of methionine supplementation. There were significant differences ($p<0.05$) in final body weight, weight gain, average daily weight gain and average daily feed intake of broiler finisher chickens fed experimental diets. The control diet promoted the fastest growth, highest average daily weight gain and daily feed intake while broilers fed red sorghum-based diet had the poorest performance and the least feed intake.

There exist differences ($p<0.05$) in the final body weight, and average daily weight gain of chickens fed the red and white sorghum-based diets. The differences observed in the performance of broiler chickens fed the red and white sorghum-based diets may be due to the earlier reported anti-nutrients especially tannin content which is higher in the red sorghum compared to the white variety. Similar findings were reported by Truong *et al.* (2017) and McCuistion *et al.,* (2019).

The feed conversion ratio of broiler chickens fed experimental diets were similar across dietary treatments. Broiler chickens fed control diet performed better and had the same feed efficiency as those fed white sorghum-based diet while broilers fed the red sorghum-based diet gave the poorest feed efficiency. This may be due to the nutrient encapsulating attributes of the high tannin contents of red sorghum compared to the lesser proportion reported for white sorghum variety. Birds fed 0.6% methionine supplementation had heavier final body weight and consumed the most diets per day. Whereas, broiler chickens fed 0.2% methionine supplementation had higher overall weight gain and daily weight gain. Methionine supplementation had significant influence ($p<0.05$) on the final body weight, weight gain, average daily weight gain and feed intake.

Studies (Alfred, 2012; Olusuyi *et al.,* 2022) reported that increased methionine supplementation in diets of broilers improved feed intake and body weight gain. However, there exist no difference in feed conversion ratio of broiler finisher chickens fed experimental diets. Birds fed 0.2% methionine supplementation had better weight gain than those fed increased methionine level. Broiler chickens fed control and white sorghum diets gave the most efficient feed conversion ratio while those fed the red sorghum-based diet had the poorest feed efficiency and were 12.98% higher than the control. Farahat *et al.* (2020) obtained similar results but of closer range (8%) between the birds fed control and sorghum-based diets, while George *et al.* (2017) and Córdova-Noboa *et al.* **(**2018) found no difference in FCR of birds fed maize-soy and sorghum-based diets.

Table 3 presents the results of the interactions of maize, red and white sorghum on two levels of methionine supplementation. There was significant influence ($p<0.05$) of sorghum variety/colour on final body weight and average daily feed intake of broiler chickens fed experimental diets.

Table 2: Growth performance of finisher broiler chickens fed maize based, red and white sorghum-based diets at 0.2% and 0.6% levels of methionine supplementation

	Diets				Methionine levels		
Parameters	**MZ**	**RS**	**WS**	**p**	**0.2%**	**0.6%**	**p**
Initial body weight (g/bird)	588.1	552.08	548.03	0.21	529.93	595.53	0.38
Final body weight (g/bird)	1285.63[a]	1058.00[c]	1116.45[b]	0.01	1125.08[b]	1181.63[a]	0.03
Average weight gain (g/bird)	24.91[a]	18.07[c]	20.30[b]	<0.001	21.26[a]	20.93[b]	0.009
Average feed intake (g/bird)	127.40[a]	105.95[b]	103.43[b]	0.007	110.05[b]	114.46[a]	0.02
Feed Conversion Ratio	5.16	5.93	5.16	0.33	5.26	5.57	0.27

MZ: Maize; RS: Red sorghum; WS: White sorghum; p: <0.05

The highest final body weight was obtained in broiler chickens fed maize with higher inclusion of methionine while the least was found in chickens fed high methionine supplementation of the red sorghum.

The non-significant effects of increased methionine supplementation on the sorghum-based diets could be due to the higher requirements of sulphur-containing amino acids necessary for detoxifications of the high tannin concentrations in grain sorghum to produce 4-o-methyl gallic acids which is excreted in urine. Thus, it appeared higher methionine supplementation produced depressing effects on growth of the broiler chickens fed red sorghum-based diets. There was significant interaction effect of sorghum and methionine supplementation on broilers fed experimental diets. The final body weight changes with variations in sorghum type (red or white) and the inclusion levels of methionine in the diets. Performance of broilers on maize based and white sorghum-based diets at different methionine inclusion levels improved with increased methionine supplementation. Whereas for those on red sorghum-based diets, final body weight decreased with increased inclusion of methionine supplementation.

Also, the red sorghum has been implicated in many studies to inherently contain high tannin content which could be the cause of the inferior performance of birds fed the diets. The results of this study are in consonance with those of Liu *et al.* (2013), Silveira *et al.* (2017), Saleh *et al.* (2019) and Moritz *et al.* (2022) that responses of broiler chickens to sorghum-based diets depends largely on variety/colour, with the white variety better utilised than others.

The higher feed intake observed in broilers fed the control diet could be related to the overall low AMEn content of maize compared to sorghum. Birds will eat to meet their requirements for nutrients and energy. This finding was similarly reported by Schaumburg (2020) on evaluation of sorghum as alternative carbohydrate source for poultry birds.

Results in Table 4 show the energy metabolisability of broiler chickens fed different energy sources supplemented with methionine levels. The values obtained for all evaluated parameters were numerically higher in sorghum than those obtained in broilers fed maize-based diets. There existed significant differences ($p<0.05$) in the apparent and true metabolisable energy of the experimental diets fed to broiler chickens. Although, similarities existed ($p>0.05$) in the values obtained for broiler chickens fed the two sorghum varieties which were significantly higher ($p<0.05$) compared with those fed maize-based diets. However, there existed no significant difference ($p>0.05$) in nitrogen corrected apparent and true metabolisable energy between the two (red and white) sorghum varieties and the maize-based diets.

Similar reports were reported by Sedghi *et al.* (2012), Khodami *et al.* (2015), Mabelebele *et al.* **(**2018) and Ebhadi *et al.* (2018) who found out that nutritional value and energy utilisation of sorghum depends on colour and varietal differences. Moritz *et al.* (2022) reported values within the range of 3,001 to 3,599 Kcal/Kg DM in apparent energy metabolisability of broiler chickens fed sorghum diets. These values were below the range obtained in this study. The inconsistencies in reported values could be due to the differences in ecological conditions and variety/colour as well as the mode of preparation of the sorghum grains.

The results in Table 5 show the interaction effects of sorghum varieties and inclusion levels of methionine supplementation on energy metabolisability of finisher broiler chickens fed experimental diets. For all the sorghum-based diets fed to broilers, there existed significant ($p<0.05$) improvement in energy metabolisability with increased inclusion level of methionine supplementation,

The significant interaction effect of sorghum type (red and white) and inclusion levels of methionine supplementation was observed in all evaluated metabolisable energy values. These results could imply that variations in methionine inclusion levels of different sorghum types (red and white) led to varied metabolisable energy values.

Table 3: Interaction effect of sorghum type and methionine levels of diets on the performance of finisher broiler chickens

	MZ		RS		WS					
Parameters	**0.2%**	**0.6%**	**0.2%**	**0.6%**	**0.2%**	**0.6%**	**SORG**	**MET**	**SORG X MET**	**±SEM**
Initial body weight (g/bird)	537.50	638.69	556.00	548.15	496.30	599.79	0.10	0.62	0.28	13.79
Final body weight (g/bird)	1227.92[b]	1343.33[a]	1081.66[cd]	1034.33[d]	1065.65[cd]	1167.24[c]	0.001	0.04	<0.001	32.97
Average weight gain (g/bird/d	24.66	25.17	18.77	17.36	20.33	20.27	0.59	0.11	0.30	1.38
Average feed intake (g/bird/d)	120.46[ab]	134.34[a]	106.89[bc]	105.00[c]	102.81[c]	104.04[c]	0.007	0.08	0.71	3.67
Feed Conversion Ratio	4.93	5.38	5.78	6.07	5.07	5.26	0.56	0.94	0.52	0.18

MZ: Maize; RS: Red sorghum; WS: White sorghum; SORG: effect of Sorghum; MET: effect of Methionine supplementation; SORG x MET: interaction effects of sorghum variety x methionine supplementation; SEM: Standard error of the means

Table 5: Interaction effect of different energy sources and methionine levels on finisher broiler chicken

	MZ		RS		WS					
Parameters (Kcal/Kg DM)	**0.2%**	**0.6%**	**0.2%**	**0.6%**	**0.2%**	**0.6%**	**SORG**	**MET**	**SORG X MET**	**±SEM**
AME	2526.86[b]	2410.26[d]	2470.23[c]	2530.45[b]	2396.48[d]	2596.88[a]	<0.001	0.015	0.001	21.32
AME_n	2460.38[b]	2354.24[e]	2393.75[d]	2445.23[c]	2316.07[f]	2514.57[a]	<0.001	0.01	0.04	20.28
TME	2500.20[b]	2383.93[d]	2444.27[c]	2502.44[b]	2370.16[e]	2595.24[a]	<0.001	0.018	0.001	23.25
TME_n	2491.30[b]	2384.77[d]	2426.20[c]	2477.67[b]	2346.61[e]	2547.04[a]	<0.001	0.007	0.013	20.37

AME: Apparent metabolisable energy; AMEn: N-corrected AME; TME: True metabolisable energy; TMEn: N-corrected TME; MZ: Maize; RS: Red sorghum; WS: White sorghum; SORG: effect of Sorghum; MET: effect of Methionine supplementation; SORG x MET: interaction effects of sorghum variety x methionine supplementation; SEM: Standard error of the means

Table 4: Effect of energy source and methionine levels on energy metabolisability of finisher broiler chicken

					Methionine levels		
Parameters (Kcal/Kg DM)	**MZ**	**RS**	**WS**	**P**	**0.2%**	**0.6%**	**p**
AME	2468.56[b]	2501.34[a]	2496.68[a]	0.04	2465.17[b]	2512.53[a]	0.012
AME_n	2407.31	2419.49	2415.32	0.42	2390.07	2438.01	0.60
TME	2442.07[b]	2473.35[a]	2482.70[a]	0.002	2438.21	2493.87	0.015
TME_n	2438.03	2451.93	2446.82	0.11	2421.37	2469.82	0.80

AME: Apparent metabolisable energy; AMEn: N-corrected AME; TME: True metabolisable energy; TMEn: N-corrected TME

The increasing levels of TMEn and AMEn with higher inclusion of methionine in sorghum-based diets could imply higher contents of starch availability in the sorghum grain than maize grain owing to improved conversion of bound tannin to the hydrolysed form, and its subsequent release in urine. The seemingly inferior performance of broiler chickens fed sorghum diets compared to those on maize may be due to the anti-nutrients content of sorghum grain which could have encapsulated the grain and binds the release of nutrients (del Puetro *et al.*, 2016).

CONCLUSION

Replacing maize with red and/or white sorghum in diets of finisher broiler chickens led to depressed performance. Nonetheless, the high metabolisable energy of finisher broiler chickens fed sorghum-based diets holds significant potentials provided an improvement in the feeding values of sorghum grain is explored to take advantage of this low-cost feed ingredient for least cost broiler production in Nigeria and other major sorghum producing regions.

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