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Impact of Dietary Xylanase-Beta-Glucanase Supplementation on the Performance of Broiler Chickens Fed Sorghum-Soybean-based Diet

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Abstract

This study evaluated the effect of xylanase-β-glucanase (Axtra®XB) blend on the performance, carcass characteristics, gut morphology, haematology and litter quality of broiler chickens fed sorghum-soybean-based diet. A total of 450, day-old male (Ross 308) chicks (40.00 + 0.55g) was assigned to five groups, with 6 replicates per treatment and 15 birds per replicate pen. The experimental diets were; maize-soybean, sorghum- soybean (without Axtra®XB enzyme), 250, 500 and 750 mg Axtra®XB per kg of sorghum-soybean diet. A two-phase (starter - d 1 to 28 and finisher - d 29 to 56) feeding program was employed under the deep litter system. Growth performance, body weight, weight gain, feed intake, feed conversion ratio and mortality were weekly monitored. At d 56, six birds were randomly picked per replicate for carcass and hematological analyses. Data were subjected to the completely randomized design using the general linear models procedure of GENSTAT (2012) and Duncan's multiple range test was used to compare treatments ($P < 0.05$). There were significant ($P < 0.05$) effects of dietary treatments on the growth performance, prime cuts, relative organ weights, gastrointestinal tract morphometry, haematological indices and litter quality of broilers. Compared to birds on maize-soybean diet, 0.72 - 1.42% ($P = 0.032$), 1.82% ($P = 0.043$) and 19.82% improvements were recorded in daily weight gains, feed conversion ratio and mortality rate, respectively in birds fed sorghum-soybean diets especially at 750 mg Axtra®XB supplementation. Dressing percentage and breast yield had increased by 0.59% and 6.65 - 8.00%, respectively with reduced organ weights, gastrointestinal length and 40.82% abdominal fat pad in birds fed up to 500 mg Axtra®XB supplemented diet. Litter quality also improved ($P < 0.05$) at increasing level of supplementation. Haematological indices also varied ($P < 0.05$) between dietary treatments. At increasing level of Axtra®XB supplementation, significant reduction in the levels of white blood cells, haemoglobin and packed cell volume were observed. The results indicated improved broiler performances following dietary Axtra®XB supplementation but beyond 500mg/kg diet the health of the birds could be compromised.

Keywords: *Enzyme Blend; Growth Response; Broilers; Carcass Yield; Litter Quality; Axtra®XB*

Abbreviations

IBW: Initial Body Weight; D: Day; FBW: Final Body Weight; ADWG: Average Daily Weight Gain; ADFI: Average Daily Feed Intake; FCR: Feed Conversion Ratio; ANOVA: Analysis Of Variance; TWG: Total Weight Gain; ADWG: Average Weekly Weight Gain; TFI: Total Feed Intake; SS:

Sorghum-Soybean; XB: Xylanase-Beta-Glucanase; DW: Dressed Weight; GIT: Gastrointestinal Tract; Nsps: Non-Soluble Polysaccharides; EDTA: Ethylenediaminetetraacetic Acid; Hb: Haemoglobin; PCV: Pack Cell Volume; RBC: Red Blood Cells; WBC: White Blood Cells; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Haemoglobin; MCHC: Mean Corpuscular Haemoglobin Concentration; NIH: National Institutes Of Health; NRC: National Research Council

Introduction

Globally, there is the search and introduction of cheaper, available and alternative feed materials into poultry diets as a means of increasing the flexibility of formulated rations (without compromising poultry performance) due to price volatility in conventional feed raw materials [1]. More so, for the sustainability of commercial poultry production, efficient feed utilization is emphasized [2]. Several feed enzymes as single or mixtures are known to counteract the anti-nutritive effects of non-soluble polysaccharides (NSPs), improve dietary nutrients availability thus increasing the potentials of alternative feed ingredients in poultry feeds [1].

Sorghum (*Sorghum bicolor*) is one of the important cereal grains ranking fifth behind maize, rice, wheat and barley with about 11% crude protein, 3% fat and 70% carbohydrates [3]. In Nigeria, there is an increasing use of sorghum as alternative energy source to maize due to its comparable feeding value and lower feed cost [4,5].

However, three main anti-nutrients; kafirin (the dominant protein fraction in grain sorghum), phenolic compounds (such as condensed tannin) and phytate (*myo*-inositol hexaphosphate-IP6) have been implicated for the low starch and energy utilization in animals fed sorghum diets [6]. Reports of [7,8] indicated that arabinoxylans and beta-glucans are the main fibrous anti-nutrients present in many alternatively cheaper feed materials such as wheat, sorghum, barley and sunflower meal. Ravindran., *et al.* [9] and Moftakharzadeh., *et al*. [10] noted that the presence of β-glucans, phytate and other anti-nutrients also cause viscose conditions within bird's intestinal lumen thus hindering nutrient digestion and absorption. Das., *et al.* [2] further explained that following feed consumption, several nutrients will be lost because the birds' digestive system cannot efficiently utilize the un-hydrolyzed NSPs found within the cereal grains cell wall thereby resulting to poor feed efficiency.

To maximize sorghum utilization, exogenous feed enzyme supplementations are considered [11]. Enzymes currently incorporated into poultry diets include: β-glucanases, xylanases, phytases, proteases, lipases, and galactosidases [11-13]. Their mode of action is to reduce digesta viscosity, enhance digestion and absorption of nutrients (especially fat and protein), improve apparent metabolizable energy (AME) value of diet, increase feed intake, weight gain, feed gain ratio, reduce beak implication and vent plugging, decrease size of gastrointestinal tract, reduce water intake and water content of excreta [14].

There are contradictory results on the effect of dietary enzymes supplementations either as single or mixtures on poultry performance. While some authors indicated no improvements in broiler performances [15-17] and NSPs digestibility [18], some others indicated little effects [19].

On the other hand, several reports showed significant effects of enzyme supplementations in poultry. Multi-enzyme supplementations are known to improve the nutritive value of corn-soybean diets in broiler chicks [20-22]. Alagawany., *et al.* [23] reported significant improvement in broilers fed diet supplemented with Axtra®XAP. Further studies indicated that dietary enzyme supplementations (such as Xylanase, Phytase or blends) resulted in improved broiler live-weight [24-27] total weight gain [28], nutrient digestibility and availability [29-31] as well as decrease fresh feacal output [26]. Bhuiyan., *et al*. [32] reported an improvement on the body weight of young birds fed sorghum based-diets with higher feed intake and conversion ratio following multiple enzyme supplementation. Avila-Ramos., *et al*. [33] noted that the addition of phytase and multiple-enzyme complex in sorghum-soybean diets improved broiler performance. A 2.9 - 5.2% improvement in feed conversion was observed in 42 day-old broilers fed diets were supplemented with 0.05 - 0.2 kg of Axtra®XB in corn, wheat, oat, barley and rye diets [7]. However, there is a dearth of information on the effects of Axtra®XB enzyme supplementation on broilers fed sorghum-based diet [6]. The present study attempted to evaluate the responses of broiler chickens to xylanase-β-glucanase enzyme blend in a sorghum-soybean-based diet.

Materials and Methods

Location of study

The field trial was conducted at the Poultry unit of the University of Calabar, Teaching and Research Farm, Calabar. This site is located within latitude 4° 58^{1}N and 15° 39^{1} N and longitudes 8° 20^{1}E and 10° 43^{1}E of the equator, it has relative humidity of 55 - 99%, elevated at 99 meters above sea level with temperature and rainfall ranges of 25° - 30°C and 1,260 - 3,500 mm, respectively [34].

The experimental protocol was reviewed and approved by Animal Ethics Committee of the University of Calabar, Nigeria and animals were cared for according to the NIH standard guidelines described in the NRC [35] guide for the care and use of laboratory animals.

Experimental diets

All feed ingredients (including maize, sorghum, soybean meal, palm kernel cake, wheat offal, crayfish dust, methionine, lysine, vitamin-mineral premix, di-calcium phosphate, palm oil and salt) were purchased from Watt market, a local market in Calabar South Local Government Area of Cross River State, Nigeria. A commercial enzyme mixture; Xylanase-Beta-glucanase (Axtra®XB), a product of DuPont was provided by Agrited Nigeria Ltd. Axtra®XB is a preparation of endo-1, 4-β-xylanase (4,000 units/kg) and endo -1, 3 (4) - β - glucanase (3,000 units/kg) produced by *Trichodema reesei* and heat stable at 90°C (Dupont Industrial Biosciences, Marlborough, Wiltshire, UK). This enzyme blend is reported to reduce feed costs and maintain poultry performance without compromising feed hygiene requirement [7].

Two basal (maize-soybean and sorghum-soybean) diets were formulated to meet or exceed all nutrient requirements for broilers stipulated in the NRC (2012) guideline. The five dietary treatments at the starter and grower (Table 1) periods consisted of 100 per cent maize-soybean diet (positive control diet), 100 per cent sorghum-soybean diet without enzyme (negative control diet), 250, 500 and 750 mg of xylanase-β-glucanase mixture (Axtra® XB) enzyme per kg of sorghum-soybean diet to constitute Treatment 1, 2, 3, 4 and 5 respectively. The nutrient contents of the basal diets at the starter and finisher phases were also calculated.

Experimental birds and management

A total of 450 day-old male Agrited Ross 308 strain of broiler chicks was purchased from a local distributor and assigned to 5 treatments of 6 replicates with 15 chicks assigned to each replicate pen (2m × 2m i.e. 15 chicks per m^{2}) under the deep litter system. The average initial body weight of chicks in each pen was 40 + 0.55gr. Ambient temperature was maintained at 34°C for the first one week of the experiment, thereafter reduced steadily to 22°C until d 21 of age under continuous lighting regime. Mash feed and water were offered ad libitum throughout the experiment.

Response criteria

The under-listed parameters were measured.

Growth performance indices

All of birds were weighed at d 7, 14, 21, 28, 35, 42, 49 and 56 of age and pen feed intake was measured throughout these periods. Weekly weight gain and feed conversion ratio (FCR) were then calculated. Death observed per pen was recorded as it occurred while data on feed wastage and mortality recorded were used to adjust performance criteria.

Carcass and gastrointestinal parameters

On d 56, six birds per pen were randomly picked for carcass analyses. Prior to slaughter, the birds were starved of feed overnight with an ample supply of drinking water. Birds were individually weighed, slaughtered and eviscerated. Carcass weight, thigh, breast (inclusive of skin and bone), digestive and internal organs (oesophagus, crop, proventriculus, gizzard, liver, kidney, heart, spleen and lungs) were carefully separated, weighed using a sensitive electronic scale (Model- 110C) and expressed as a percentage of live weight.

At d 29 and 56 intestinal contents were removed in order to determine gastrointestinal parameters. Gastro-intestinal tract was obtained *in toto* and cleaned of all adhering tissues. The intestine was segmented into; the duodenum (pancreatic loop), jejunum (from the

Ingredient	Sorghum- soybean diet		Standard corn – soybean diet	
	Starter	Finisher	Starter	Finisher
Corn	---	----	50.00	55.00
Sorghum	50.00	55.00	----	----
Soybean meal	32.00	25.00	32.00	25.00
Palm kernel cake	4.45	4.45	4.45	4.45
Wheat offal	5.00	7.00	5.00	7.00
Crayfish dust	5.00	5.00	5.00	5.00
DCP	2.00	1.80	2.00	1.80
Methionine	0.30	0.20	0.30	0.20
Lysine	0.25	0.15	0.25	0.15
Vit. Min. Premix	0.50	0.20	0.50	0.20
Palm oil	0.25	1.00	0.25	1.00
Salt	0.25	0.20	0.25	0.20
Total	100.00	100.00	100.00	100.00
Calculated nutrient;				
% Crude protein	23.00	20.80	23.30	21.00
% Crude fibre	3.93	3.95	3.96	3.99
ME (Kcal/kg)	2,840.29	2,920.57	2,800.00	2,920.14
Analyzed nutrient:				
% Crude protein	22.84	18.74	23.60	18.36
% Crude fibre	4.06	4.19	4.15	4.24

Table 1: *Gross composition and calculated nutrient contents (%) of the experimental diets.*

**Vitamin BCP (premix; 0.25% vitamins and Trace elements), each 2.5kg supplied the following: Vitamin A 10,000,000 I.U, Vitamin D 2,000,000 I.U, Vitamin E 20,000I.U, Vitamin K 2,250 mgr, Thiamine 1,750 mgr, Riboflavin B2 5,000 mgr, Pyridoxine B6 2,750 mgr, Niacin 27,500 mgr, Vitamin B1215 mgr, Pantothenic acid 7,500 mgr, Biotin 50 mgr, Cholin chloride 400gr, Antioxidant 125 gr, Manganese 80 gr, Zinc 50 gr, Iron 20 gr, Copper 5 gr, Iodine 1.20 gr, Selenium 200 gr, Cobalt 200 gr.*

pancreatic loop to Meckel's diverticulum), the ileum (from Meckel's diverticulum to the ileocecal junction) and the caecum and the weight and length of each segment were measured. With a glass electrode pH meter, the acidity and alkalinity of the intestinal digesta were immediately read.

Haematological analysis

Prior to slaughter, 5ml of blood was collected from each bird by puncturing the brachial vein with a 5ml scalp vein needle and was placed into sterile, well labelled plastic bottle containing ethylenediaminetetraacetic acid (EDTA) as the anticoagulant for determination of haematological parameters. All haematological parameters (Packed cell Volume, Erythrocyte count, Haemoglobin concentration, total white blood cell counts were determined by standard laboratory methods as described by Benerjee [36]. Differential white blood cell counts (eosinophils, neutrophils, lymphocytes and monocytes) were calculated.

Litter quality

On d 10, 21, 39 and 56, litter quality of each pen was evaluated by dividing each pen into four points and litter quality for each point was scored and averaged per pen as described by Chalghoumi., *et al* [37].

Visual score ranging from 1 to 4 was used:

- Extremely dry with no caked litter
- Dry with patches of caked litter
- Wet with moderate amount of caked litter
- Extremely wet with entire point covered with caked litter.

To obtain average litter score six independent assessors were employed.

Statistical analysis

Data were subjected to the completely randomized design using the general linear models procedure of GENSTAT [38] and Duncan's multiple range test was used to compare treatments ($P < 0.05$).

Results and Discussion

The results of the growth, carcass, gastrointestinal, haematology and litter quality of broilers fed diet supplemented with Axtra®XB enzyme are presented as follows.

Growth performance

At the starter phase (Table 2), final body weight (FBW) increased by 2.27, 3.10, 3.58 and 4.48% in birds fed sorghum; without enzyme, with enzyme at 500, 250 and 750mg of Axtra®XB enzyme, respectively. Average daily weight gain (ADWG) followed similar trend with an increase of 2.40, 2.88, 3.80 and 4.69%. Average daily feed intake (ADFI) was highest ($P = 0.036$) in birds fed 500 mg Axtra®XB, followed by those on 250, 750 mg Axtra®XB, sorghum without enzyme and least in those on maize diet. No effect ($P > 0.05$) of dietary treatments was observed on feed conversion ratio (FCR). Implying that all birds were able to utilize their feed effectively. No mortality ($P>0.05$) was recorded across treatments in the first 28d of experiment.

Parameters	Maize-Soybean	Sorghum-Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/Kg	p-value
IBW (g)	40.00	40.00	40.00	40.00	40.00	0.000
FBW (g)	762.67^{c}	780.00^{b}	790.00^{a}	783.33^{ab}	796.67^{a}	0.034
TWG (g)	722.67^{c}	740.00^{b}	750.00^{a}	743.33^{ab}	756.67^{a}	0.024
AWWG (g/wk)	180.67^{b}	185.00^{a}	187.50^{a}	185.83^{a}	189.17^{a}	0.032
ADWG (g/d)	25.81^{b}	26.43^{a}	26.79^{a}	26.55^{a}	27.02^{a}	0.050
TFI (g)	1426.17^{b}	1432.50^{ab}	1483.50^{a}	1507.00^{a}	1456.17^{a}	0.029
AWFI (g/wk)	356.54^{b}	358.13^{b}	370.88^{a}	376.75^{a}	364.04^{ab}	0.025
ADFI (g/d)	50.94^{b}	51.16^{b}	52.98^{a}	53.82^{a}	52.01^{ab}	0.036
FCR	1.97	1.94	1.98	2.03	1.93	0.053
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.000

Table 2: *Growth performance of starter (d 1 - 28) broiler chickens fed enzyme-sorghum diet.*

^{abc} *= Means with different superscript on the same row differ significantly ($P < 0.05$).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

At the finisher phase (Table 3), FBW increased ((P = 0.041) by 0.70, 0.85, 1.22 and 1.37% in birds fed sorghum diet without enzyme, with 750, 250 and 500 mg Axtra®XB, respectively compared to those on maize diet. While 0.21% (250 mg) and 0.79% (500 mg) increases were obtained, a 0.71% reduction in ADWG was recorded in birds fed 750 Axtra®XB. The use of sorghum and addition of 250 mg Axtra®XB resulted in poorer (P = 0.034) feed conversion ratio while a 1.74% improvement was obtained in birds fed 750mg Axtra®XB. Similar FCR value was obtained in birds fed maize-soybean and those fed 500 mg Axtra®XB supplemented sorghum-soybean diet. Mortality was highest (P = 0.042) in birds fed sorghum without enzyme diet with the least value recorded in those fed 500 mg Axtra®XB. This could imply that sorghum diet could expose the birds to some health issues which were ameliorated following enzyme supplementation especially at 500 mg Axtra®XB supplementation.

Parameters	Maize-Soybean	Sorghum-Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
IBW (g)	762.67^{c}	780.00^{b}	790.00^{a}	783.33^{ab}	796.67^{a}	0.034
FBW (g)	2535.50^{b}	2553.33^{ab}	2566.67^{a}	2570.33^{a}	2557.00^{ab}	0.041
TWG (g)	1772.83^{ab}	1773.33^{ab}	1776.67^{a}	1787.00^{a}	1760.33^{b}	0.036
AWWG (g/wk)	443.21^{ab}	443.33^{ab}	444.17^{ab}	446.75^{a}	440.08^{b}	0.026
ADWG (g/d)	63.32^{b}	63.33^{b}	63.45^{ab}	63.82^{a}	62.87^{c}	0.047
TFI (g)	4073.33^{cd}	4298.83^{abc}	4302.00^{ab}	4136.25^{a}	3983.47^{d}	0.038
AWFI (g/wk)	1018.33^{cd}	1074.71^{abc}	1075.50^{ab}	1034.06^{a}	995.87^{d}	0.042
ADFI (g/d)	145.48^{cd}	153.53^{abc}	153.64^{ab}	147.72^{a}	142.27^{d}	0.011
FCR	2.30^{b}	2.42^{a}	2.42^{a}	2.31^{b}	2.26^{c}	0.034
Mortality, (%)	3.33^{b}	6.67^{a}	3.33^{b}	2.67^{c}	3.33^{b}	0.042

Table 3: *Growth performance of finisher (d 29 - 56) broiler chickens fed enzyme-sorghum diet.*

^{abcd} *= Means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

On overall growth (Table 4), there were increased (P = 0.032) average daily weight gains (0.72 - 1.41%) in birds fed sorghum with or without enzyme compared to those on maize diet. ADFI also increased by 2.61 - 5.23% in birds fed sorghum diet supplemented with up to 500 mg Axtra®XB but a 1.09% reduction was observed in those fed 750mg Axtra®XB. FCR was also poorer (P = 0.043) in broilers fed sorghum diet supplemented with 250 mg Axtra®XB but at 750 mg supplementation, a 1.82% improvement was recorded.

The present findings revealed significant improvement in broiler growth performance following dietary Axtra®XB supplementation in sorghum-soybean diet especially at 500 mg Axtra®XB/kg diet Xylanase and B-Glucanase targets the anti-nutrients found in the grain fibre thus improving digestion by releasing of nutrients, reducing digesta viscosity, reducing production of excessive secretion into the guts while improving litter quality and faecal consistency [7].

The addition of enzymes is known to breakdown NSPs surrounding the starch molecules especially those of β-glucans and pentosans [39] causing an increase in nutrient and energy availability [40].

The results are in line with the findings of Wang., *et al*. [14]; Avila-Ramos., *et al*. [33] and Saleh., *et al.* [27] who reported increased feed intake, weight gain and decreased size of gastrointestinal tract following enzyme supplementation into poultry diets. Data obtained for average daily weight gain and feed conversion were also consistent with the reports of Moftakharzadeh., *et al.* [42] that significant improvement occurs in broilers following xylanase-B-glucanase supplementation in a wheat-barley diet.

Parameters	Maize-Soybean	Sorghum-Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	P- value
IBW (g)	40.00	40.00	40.00	40.00	40.00	0.000
FBW (g)	2535.50^{b}	2553.33^{a}	2566.67^{a}	2570.33^{ab}	2557.00^{a}	0.041
TWG (g)	2495.50^{b}	2513.33^{ab}	2526.67^{a}	2530.33^{a}	2517.00^{ab}	0.037
AWWG (g/wk)	311.94^{b}	314.17^{ab}	315.83^{a}	316.29^{a}	314.63^{ab}	0.050
ADWG (g/d)	44.56^{b}	44.88^{ab}	45.12^{a}	45.19^{a}	44.95^{a}	0.032
TFI (g)	5499.50^{c}	5731.33^{a}	5787.50^{a}	5643.25^{b}	5439.64^{d}	0.035
AWFI (g/wk)	687.44^{bc}	716.42^{a}	723.44^{a}	705.41^{ab}	679.96^{c}	0.024
ADFI (g/d)	98.21^{b}	102.35^{a}	103.35^{a}	100.77^{ab}	97.14^{b}	0.041
FCR	2.20^{b}	2.28^{a}	2.29^{a}	2.23^{ab}	2.16^{c}	0.043
Mortality (%)	3.33^{b}	6.67^{a}	3.33^{b}	2.67^{c}	3.33^{b}	0.03

Table 4: *Growth performance of broilers fed sorghum-soybean based diets (days 1 - 56).*

^{abcd} *= Means with different superscript on the same row differ significantly (P < 0.05).*

SEM = Standard error of means.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

A 2.9 - 5.2% improvement in broilers feed conversion following 0.05 - 0.2 kg of Axtra®XB supplementation has been reported [7] which the present study agrees with at 250 - 750 mg Axtra®XB in broilers fed sorghum diet. Hossein and Afshan [30] had suggested that the xylanase in the enzyme blend significantly reduce the competition for nutrient utilization from microorganisms in the gut, thus enhancing the presence of available nutrients and subsequent improved performances observed. These results indicated that Axtra®XB enzyme significantly improved broiler performances fed diverse grain cereals thus increasing the flexibility of the feed resources available for sustainable poultry production. Contrary to this finding, other reports indicated that live body weight, feed conversion, feed intake and mortality were not significantly affected by dietary enzyme supplementations [40,43]. This present study agrees with the results of Khan., *et al.* [41] and Chalghoumi., *et al*. [37] who observed decreased mortality rate in broilers fed enzyme supplemented diets.

Carcass characteristics

Table 5 and 6 revealed that dietary Axtra®XB supplementation significantly (P < 0.05) influenced carcass characteristics in broiler chickens. Dressing percentage had increased by 0.59% in the carcass of birds fed sorghum with 500 mg Axtra®XB while an 8.69% decrease was noticed in those on 750 mg Axtra®XB diet. Breast yield was 6.65 - 8.00% larger in carcasses of birds on 250 - 500 mg but 2.49% smaller in those on 750 mg Axtra®XB diet. This results suggested that sorghum diet supplemented with 750 mg Axtra®XB could reduce the carcass yield of broiler chickens.

Compared to birds on maize diet, relative organ weights decreased (P < 0.05) in birds fed diet containing sorghum with or without XB enzyme. Full and empty gizzard weights were reduced to 35.03% (P = 0.016) and 39.91% (P = 0.013), respectively in birds fed 750 mg XB sorghum diet. Also, a 40.82% (P = 0.018) reduction in abdominal fat pad was observed in chickens fed 500 mg XB sorghum diet.

The present findings agree with those of Moftakharzadeh., *et al.* [42] that enzyme supplementation significantly reduced the gastrointestinal weights and lengths in broilers. Shakouri., *et al.* [13] noted that the addition of enzyme to the diet could lead to the utilization of undigested feed in the gut leading to faster intestinal motility and digestive excretions thus causing a decrease in the size of gastrointestinal tract and organs as observed in present findings. The increase in abdominal fat pad recorded at 750 mg Axtra®XB were similar to the

Parameters	Maize-Soybean	Sorghum Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
Live weight, g	2535.50^{b}	2553.33^{a}	2566.67^{a}	2570.33^{ab}	2557.00^{a}	0.041
Dressed weight, g	2181.54^{a}	2170.33^{ab}	2215.81^{a}	2224.63^{a}	2010.83^{b}	0.026
Dressing percentage, %	86.04^{a}	85.00^{ab}	86.33^{a}	86.55^{a}	78.64^{b}	0.041
Prime cuts (%DW)						
Back	16.08	15.95	15.97	15.91	15.76	0.062
Breast	22.12^{ab}	23.59^{a}	23.89^{a}	23.19^{a}	21.57^{b}	0.043
Drumstick	12.00^{a}	11.89^{a}	11.83^{b}	12.01^{a}	10.85^{b}	0.025
Thigh	13.35^{a}	13.26^{ab}	13.89^{a}	13.72^{a}	12.22^{b}	0.022
Wings	8.72	8.77	8.80	8.89	8.57	0.057
Neck	4.84^{ab}	5.13^{a}	5.44^{a}	5.38^{a}	4.43^{b}	0.041
Shank	4.40^{a}	3.99^{ab}	3.98^{ab}	4.61^{a}	3.23^{b}	0.045
Head	2.53^{a}	2.51^{a}	2.53^{a}	2.84^{a}	2.01^{b}	0.038

Table 5: *Prime cuts in broilers fed sorghum-XB diet.*

^{ab} *= Means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra® XB = Xylanase-B-glucanase enzyme.

Parameter, % LW	Maize-Soybean	Sorghum-Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
Heart	0.52^{ab}	0.54^{a}	0.41^{bc}	0.38^{c}	0.39^{c}	0.041
Liver	2.32^{a}	1.98^{abc}	1.82^{bc}	1.80^{bc}	1.70^{bc}	0.050
Full gizzard	2.94^{a}	2.04^{bc}	2.05^{bc}	2.22^{bc}	1.91^{c}	0.016
Empty gizzard	2.33^{a}	1.63^{bc}	1.68^{bc}	1.60^{bc}	1.40^{c}	0.013
Spleen	0.22^{a}	0.16^{abc}	0.15^{bc}	0.11^{c}	0.10^{c}	0.017
Lungs	0.40	0.46	0.44	0.51	0.38	0.025
Proventriculus	0.67^{a}	0.65^{ab}	0.54^{abc}	0.48^{c}	0.45^{c}	0.026
Pancreas	0.37^{a}	0.26^{ab}	0.23^{b}	0.21^{b}	0.18^{b}	0.031
Abdominal fat	2.67^{ab}	1.83^{b}	1.76^{b}	1.58^{b}	2.77^{a}	0.018
Oesophagus	0.20^{a}	0.16^{ab}	0.13^{b}	0.15^{ab}	0.15^{ab}	0.021
Crop	0.29^{bc}	0.27^{bc}	0.26^{c}	0.55^{a}	0.40^{ab}	0.037
Gall bladder	0.18	0.17	0.19	0.15	0.17	0.01
Trachea	0.17	0.16	0.16	0.11	0.11	0.01

Table 6: *Relative organ weights of broilers fed the dietary treatments.*

^{abc} *= Means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra® XB = Xylanase-B-glucanase Enzymes.

findings of Moftakharzadeh., *et al.* [42] also noted that the increase was probably due to enhanced nutrient availability and energy in the diet as observed in the feed conversion but with lowered dressing percentage.

Breast yield was improved up to 500 mg Axtra®XB compared to value for birds fed maize-soybean diet contrary to the report of Hussein., *et al.* [40] who observed that carcass yield and abdominal fat pad were not influence by enzyme supplementation. Differences in results could be as a result of diet and enzyme used.

Gastro-intestinal morphology

The result of the gastrointestinal morphology of broilers fed Axtra®XB supplemented sorghum diet is presented in table 7. Total GIT Length (including length of the duodenal, jejunum and ceaca) decreased (P = 0.027) in chickens fed Axtra®XB-Sorghum diet. Gastro-intestinal pH (except for Duodenum pH) did not differ (P > 0.05) between dietary treatments. Moftakharzadeh., *et al.* [42] earlier reported no effect of enzyme supplementation on intestinal pH which the present study agrees with indicating that dietary treatment does not alter the acidity nor alkalinity of intestinal digesta therefore not inhibiting gut microbiota required for effective intestinal digestion.

Parameter	Maize-Soybean	Sorghum-Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
Intestinal weight (g)						
Total GIT	101.79^{b}	130.92^{a}	102.56^{b}	106.24^{b}	103.92^{b}	0.042
Duodenum	11.39^{a}	11.70^{a}	10.62^{ab}	9.79^{ab}	9.01^{b}	0.028
Jejunum	15.71^{a}	15.37^{a}	10.85^{c}	14.42^{b}	14.24^{b}	0.045
Ileum	56.50^{c}	85.34^{a}	64.71^{b}	64.21^{b}	62.73^{b}	0.034
Caecum	18.19^{a}	18.51^{a}	16.38^{b}	18.20^{a}	17.94^{b}	0.048
Intestinal length (cm)						
Total Intestinal length	228.80^{ab}	223.80^{ab}	227.20^{a}	221.60^{ab}	210.20^{b}	0.027
Duodenum	19.00^{a}	16.20^{b}	18.60^{ab}	18.60^{a}	14.80^{b}	0.029
Jejunum	29.20^{a}	27.60^{ab}	29.60^{a}	27.00^{ab}	24.40^{b}	0.049
Ileum	156.40	155.00	153.40	152.00	148.00	0.062
Caecum	24.20^{ab}	25.00^{a}	25.60^{a}	24.00^{ab}	23.00^{b}	0.048
Crop pH	5.00	5.40	5.00	5.40	5.40	0.100
Gizzard pH	4.20	4.60	4.80	4.40	5.20	0.150
Proventriculus pH	5.00	5.00	5.40	5.20	5.20	0.070
Duodenum pH	5.40^{a}	5.20^{b}	5.20^{b}	5.20^{b}	5.20^{b}	0.047
Jejunum pH	6.00	5.60	5.60	5.40	5.20	0.100
Ileum pH	5.40	6.20	6.40	6.20	6.40	0.140
Caeca pH	6.4	6.40	7.00	5.80	6.80	0.140

Table 7: *Effect of dietary treatments on the gastrointestinal tract morphometry.*

^{abc} *= means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant level.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

Haematological indices

Table 8 shows that there were significant (P < 0.05) variations haematological profile of birds fed different dietary treatments. Similar haematological values were obtained between birds on maize and Sorghum diets, implying that inclusion of sorghum into broiler chicken diet has no adverse effects on their blood profile and does compromise their health status.

Parameter	Maize-Soybean	Sorghum -Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
White Blood Cells- WBC (x10^{3}N/L)	241.30^a	242.40^a	245.90^a	240.00^a	230.70^h	0.025
Red Blood Cells - RBC (x10^{3}N/L)	2.15^{ab}	2.25b^{ab}	2.47^a	2.22^{ab}	1.98^b	0.042
Haemoglobin- Hb (g/dl)	9.50^{ab}	9.60^{ab}	10.00^a	9.10^{ab}	8.80^b	0.021
Pack cell volume - PCV (%)	30.10^{bc}	30.80^b	33.20^a	30.10^{bc}	29.20^c	0.038
Mean Corpuscular Volume - MCV (fl)	135.60^b	136.90^b	134.40^b	135.60^b	147.50^a	0.040
Mean Corpuscular Haemoglobin- MCH (pg)	42.80^b	42.70^b	40.50^c	41.00^{bc}	44.40^a	0.026
Mean Corpuscular Haemoglobin concentration- MCHC (g/d)	31.60^a	31.20^a	30.10^b	30.20^b	30.10^b	0.042
Platelet (x10^{3}N/L)	0.00^d	2.00^b	1.00^c	0.00^d	4.00^a	0.012
Neutrophils (%)	46.00^b	26.00^d	38.00^c	31.00^{cd}	60.00^a	0.018
Lymphocytes (%)	42.00^c	70.00^a	56.00^b	58.00^b	0.00^d	0.003
Eosinophils (%)	8.00^a	4.00^b	4.00^b	7.00^a	0.00^c	0.006
Mesophils (%)	4.00^a	0.00^c	2.00^b	4.00^a	0.00^c	0.003
Basophils (%)	0.00	0.00	0.00	0.00	0.00	0.000

Table 8: *Hematological indices of broiler chickens fed sorghum-soybean-based diets.*

^{abc} *= means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

WBC, RBC and Hb concentrations appeared to decrease at increasing level of Axtra®XB supplementation. These reductions in the values of WBC, PCV and Hb and higher differential counts could imply adverse immune response to 750 mg Axtra®XB diet causing decreased red blood cell production due to the presence of anti-nutrients and consequent sub-clinical mild bacterial infections or allergic conditions in the birds.

The values for all the haematological parameters measured were within the normal ranges reported [44] for broiler chickens. These results indicated that despite the variation in haematological values observed probably due to sub-clinic infections, all birds were healthy without any clinic symptoms of anaemia, dehydration, allergic conditions or bacterial infections. Maize thus did not have any superiority over sorghum on the health status of broilers and enzyme supplementations especially at 500 mg Axtra®XB provided additional immunity for the birds.

Litter quality

Table 9 indicated that dietary Axtra®XB supplementation improved (P = 0.034) litter quality in broiler pens. At d 10, there was no differences (P = 0.016) in the litter quality score between dietary treatments. Increasing Axtra®XB in broiler diet was observed to improve (P < 0.05) litter quality compared to those on the maize-soybean or sorghum- soybean without enzyme diets. All through the growth period,

similar litter quality scores were recorded in the pen of broilers fed maize or sorghum based diets without enzyme supplementation. Litter quality tends to become poorer at advanced ages due to increased humidity in the pen and heat generated from the chickens and their droppings [37]. Yang., *et al*. and Moftakharzadeh., *et al.* [42] had earlier observed an improvement in litter quality score and decrease fresh faecal output [26] in broiler fed enzyme blends, which the present result agrees with but contradicts the report of Chalghoumi., *et al*. [37] who reported non-significant effect. Pasquali., *et al*. [45,46] also reported reduced litter moisture in birds fed sorghum-based diets at 35 - 42d post hatch. The broiler strain, enzyme, age of birds, weather condition and type of feed could affect the results obtained. A good litter quality tends to reduce ammonia build up in the pen, the incidence of hock bums and breast blisters, thereby improving the carcass quality of broiler chickens and reducing the risk of coccidian infections [37].

Day	Maize-Soybean	Sorghum -Soybean (SS)	SS + XB 250 mg/kg	SS + XB 500 mg/kg	SS + XB 750 mg/kg	p-value
10	1.68	1.68	1.68	1.66	1.66	0.160
21	2.20^{a}	2.20^{a}	1.91^{ab}	1.88^{ab}	1.83^{b}	0.034
39	3.07^{a}	3.09^{a}	2.95^{ab}	2.93^{ab}	2.87^{b}	0.024
56	3.70^{a}	3.70^{a}	3.63^{ab}	3.58^{b}	3.56^{b}	0.032

Table 9: *Litter quality score of broiler chickens fed enzyme-sorghum diet.*

^{ab} *= Means with different superscript on the same row differ significantly (P < 0.05).*

p-value = Significant value.

SS = Sorghum-soybean base diet.

Axtra®XB = Xylanase-B-glucanase enzymes.

Conclusion

This study concludes that sorghum can comfortably replace maize in broiler diets at the starter, finisher and overall production periods. Dietary supplementation with up to 500 mg Axtra®XB/kg of sorghum-soybean diet improved broiler performances.

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Conflict of Interest

The authors state that there is no conflict of interest that could be noted as bias to the results of the research reported.

Bibliography

1. Amerah AM. "Interactions between wheat characteristics and feed enzymes supplementation in broiler diets". *Animal Feed Science Technology* 199 (2015): 1-9.
2. Das AK., *et al*. "Comparative study of various enzyme solutions on nutrient utilization with feed cost optimization in broilers". *Poultry Punch* (2019).
3. Gangaiah B. "Kharif Crops". New Delhi, NISCAIR (CSIR) (2007).
4. Makinde OJ., *et al*. "Growth performance and carcass characteristics of finisher broilers fed rice offal based diets supplemented with exogenous enzyme". *Greener Journal of Agricultural Sciences* 4.4 (2014): 144-149.
5. Kennedy OOO., *et al*. "Effects of turmeric rhizome powder on growth, carcass and meat quality of Japanese quails fed sorghum-soybean-based diets". *Journal of Livestock Science* 11(2020): 1-7.

6. Liu SY., *et al*. "Comparative performance of broiler chickens offered ten equivalent diets based on three grain sorghum varieties as determined by response surface mixture design". *Animal Feed Science and Technology* 218 (2016): 70-83.

7. Amerah AM. "Getting more from mixed grain diets". *International Poultry Production* 9.6 (2011).

8. Truong HH., *et al*. "Performance of broiler chickens offered nutritionally-equivalent diets based on two red grain sorghums with quantified kafirin concentrations as intact pellets or re-ground mash following steam-pelleting at 65 or 97°C conditioning temperatures". *Animal Nutrition* 1 (2015): 220-228.

9. Ravindran V., *et al*. "Influence of β-glucanase supplementation on the metabolisable energy and ileal nutrient digestibility of normal starch and waxy barleys for broiler chickens". *Animal Feed Science and Technology* 134.1 (2007): 45-55.

10. Moftakharzadeh SA., *et al*. "Influence of nutrient matrix values application for exogenous enzymes and feeding wheat/barley on performance, gastrointestinal characteristics, viscosity of jejunal digesta, litter moisture and water consumption of broilers". *Livestock Research for Rural Development* 30.2 (2018): 21.

11. Alagawany M., *et al*. "The role of exogenous enzymes in promoting growth and improving nutrient digestibility in poultry". *Iranian Journal of Veterinary Research* 19.3 (2018): 157-164.

12. Khattak FM., *et al*. "Enzymes in poultry production". *Journal of Animal and Applied Science* 16.1-2(2006): 1-7.

13. Shakouri MD., *et al*. "Intestinal function and gut microflora of broiler chickens as influenced by cereal grains and microbial enzyme supplementation". *Journal of Animal Physiology and Nutrition* 93 (2009): 647-658.

14. Wang Z., *et al*. "Effects of enzyme supplementation on performance nutrient digestibility gastrointestinal morphology and volatile fatty acid profiles in the hindgut of broilers fed wheat-based diets". *Poultry Science* 84.6 (2005): 875-881.

15. Scheideler SE., *et al*. "Multiple-enzyme (Avizyme) supplementation of corn-soybased layer diets". *Journal of Applied Poultry Research* 1 (2005): 77-86.

16. Sharifi SD., *et al*. "Effects of inclusion of hull-less barley and enzymes supplementation of broiler diets on growth performance, nutrient digestion and dietary metabolisable energy content". *Journal of Central European Agriculture* 13(2012): 193-207.

17. Ahmed I., *et al*. "Effect of different enzyme complex at different wheat-based diets on growth performance of broilers". *Journal of Entomology and Zoology Studies* 5.3 (2017): 525-531.

18. Hartini S and P Purwaningsih. "Effects of adding non-soluble starch polysaccharides and exogenous enzymes to a commercial broiler diets on the growth performance and carcass weight of broiler chickens". *Pakistan Journal of Nutrition* 16.4 (2017): 227-235.

19. Kocher A., *et al*. "Effects of enzyme combinations on apparent metabolizable energy of corn-soybean meal-based diets in broilers". *Journal of Applied Poultry Research* 12 (2003): 275-283.

20. Raza S., *et al.* "Effect of enzyme supplementation of broiler diets containing varying level of sunflower meal and crude fiber". *Pakistan Journal of Botany* 41 (2016): 2543-2550.

21. Kalantar M., *et al*. "Different dietary source of non-starch polysaccharides supplemented with enzymes affected growth and carcass traits, blood parameters and gut physicochemical properties of broilers". *Global Journal of Animal Scientific Research* 3 (2015): 412-418.

22. Zamani HU., *et al*. "Effects of feeding palm kernel cake with crude enzyme supplementation on growth performance and meat quality of broiler chicken". *International Journal of Microbiology and Biotechnology* 2 (2017): 22-28.

23. Alagawany M *et al*. "The effectiveness of dietary sunflower meal and exogenous enzyme on growth, digestive enzymes, carcass traits, and blood chemistry of broilers". *Environmental Science and Pollution Research International* 24.13 (2017): 12319-12327.

24. Zhou Y., *et al*. "Improved energy-utilizing efficiency by enzyme preparation supplement in broiler diets with different metabolizable energy levels". *Poultry Science* 88.2 (2009): 316-322.

25. Ahmad Z., *et al*. "Effect of oral application of xylanase on some hematological and serum biochemical parameters in broilers". *Pakistan Veterinary Journal* 33.3 (2013): 388-390.

26. Tang D., *et al*. "Effects of maize source and complex enzymes on performance and nutrient utilization of broilers". *Asian-Australasian Journal of Animal Sciences* 27.12 (2014): 1755-1762.

27. Saleh AA., *et al*. "Effects of Dietary Xylanase and Arabinofuranosidase Combination on the Growth Performance, Lipid Peroxidation, Blood Constituents, and Immune Response of Broilers Fed Low-Energy Diets". *Animals* 9 (2019): 467.

28. Nikam MG., *et al*. "Effect of dietary supplementation of non-starch polysaccharides hydrolyzing enzymes on performance of broilers reared on sub-optimal diets". *Asian Journal of Science and Technology* 7 (2016): 3223-3226.

29. Sherif K. "Performance of broiler chicks fed plant protein diets supplemented with commercial enzymes". *Journal of Agricultural Science Mansoura University* 34 (2009): 2819-2834.

30. Hosseini SM and M Afshar. "Effects of feed form and xylanase supplementation on performance and ileal nutrients digestibility of heat-stressed broilers fed wheat-soybean diet". *Journal of Applied Poultry Research* 45.1 (2017): 550-556.

31. Yuan L., *et al*. "Effects of protease and non-starch polysaccharide enzyme on performance, digestive function, activity and gene expression of endogenous enzyme of broilers". *PLoS One* 12 (2017): e0173941.

32. Bhuiyan AKFH., *et al*. "Indigenous chicken genetic resources in Bangladesh: Current status and future outlook". *Animal Genetic Resources Information* 36 (2005): 73-84.

33. Avila-Ramos F., *et al*. "Effects of dietary oregano essential oil and vitamin E on the lipid oxidation stability of cooked chicken breast meat". *Poultry Science* 91 (2012): 505-511.

34. Google Earth. Geo Names, Geographical database. Travelling hick for Calabar, Cross River State, Nigeria. Time Zone, Latitude, Longitude, elevation and map/ Satellite image (2020).

35. NRC. "The Nutrient Requirements of Poultry". 9th Revised Edition. National Research Council. Washington, D.C., National Academy Press (1994).

36. Benerjee GC. Animal Blood. In: A textbook of animal husbandry, Benerjee, G. C, (Edition.), 8th Edition. New Delhi, Oxford and IBH Co. PVT LTD (2016): 134.

37. Chalghoumi R., *et al*. "Commercial dietary enzyme products in broiler chicken fed reduced energy diets based on corn and soybean meal". *Large Animal Review* 26 (2020): 31-37.

38. GENSTAT. GENSTAT statistical package. 15th Edition (2012).

39. Ravn JL., *et al*. "A commercial GH 11 xylanase mediates xylan solubilisation and degradation in wheat rye and barley as demonstrated by microscopy techniques and wet chemistry methods". *Animal Feed Science and Technology* 219 (2016): 216-225.

40. Hussein EOS., *et al*. "Effect of a low-energy and enzyme-supplemented diet on broiler chicken growth, carcass traits and meat quality". *Archives of Animal Breeding* 62 (2019): 297-304.

41. Khan, SH., *et al*. "Influence of enzymes on performance of broilers fed sunflower-corn based diets". *Pakistan Veterinary Journal* 26 (2006): 109-114.

42. Moftakharzadeh SA., *et al*. "Effect of using the Matrix Values for NSP-degrading enzymes on performance water intake litter moisture and jejunal digesta viscosity of broilers fed barley-based diet". *Acta Scientiarum Animal Sciences* 39.1 (2017): 65-72.

43. Sayyazadeh H., *et al*. "Influence of enzyme supplementation of maize, wheat and barley-based diets on the performance of broiler chickens". *Pakistan Journal of Biological Sciences* 9 (2006): 616-621.

44. Kwari ID., *et al*. "Growth, hematology and serology of broiler chickens fed different cultivars of sorghum as replacement for maize in the semi-arid zone of Nigeria". *International Journal of Poultry Science* 10.8 (2011): 608-612.

45. Pasquali GAM., *et al*. "Maize replacement with sorghum and a combination of protease, xylanase, and phytase on performance, nutrient utilization, litter moisture, and digestive organ size in broiler chicken". *Canadian Journal of Animal Science* 97 (2017): 328-337.

46. Kocher A., *et al*. "A Dual-Enzyme Product Containing Protease in Broiler Diet: Efficacy and Tolerance". *Journal of Applied Animal Nutrition* 3 (2015): 6.

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