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Growth performance, nutrient digestibility and serum biochemical indices of finisher broiler chickens fed varying levels of sorghum in replacement of maize with the supplementation of exogenous enzymes

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***Target Audience:** Nutritionist, Researchers, Feed millers and Poultry farmers.*

Abstract

A 28 days feeding trial was conducted with a total of one hundred and eighty broiler chickens to evaluate the effect of maize-sorghum based diets supplemented with exogenous enzyme on growth performance, nutrient digestibility and serum biochemical indices of finisher broiler chickens. Six experimental diets were formulated in which maize based diet served as Control (T1). Maize in the control diet was replaced by sorghum at the levels of 20% (T2), 40% (T3), 60% (T4), 80% (T5), and 100% (T6), respectively with 50g/100kg enzyme supplementation. The broiler chicks were allotted to six dietary treatments of 30 birds replicated three times with 10 birds per replicate. Dietary Treatments showed significant (P<0.05) effect on final weight and total feed intake. Similar higher statistical values of 1814.67g and 1804.67g were recorded for final weight in birds fed 80% sorghum (T5) and 100% sorghum (T6). Dietary Treatments had significant (p < 0.05) influence on Total protein and cholesterol. Varying levels of sorghum showed (p<0.05) effect on dry matter, crude protein and crude fiber digestibility. In conclusion, feeding finisher broiler chickens up to 100% sorghum replacement level for maize with enzyme supplementation improved growth performance and efficient nutrient digestibility without deleterious effect on the birds.

***Keywords:** Maize-sorghum; Enzyme; Performance; Serum biochemistry; Nutrient digestibility; Broilers.*

Description of Problem

The insufficient supply of feedstuffs at economic prices has continue to limit the production and availability of animal protein consumption in the developing countries of the world. Maize served as a staple food for humans and a major raw material for most industries. Also, as a major source of energy in poultry diets makes it expensive and sometimes unavailable due to its seasonality. This resulted in increased cost of feed production with a corresponding increase in the prices of poultry products. This situation has compelled animal nutritionists to intensify research into alternative feed sources to reduce cost of animal proteins.

Sorghum is an important cereal crop and plays a key role in animal feed (1). In regard to the nutritive value, cost and availability, sorghum grain is probably the next alternative to maize in poultry feed (2). Although sorghum I s similar to maize in chemical composition but it has been associated with sub-optimal and inconsistent poultry performance (3 and 4). Some sorghum varieties may contain condensed tannin, which has pronounced anti-nutritive properties. Sorghum grains contain high levels of phytate

or phytic acid (5). In addition to chelating minerals, phytate binds with protein through binary and ternary complexes and binds with starch directly or indirectly through starch granule-associated protein. Due to this relationship, the enzymatic degradation of phytate increases availability of starch and protein in the sorghum (6). Sorghum-based diets are associated with inferior broiler performance in comparison to maize and wheat based diets (7). The purpose of adding enzymes to poultry feeds is mainly to improve the utilisation of nutrients. As described by (8), the mechanisms of xylanase include the degradation of the non-starch polysaccharides (NSP) in the cell wall matrix of the ingredients with the release of the encapsulated nutrients and lowered viscosity of digesta caused by soluble NSP and improved rate of diffusion between enzymes and digestion end products. Xylanases, β-glucanases, and phytases are enzymes commonly used in poultry feeds. The hydrolysis of the phytate increases the availability of phytate-bound phosphorus (phytate-P) and reduces its excretion (9). It also increases protein and starch utilisation (7). Combinations of xylanase and phytase have been of great interest in wheat-based diets. Enhanced apparent metabolisable energy (AME) and improved protein digestibility in wheat-based diets supplemented with xylanase and phytase have been reported (10).

Despite the popularity of the use of phytase and carbohydrases or their combinations in wheat- and barley based diets, there is scarcity of published data on the advantage of multi-enzyme in maize-sorghum based diets. Growth response, nutrient digestibility and serum biochemical values could serve as base line information regarding comparison of nutrient utilization and efficiency. Serum biochemistry information provides a valuable opportunity to clinically evaluate the quality of feed. Therefore, this study tends to evaluate the impact of exogenous multi-enzyme added to sorghum-based diets on growth response, nutrient digestibility and serum biochemical indices of finisher broiler chickens.

Materials and methods

Experimental site

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm of the Taraba State University, Jalingo located between latitude 6^{o} 30' and 9^{o} 30' N and longitude 9^{o} 00' and 12^{o} 00' E in Guinea Savannah Zone of Northern Nigeria (11). It has an annual rainfall range of 1000mm – 1500mm, the ambient temperature of the area range between 30 – 38^{o}C with an average of 29^{o}C.

Experimental birds and management

A total of 180 four weeks old unsexed broiler chicks of commercial strain (arbor acre) were purchased from a reputable farm. The chicks were weighed and allotted to six dietary treatments of three replicates each in a Completely Randomized Experimental Design. Each replicate consists of 10 chicks, to have a total of 30 birds per treatment. Birds were reared on deep litter housing system for 28 days. Routine vaccinations and medications were strictly followed and feed and water were provided *ad libitum*.

Source of test ingredients

Sorghum was purchased from local market in Jalingo. The additive used in this study is a commercial multi-enzyme called Zympex. Zympex was sourced from Novus International USA and it contains alpha-amylase, acid protease, alpha-glucosidase, beta-mannanase, xylanase and beta-glucanase. The inclusion rate is 500g/ton of feed.

Experimental diets

The experimental diets were formulated to meet (12) minimum nutrient requirement. The diets consist of maize based diet (control T1),

20%, 40%, 60%, 80%, and 100% varying levels of sorghum as replacement for maize in the control diet denoted by T2, T3 T4, T5 and T6 respectively. Zympex enzyme 50g/100kg diet was supplemented across dietary levels as presented in Table 1.

Table 1: Percentage composition of broiler chickens finisher diets (28th – 56th days)

Sorghum levels	**0%**	**20%**	**40%**	**60%**	**80%**	**100%**
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
Ingredients:						
Maize	60.00	48.00	36.00	24.00	12.00	0.00
Sorghum	0.00	12.00	24.00	36.00	48.00	60.00
Palm oil	2.00	2.00	2.00	2.00	2.00	2.00
Soya bean meal	13.40	13.40	13.40	13.40	13.40	13.40
Groundnut cake	12.20	12.20	12.20	12.20	12.20	12.20
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00
Rice offal	6.00	6.00	6.00	6.00	6.00	6.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.55	1.55	1.55	1.55	1.55	1.55
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Supplementation:						
Phytase 50g/100kg	-	+	+	+	+	+
Calculated analysis:						
ME (kcal/kg)	3006.24	2981.04	2955.84	2930.64	2905.44	2880.24
Crude protein (%)	19.03	19.25	19.48	19.71	19.94	20.17
Crude fibre (%)	3.24	3.24	3.24	3.24	3.24	3.24
Ether extract (%)	4.03	3.91	3.79	3.67	3.55	3.43
Ca (%)	1.19	1.20	1.20	1.20	1.21	1.21
P (%)	0.44	0.46	0.49	0.52	0.55	0.57
L-Lysine (%)	0.90	0.91	0.92	0.93	0.95	0.96
DL-Methionine (%)	0.53	0.52	0.51	0.50	0.49	0.48

\- No enzyme supplementation
\+ Enzyme supplementation

Data Collection

Growth performance characteristics

The initial weights of the birds were taken at the commencement of the study. The live weights of the birds as well as the feed consumption of each replicate were measured weekly.

Feed conversion ratio for each replicate was determined by dividing the feed intake by the weight gain.

$$Feed\ intake/bird\ (g) = \frac{Quantity\ of\ feed\ fed - Quntity\ of\ feed\ left\ over}{Number\ of\ birds \times 28\ days}$$

$$Daily\ weight\ gain\ (g) = \frac{Final\ live\ weight - Initial\ weight}{Number\ of\ birds\ \times 28}$$

$$Feed\ conversion\ ratio\ = \frac{Quantity\ of\ feed\ consumed}{Weight\ gain}$$

Serum biochemical analysis

At the end of 28th day of the study, blood samples were drawn from the wing vein of 3 birds per treatments that is one from each replicates. 2m1 of blood was collected into a clean syringe and put in plane bottle for serum biochemical analyses. The blood samples were allowed to clot, they were refrigerated for 6 hours and then spun in a centrifuge at 900 rpm for 20 minutes. The separated serum were stored in the freezer at -2°C prior to analysis for serum metabolites such as serum total protein, albumin, globulin, creatinine, uric acid and cholesterol.

Nutrient digestibility

Metabolic trial was conducted at the 28th day of the study. A bird per replicate was randomly selected and housed separately in appropriate metabolic cage fitted with feeder and drinker. The birds were allowed to acclimatize for two days before the commencement of 4 days feeding and excreta collection. A known weight of feed was given and excreta collected per bird per day were oven dried and use for analyses. Proximate composition of the feed and dried excreta were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash using standard method of (13).

$$DM\ digestibility = \frac{(DM\ of\ feed \times\ feed\ intake) - (DM\ of\ excreta \times\ excreta\ output)}{(DM\ of\ feed \times\ feed\ intake)} \times \frac{100}{1}$$

$$CP\ digestibility = \frac{(CP\ of\ feed \times\ feed\ intake) - (CP\ of\ excreta \times excreta\ output)}{(CP\ of\ feed \times feed\ intake)} \times \frac{100}{1}$$

$$CF\ digestibility = \frac{(CF\ of\ feed \times feed\ intake) - (CF\ of\ excreta \times excreta\ output)}{(CF\ of\ feed \times feed\ intake)} \times \frac{100}{1}$$

$$EE\ digestibility = \frac{(EE\ of\ feed \times feed\ intake) - (\ EE\ of\ excreta \times excreta\ output)}{(EE\ of\ feed \times feed\ intake)} \times \frac{100}{1}$$

$$Ash\ digestibility = \frac{(Ash\ of\ feed \times feed\ intake) - (\ Ash\ of\ excreta \times\ excreta\ output)}{(Ash\ of\ feed \times feed\ intake)} \times \frac{100}{1}$$

Statistical Analysis

Data collected were subjected to One–way Analysis of Variance (ANOVA) in a Completely Randomized Design using (14) while significant means was separated using Duncan's Multiple Range Test at 5% level of significance.

Results and Discussion

The growth performance of finisher broiler chickens fed maize-sorghum based diets supplemented with enzyme is presented in Table 2. Dietary Treatments showed significant ($P<0.05$) effect on final weight, total weight gain, daily weight gain and total feed intake among the parameters measured. The observation in this study corroborated literature finding that an increased feed intake and weight gain with depressed feed efficiency was reported when xylanase enzyme was supplemented to sorghum-based broiler diets (7). Weight gain and feed conversion ratio (FCR) improved with protease enzyme supplementation in maize-sorghum base diets for broiler chickens (15). (16) reported improved weight gain and FCR in sorghum-yellow maize based diets with enzyme supplementation. However, result of this finding was in contrast with report of (17) who reported no significant ($P>0.05$) influence among performance parameter measured when broiler chickens were fed sorghum based diets with enzyme supplementation.

Similar higher statistical values of 1814.67g and 1804.67g were recorded for final weight in birds fed 80% sorghum (T5) and 100% sorghum (T6) with enzyme supplementation respectively. Least significant ($P<0.05$) value of 1784.00g was recorded for final weight in birds fed 0% sorghum (control diet). Birds fed diet containing 40% sorghum and 60% sorghum replacement level with enzyme showed similar statistical value 1794.67 and 1802.33g respectively. Total weight gain and daily weight gain followed similar pattern with final weight. Birds fed 80% sorghum (T5) and 100% sorghum level (T6) with enzyme revealed higher statistical values of 40.85g and 40.53g respectively for daily weight gain. Least significant ($p<0.05$) value 39.75g was recorded for daily weight gain in the birds fed 0% sorghum (control). This supported the report of (18) that birds fed 75% or 100% sorghum showed significant ($p<0.05$) increase in body weight gain. Similarly (19, 20 and 21) reported that all dietary maize portion of broiler diets can be replace with sorghum without adverse effect on live weight, feed intake and FCR. Improved growth performance in this study could be attributed to ability of the enzyme to cause degradation of the non-starch polysaccharide (NSP) in the cell wall matrix of feed ingredients with the release of the encapsulated nutrients and lowered viscosity of digesta caused by soluble NSP and improved rate of diffusion between enzyme and digestion end products (8). Exogenous enzymes expose the locked nutrient in the ingesta to endogenous enzymes for proper unlocking of the nutrients by means of stimulating the intestinal motility in broiler chicken.

The report of this finding was at variance to (6) who reported that enzyme inclusion did not improve feed intake, body weight gain and FCR at all ages when broiler chickens were fed sorghum based diet with enzyme supplementation. Feed intake recorded in this study revealed higher ($P<0.05$) statistical values for the birds fed varying levels of sorghum (T2, T3, T4, T5, and T6) with enzyme supplementation. This supported the finding that broiler chickens on high tannin sorghum based diets had higher feed intake and feed efficiency (22).

Table 2: Effect of maize-sorghum based diets with enzyme supplementation on growth response of finisher broiler chickens (5 – 8 weeks)

Sorghum levels	0%	20%	40%	60%	80%	100%	
Parameters	T1	T2	T3	T4	T5	T6	SEM
Initial weight (g)	671.00	669.67	670.33	669.67	670.67	669.67	0.25
Final weight (g)	1784.00^{d}	1792.33^{cd}	1794.67^{bc}	1802.33^{bc}	1814.67^{a}	1804.67^{ab}	2.49
Weight gain (g/bird)	1113.00^{d}	1122.66^{cd}	1124.34^{bc}	1132.66^{bc}	1144.00^{a}	1135.00^{ab}	2.53
Daily weight gain (g/bird)	39.75^{d}	40.10^{cd}	40.16^{bc}	40.45^{bc}	40.86^{a}	40.54^{ab}	0.09
Feed intake (g/bird/week)	2987.67^{b}	2990.00^{ab}	2991.00^{ab}	2993.33^{ab}	2996.00^{a}	2992.33^{ab}	0.81
Daily feed intake (g/bird)	106.70	106.79	106.82	106.91	107.00	106.87	0.03
Feed conversion ratio	2.68	2.66	2.66	2.64	2.62	2.64	0.01

^{abcd} Mean on the same row having different superscripts were significantly (P<0.05) different.

Serum biochemical indices

The result of varying inclusion levels of sorghum as a replacement for maize with enzyme supplementation on serum biochemical indices of finisher broiler chickens is presented in Table 3. Varying inclusion level of sorghum had significant ($p < 0.05$) influence on Total protein, Albumin, globulin and cholesterol. Total protein did not follow any specific pattern. Birds fed control (T1) diet and birds fed 60 % sorghum inclusion (T4) revealed least ($p < 0.05$) values of 3.50 g/dl and 3.37 g/dl respectively. Similar result was observed for albumin with birds fed 60 % sorghum (T4) recorded the least value while statistical similar higher values were recorded across dietary treatments. Globulin increased with increased level of sorghum up to 80 % inclusion level (T5). Creatinine followed no specific trend with birds fed diet containing 40 % sorghum (T3) recorded least ($p < 0.05$) value of 0.64 mg/dl. Normal blood composition as observed in this study is a reflection of good animal performance (23). Birds fed 80 % sorghum (T5) showed higher value of 149.00 mg/dl for cholesterol. Birds fed 40 % and 60 % inclusion levels of sorghum (T3 and T4) showed similar values 126.70 mg/dl and 127.25 mg/dl for cholesterol. Values recorded for serum biochemistry across the parameters corroborated normal values reported for healthy chicken (24 and 25). Serum biochemistry provide useful information about viscera organ damage especially liver and kidney (26).

Table 3: Effect of varying levels of sorghum with enzyme supplementation on serum biochemical indices of finisher broiler chickens (8 weeks)

Sorghum levels	0%	20%	40%	60%	80%	100%	
Parameters	T1	T2	T3	T4	T5	T6	SEM
Total protein (g/dl)	3.49^{b}	3.70^{ab}	3.99^{a}	3.36^{b}	4.10^{a}	3.96^{a}	0.070
Albumin (g/dl)	2.03^{ab}	2.20^{ab}	2.45^{a}	1.67^{b}	2.03^{ab}	2.29^{a}	0.080
Globulin (g/dl)	1.46^{b}	1.50^{b}	1.54^{ab}	1.69^{ab}	2.07^{a}	1.67^{ab}	0.081
Glucose (mg/dl)	173.00	180.33	179.37	174.33	163.67	157.33	3.710
Creatinine (mg/dl)	0.66	0.70	0.64	0.73	0.76	0.69	0.011
Uric acid (mg/dl)	0.22	0.27	0.25	0.20	0.21	0.23	0.240
Cholesterol (mg/dl)	124.20^{d}	139.05^{b}	126.70^{cd}	127.25^{cd}	149.00^{a}	133.50^{bc}	2.250

^{abcd} Mean on the same row having different superscripts were significantly (P<0.05) different.

Nutrient digestibility

Nutrient digestibility of finisher broiler chickens fed maize-sorghum based diets with enzyme supplementation is shown in Table 4. Maize-sorghum based diet with enzyme supplementation showed significant ($p<0.05$) effect on the parameters determined. Dietary Treatments showed significant ($p<0.05$) effect on dry matter, crude protein, either extract and crude fiber digestibility among the parameter determined. Dry matter digestibility followed no specific pattern with birds fed control diet (T1) and birds on 80% sorghum (T5) shown similar higher ($p<0.05$) statistical values of 73.83% and 75.33% respectively.

The crude protein digestibility revealed that birds fed control diet (T1) had higher statistical value 71.39% while the lower crude protein digestibility were observed in sorghum containing diets (T2, T3, T4, T5 and T6) at comparative level to control diet (T1) could be attributed to Karifins low digestibility (27) and the existence of condensed tannin which is capable of binding to dietary protein (28). (7) reported that approximately 50% of sorghum protein consists karifins which is located in protein bodies in sorghum endosperm where it is intimately associated with starch granules. Protein-carbohydrate, protein-polyphenol and carbohydrate- polyphenol interaction are the main factors affecting crude protein digestibility (29). Statistical close values (71.83 - 74.44) were recorded for ether extract across dietary treatments with birds fed T5 shown least ($p<0.05$) value of 71.83%. Crude fiber digestibility followed no specific trend with birds fed 40% sorghum (T3) shown least ($p<0.05$) value 60.79%. Birds recorded similar statistical values for crude fiber across dietary treatments. Dietary treatments had no ($p>0.05$) effect on ash digestibility. This observation could be attributed to ability of phytate to form chelate with minerals. In addition to chelating minerals, phytate binds with protein through complexes and bind with starch directly or indirectly through starch granule associated protein.

Table 4: Effect of varying levels of sorghum with enzyme supplementation on nutrient digestibility of finisher broiler chickens (8 weeks)

Sorghum levels	0%	20%	40%	60%	80%	100%	
Parameters	T1	T2	T3	T4	T5	T6	SEM
Dry Matter (%)	73.83^{ab}	70.20^{c}	69.66^{c}	71.66^{bc}	75.33^{a}	72.33^{abc}	0.53
Crude Protein (%)	71.39^{a}	68.79^{bc}	67.59^{c}	69.51^{b}	69.05^{bc}	68.17^{bc}	0.32
Ether Extract (%)	72.23^{ab}	73.06^{ab}	74.44^{a}	72.46^{ab}	71.83^{b}	72.66^{ab}	0.26
Crude Fibre (%)	65.37^{ab}	62.44^{ab}	60.79^{b}	67.06^{a}	62.36^{ab}	63.09^{ab}	0.64
Ash (%)	59.10	60.22	61.10	60.31	59.38	61.43	0.31

^{abc} Mean on the same row having different superscripts were significantly ($P<0.05$) different.

Conclusion and Applications

1. Varying inclusion levels of sorghum with enzyme supplementation improved weight gain and feed intake among the parameters measured for finisher broiler chickens.
2. Sorghum could replace maize up to 80% and or 100% replacement level with enzyme supplementation for improved growth performance and efficient nutrient digestibility without hazardous effect on finisher broiler chickens.

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