British Journal of Multidisciplinary and Advanced Studies:
Agriculture, 4(5),33-48, 2023
Print ISSN: 2517-276X
Online ISSN: 2517-2778
Website: https://bjmas.org/index.php/bjmas/index
Published by European Centre for Research Training and Development-UK

Performance and Internal Organ Characteristics of Broiler Chickens Fed Red Sorghum (*Sorghum bicolor* L. (Moench)) Based Diets Supplemented with Complex Enzyme (Kingzyme®)

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doi: https://doi.org/10.37745/bjmas.2022.0304 Published September 23, 2023

Gworgwor, Z. A., Edeh, I. E., Yusuf, H. B. and Soji, W. M. (2023) Performance and Internal Organ Characteristics of Broiler Chickens Fed Red Sorghum (Sorghum bicolor L. (Moench)) Based Diets Supplemented with Complex Enzyme (Kingzyme®), *British Journal of Multidisciplinary and Advanced Studies*: Agriculture, 4(5),33-48

ABSTRACT: *The study was designed to study the effect of complex enzyme (Kingzyme®) on performance and carcass yield of broiler chickens fed red sorghum-based diets. Two hundred (200) chicks (day-old) of mixed sex was randomly allotted to five dietary treatments (T_1, T_2, T_3, T_4 and T_5) supplemented with enzyme complex (Kingzyme®) at the levels of 0.0g, 0.2g, 0.5g, 0.8g and 1.1g kg per Kg of feed respectively in a Completely Randomized Design (CRD). Each treatment was replicated four (4) times to contain ten (10) birds each. Feed and water were provided ad libitum accompanied with standard management procedures for eight weeks. At end of the experiments, eight (8) birds whose body weights are closest to the mean of the group was randomly selected from each treatment (two (2) per replicate) and was fasted overnight to reduce the gut contents and carcass contamination. The birds for each replicate was weighed to determine the live body weight, followed by slaughtering, bleeding, bled weight determination, scalding and wet plucking. The plucked weight was determined followed by evisceration, dressed weight and weighing of internal organs. The weight of the internal organs and length of small, large intestines and caecum was determined. The weights of the internal organ were expressed as the percentage of the dressed weight. Data were analyzed using Statitix Analytical Software, Version 10; and the treatment means were compared using Turkey HSD. There was no significant ($P < 0.05$) difference across the treatment groups for feed intake and growth performance at both starter and finisher phases respectively. Similarly, carcass characteristics showed no significant ($P < 0.05$) difference across the dietary treatments. Lungs, gizzard and proventriculus was significantly ($P < 0.05$) affected across the dietary treatments. Based on the result of the study, it was concluded that Red Sorghum-based diet supplemented with enzyme complex (Kingzyme®) do not have any significant effect on feed intake and growth performance of broiler chickens but can change some internal organs weights especially the lungs, gizzards and proventriculus.*
KEYWORDS: Broiler chickens, feed intakes, growth performance, Internal organs weights.

INTRODUCTION

Third world countries are confronted with surge in population with consequential effects of unemployment and increased demand for food especially that of animal protein sources, and Nigeria is of no exception to these factors. These consequential effects can be reduced by developing and exploring the economic potentials of poultry industry. Feed have been known with the greatest expense in poultry production especially in the intensive system; accounting up to 60 to 70% of total production cost in developing countries, compared to about 50 to 60% in developed countries. High demand pressure on conventional feed ingredients particularly energy and protein (conventionally sourced almost exclusively from maize and soybean) which are the bulk portion of poultry feed in terms of quantity and cost has resulted to competition and short supply in terms of food and feed for human and animal populations respectively; increase in price of animal protein sources, and short supply of maize which forms bulk of energy in poultry feeds (Onu and Madubuike, 2007). Alternative cereal grain that can partly or completely replace maize in poultry feed industry can be a possible solution. This could be achieved by gradually shifting the demand pressure on maize to other less utilized cereal crops like Sorghum. Sorghum is second largest produced and abundant cereal grain after maize; fifth most widely grown cereal crop on global scale after rice, wheat and barley. Fifty-three percent (53%) of the world’s sorghum production area is located in Sub-Saharan Africa where it covers the second largest cultivated land area after maize. Nigeria (12.6%), India (11.2%), Mexico (11.2%), and the United States (10.0%) were leading producers in 2011. In 2019, United States ranked highest producer with (8,673,000) followed by Nigeria (6,900,000); Ethiopia (5,200,000); Mexico (4,500,000); India (4,400,000); Sudan (4,000,000) and China (3,600,000) metric tons (USDA, 2019). In terms of nutritive value, cost and availability, sorghum grain is the next alternative to maize in poultry feed.

Sorghum is considered the major source of energy for poultry feeds in some Asian and most African countries, due to its high energy content. Rolled sorghum is a common practice in poultry feed formulation, although whole grain feeding is well known in rural areas (Liu *et al*., 2015). Sorghum is least utilized as major energy source in poultry feed industry in Nigeria. The limitation to use especially in poultry nutrition is due to its low starch and protein digestibility and tannin profile compared to maize. Sorghum grain can be an alternative energy source for poultry feed provided the factors limiting its digestibility is reduced or completely removed via processing and/or the use of additives (Khoddami *et al*., 2015). Sorghum contains unique structure of protein which compromises nitrogen and energy utilization by physical and chemical interactions but this could be addressed by combined or individual action of exogenous enzymes addition in broilers diets and swine. In vivo studies using pepsin and in vitro studies show that the proteins of wet cooked sorghum are significantly less digestible than the proteins of other similarly cooked cereals (Pan *et al*., 2017). This is an implication that wet cooking may hamper the digestibility of Sorghum grain.

Nutritional constraint to the use of Sorghum is the poor digestibility of its protein and starch on cooking; and this is not fully dependent on the polyphenol content. Pericarp components, gem, endosperm, cell walls, and gelatinized starch have been reported as possible factors limiting protein digestibility. During hydrothermal food processing, extensive cross-linking is formed between sorghum protein (kafirin) and starch, and the cross-linking is mainly composed of the strong disulfide bonds that are resistant to digestion. Protein-body-enriched cooked sorghum has been reported to have more than 45-50 kDa oligomers in addition to β- and γ-kafirin some of which are resistant to reduction. Cooking appears to lead to formation of disulphide-bonded oligomeric proteins that occurs to a greater extent in sorghum than in maize. Treating cooked sorghum and maize whole grain and endosperm flours with alpha-amylase to reduce sample complexity before in vitro pepsin digestion has been reported to slightly improved protein digestibility. However, treating cooked sorghum and maize samples with alpha-amylase prior to incubation with pepsin has also been reportedly led to an improvement in in-vitro protein digestibility (Duodu *et al.,* 2003).

Hydrophobic nature of kafirins (the main protein in sorghum) has also been a contributing factor to its low protein digestibility of cooked sorghum compared to cooked maize and wheat. In-vitro protein digestibility of decorticated sorghum flour cooked with heat-stable alpha-amylase has been reported to be approximately the same with that cooked without alpha-amylase. Addition of β-glucanase/pentosanase enzyme complex in poultry diets by 0.2 and 0.4 g/kg feed improved feed efficiency (Oria *et al*., 1995b). Enzyme complex could improve digestibility of sorghum (Jigare) without cooking. Limited information on the use of enzyme treated sorghum in poultry nutrition calls for possible way(s) of application of Sorghum in poultry nutrition. Exogenous enzymes - cellulase, β-glucanases, xylanases and associated enzymes, phytases, proteases, lipases, and galactosidases - have been used in the feed industry in poultry diets to neutralize the effects of viscous, non-starch polysaccharides in cereals such as barley, wheat, rye, and triticale (Pan *et al*., 2017). The application of enzymes in poultry diets has been reported by many authors in various cereal based diets with little reference to Sorghum grains. The current study therefore focuses on Performance and Internal Organ Characteristics of Broiler Chickens Fed Red Sorghum (*Sorghum bicolor* L. (Moench)) Based Diets Supplemented with Complex Enzyme (Kingzyme®)

MATERIALS AND METHODS

Study Location

The study was conducted at the Poultry Unit of Teaching and Research Farm of the Department of Animal Science and Range Management, Modibbo Adama University of Technology, Yola, Adamawa State. Yola is located in the North-Eastern part of Nigeria. It is situated within the Savannah region and lies between Latitude 7° 11' North and Longitude 11° 14' East at an elevation of 364m above sea level. The mean relative humidity ranges from 30 - 50%; and reaches minimum in February to March when it drops to as low as 10% and a maximum of about 90% in August. The maximum temperature can reach 38^{o}C particularly in April, while minimum temperature can be as low as 18°C (Adebayo, 2020). The Enzyme Complex (Kingzyme®) was purchased from Jos, Plataeu State, Nigeria. It is composed of Endo-1, 4-β-Xylanase, Endo-1, 3(4)-β-Glucanase, Endo-1, 4-β-Mannanase, Pectinase, Amylase and Cellulase at recommended inclusion level of 200g/ton of feed for broilers, layers and swine. It has a storage specification of 4 – 25°C in cool, dry and shady environments.

Experimental Animals, Design, Management and Feed Formulation

Two hundred (200) day-old chicks of mixed sex was purchased from Fidan Investment Ltd., Ibadan, Oyo State, Nigeria. They were randomly assigned to five treatment groups comprising 40 birds each. Each treatment was replicated four (4) times to contain ten (10) birds each in a Completely Randomized Design (CRD). The birds were raised in a deep litter system with a 2.16m by 1.4m by 2.2m (Length, breath and height) pen size. Standard management procedures were followed throughout the period of the experiment. Five experimental diets were formulated using red sorghum as the principal energy source. The red sorghum was purchased from Girei market, Girei Local Government area of Adamawa State, Nigeria. The treatment diets contained 0.0g, 0.2g, 0.5g, 0.8g and 1.1g of enzyme complex per kg of feed to represent treatment - T_1 (control), T_2, T_3, T_4 and T_5 –groups.

Table 1: Ingredients, Percentage Composition and Calculated Analysis of Broiler Starter Diet

	Treatments and inclusion levels				
Ingredients	**T_1 (0.0g/kg)**	**T_2 (0.2g/kg)**	**T_3 (0.5g/kg)**	**T_4 (0.8g/kg)**	**T_5 (1.1g/kg)**
Sorghum	56.60	56.60	56.65	56.72	56.71
GNC	33.32	33.30	33.30	33.20	33.10
Fish meal	1.00	1.00	1.00	1.00	1.00
Maize Offal	4.08	4.08	4.00	4.00	4.08
Kingzyme®	0.00	0.02	0.05	0.08	0.11
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00
Palm Oil	1.00	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
			Calculated analysis		
Crude Protein	22.01	22.01	22.00	21.96	21.91
Calcium	1.18	1.18	1.18	1.18	1.18
Phosphorus	0.75	0.75	0.74	0.74	0.74
Lysine	1.38	1.38	1.38	1.38	1.37
Methionine	0.58	0.58	0.58	0.58	0.58
Cysteine	0.27	0.27	0.27	0.27	0.27
ME (Kcal/kg)	2,964.04	2,963.25	2,961.92	2,959.28	2,956.64

GNC: Groundnut Cake; *To provide per kg of feed: Vitamin A: 8,500,000 IU; Vitamin D3 1,500,000 IU; Vitamin E 10,000mg; Vitamin K3 1,500mg; Vitamin B1 1,600mg; Vitamin B2 4,000mg; Niacin 20,000mg; Pantothenic Acid 5,000mg; Vitamin B6 1,500mg; Vitamin B12 10.0 mg; Folic Acid 500mg; Biotin H2 750mg; Choline Chloride 175,000mg; Cobalt 200mg; Copper 3,000mg; Iodine 1,000mg; Iron 20,000mg; Manganese 40,000mg; Selenium

200mg; Zinc 30,000mg; Antioxidant 1,250mg at inclusion rate 2.5kg Per Ton of Feed. Kingzyme®: Xylanase, Beta-Glucanase, Mannanase, and Cellulase enzymes blend

Table 2: Ingredients, Percentage Composition and Calculated Analysis of Broiler Finisher Diet

	Treatments and inclusion levels				
Ingredients	**T_1 (0.0g/kg)**	**T_2 (0.2g/kg)**	**T_3 (0.5g/kg)**	**T_4 (0.8g/kg)**	**T_5 (1.1g/kg)**
Sorghum	56.50	56.50	56.50	56.50	56.50
GNC	33.50	33.48	33.45	33.42	33.39
Maize Offal	5.00	5.00	5.00	5.00	5.00
Kingzyme®	0.00	0.02	0.05	0.08	0.11
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00
Palm Oil	1.00	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
			Calculated analysis		
Crude Protein	21.84	21.83	21.82	21.80	21.79
Calcium	1.15	1.15	1.15	1.15	1.15
Phosphorus	0.72	0.72	0.72	0.72	0.72
Lysine	1.35	1.35	1.35	1.35	1.35
Methionine	0.57	0.57	0.57	0.57	0.57
Cysteine	0.27	0.27	0.27	0.27	0.27
ME (Kcal/kg)	2,961.40	2,960.87	2,960.08	2,959.29	2,958.50

GNC: Groundnut Cake; *To provide per kg of feed: Vitamin A: 8,500,000 IU; Vitamin D3 1,500,000 IU; Vitamin E 10,000mg; Vitamin K3 1,500mg; Vitamin B1 1,600mg; Vitamin B2 4,000mg; Niacin 20,000mg; Pantothenic Acid 5,000mg; Vitamin B6 1,500mg; Vitamin B12 10.0 mg; Folic Acid 500mg; Biotin H2 750mg; Choline Chloride 175,000mg; Cobalt 200mg; Copper 3,000mg; Iodine 1,000mg; Iron 20,000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg; Antioxidant 1,250mg at inclusion rate 2.5kg Per Ton of Feed. Kingzyme®: Xylanase, Beta-Glucanase, Mannanase, and Cellulase enzymes blend

Measurements

The parameters measured were: initial weight, final weight, total weight, average daily weight, total feed intake, feed conversion ratio and percentage mortality; and were calculated by the formula below:

$$\text{Total weight gain (g)} = \text{Final Weight} - \text{Initial Weight}$$

$$\text{Average daily weight gain (g)} = \frac{\text{Total Weight Gain}}{\text{Number of Days}}$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed Intake per bird}}{\text{Weight Gain per bird}}$$

$$\text{\% Mortality} = \frac{\text{Number of death recorded}}{\text{Number of birds}} \times \frac{100}{1}$$

Statistical Analysis

The data collected was analyzed using Statitix Analytical Software, Version 10; and the treatment means were compared using Turkey HSD procedure as described by (Tukey, 1949).

Proximate Analysis

Proximate analysis for moisture, dry matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), Ash and Nitrogen Free Extract (NFE) were determined according to the methods described in AOAC (2010)

Carcass and internal organ evaluation

Eight (8) birds whose body weights are closest to the mean of the group was randomly selected from each treatment (two (2) per replicate) and was fasted overnight to reduce the gut contents and carcass contamination. The birds for each replicate was weighed to determine the live body weight, followed by slaughtering, bleeding, bled weight determination, scalding and wet plucking. The plucked weight was determined followed by evisceration, dressed weight and weighing of internal organs. The weight of the internal organs and length of small, large intestines and caecum was determined. The weights of the internal organ were expressed as the percentage of the dressed weight. The Dressing out percentage (DOP) was calculated using the formula:

$$\text{DOP} = \frac{\text{Carcas Weight}}{\text{Live Weight}} \times \frac{100}{1}$$

$$\text{Internal Organ Weight (\%)} = \frac{\text{Organ Weight (g)}}{\text{Dresses Weight (g)}} \times \frac{100}{1}$$

RESULTS

Proximate Analysis of Raw Red Sorghum Grain

The proximate profile of raw red sorghum grain is presented in Table 3. The result showed that the dry grain contained Moisture (7.5%); Dry matter (92.5%); Crude Protein (13.1%); Crude Fiber (2.5%); Ether Extract (4.0%); Ash (0.5%) and Nitrogen Free Extract (79.9%).

Feed Intake and Growth Performance of Broiler Chickens at Starter Stage (1 - 4 Weeks)

The effect of dietary treatments on feed intake and growth performance at 28 days of age are presented in Table 7. The result shows that the enzyme inclusion had no significant (P > 0.05) effect at 28 days of age. The highest final weight (667.02g) was observed in broiler chickens fed diet treated with highest enzyme blend inclusion (1.10g/kg) level. Broiler chickens fed diet containing 0.2g/kg enzyme blend showed higher total weight gain (599.72g). The highest Average Daily Weight Gain (ADWG) (22.22g) was recorded in birds on diet treated with 1.10g/kg of enzyme blends with lowest (19.91g) at 0.8g/kg enzyme blend inclusion. The total feed intake (2212.10g) of birds on diet with 0.8g/kg of enzyme blend was higher compared to the rest group. Enzyme inclusion improved final weight against the control except at inclusion level of 0.8g/kg with lower final weight (602.66g). Similar pattern was observed for total weight and average daily weight gain. Enzyme inclusion improved the total feed intake across the treatments. Feed conversion ratio (FCR) at starter phase range from 3.50 - 4.10. Birds on diet supplemented with 1.10g/kg of enzyme bled had a better FCR (3.50). There was 5% and 2.5% mortality for birds on control and diet supplemented with 0.2g/kg enzyme blend.

Table 3: Proximate analysis of Raw Red Sorghum Grain

Proximate	Moisture	DM	CP	CF	EE	Ash	NFE
Composition (%)	7.5	92.5	13.1	2.5	4.0	0.5	79.9

Table 4. Feed Intake and Growth Performance of Broiler Chickens Fed Red Sorghum Diets Supplemented with Enzyme Complex at Starter Stage (1 - 4 Weeks)

	Dietary Treatments					
Parameters	**T_1(0.0g/kg)**	**T_2(0.2g/kg)**	**T_3(0.5g/kg)**	**T_4(0.8g/kg)**	**T_5(1.10g/kg)**	**SEM**
Initial weight (g)	44.39	46.25	47.11	45.28	44.78	1.32^{ns}
Final weight (g)	637.72	645.97	642.75	602.66	667.02	34.27^{ns}
Total weight (g)	593.33	599.72	595.64	557.39	622.24	33.89^{ns}
ADWG (g)	21.19	21.42	21.27	19.91	22.22	1.21^{ns}
Total feed intake (g)	2165.50	2180.70	2191.2	2212.10	2199.70	25.22^{ns}
FCR	3.70	3.60	3.70	4.10	3.50	0.23^{ns}
% Mortality	5.00	2.50	0.00	0.00	0.00	1.70^{ns}

ADWG: Average daily weight gain; FCR: Feed conversion ratio, ns: not significant (P>0.05)

Print ISSN: 2517-276X

Online ISSN: 2517-2778

Website: https://bjmas.org/index.php/bjmas/index

Published by European Centre for Research Training and Development-UK

Feed Intake and Growth Performance of Broiler Chickens at Finisher Stage (5 - 8 Weeks)
The effect of investigated dietary treatments on growth performance at 5 - 8 Weeks of age is presented in Table 8. There was no significant (P > 0.05) difference in performance among the treatment groups. Broiler Chickens fed diet containing 0.8g/kg showed highest final weight (2079.20g) followed by those on diets with inclusion levels of 1.10g/kg (2027.70g), 0.2g/kg (1985.10g) and 0.5g/kg (1888.00g) against the control (1842.80g). Similar trend was observed for the total weigh of the birds at different enzyme inclusion levels. Birds on diet supplemented with 0.8g/kg had the highest total weight (1476.50g) followed by those on diets with inclusion levels of 1.10g/kg (1360.70g), 0.2g/kg (1339.10g) and 0.5g/kg (1245.20g) against the control which had the lowest total weight (1205.10g). Broiler chickens fed diet supplemented with 0.8g/kg of enzyme blend showed the highest average daily weight gain (52.73g) than birds on diets supplemented with 1.10g/kg (48.60g), 0.2g/kg (47.83g), 0.5g/kg (44.47g). The control showed the lowest average daily weight gain (43.04g). Birds on diet supplemented with 0.2g/kg showed higher total feed intake (3014.10g). Enzyme inclusion improved final weight, total weight, average daily weight gain and total feed intake over the control throughout the finisher stage. The feed conversion ratio (FCR) at finisher stage range form 2.05 - 2.47. Birds on diet supplemented with 0.8g/kg of enzyme had better feed conversion ratio (2.05). At finisher stage there was 5% mortality of birds only on diet supplemented with 1.10g/kg enzyme blend.

Table 5. Feed Intake and Growth Performance of Broiler Chickens Fed Red Sorghum Diets Supplemented with Enzyme Complex at Finisher Stage (5 - 8 Weeks)

	Dietary Treatments					
Parameters	**T_1(0.0g/kg)**	**T_2(0.2g/kg)**	**T_3(0.5g/kg)**	**T_4(0.8g/kg)**	**T_5(1.10g/kg)**	**SEM**
Initial weight (g)	637.72	645.97	642.75	602.66	667.02	34.27 ^{ns}
Final weight (g)	1842.80	1985.10	1888.00	2079.20	2027.70	124.10 ^{ns}
Total weight (g)	1205.10	1339.10	1245.20	1476.50	1360.70	124.40 ^{ns}
ADWG (g)	43.04	47.83	44.47	52.73	48.60	4.44 ^{ns}
Total feed intake (g)	2928.00	3014.10	2919.10	2954.90	2939.60	47.84 ^{ns}
FCR	2.47	2.41	2.37	2.05	2.19	0.23 ^{ns}
% Mortality	0.00	0.00	0.00	0.00	5.00	2.23 ^{ns}

ADWG: Average daily weight gain; FCR: Feed conversion ratio, ns: not significant (P>0.05)

Carcass Characteristics and Internal Organ Weights of Broiler Chickens

The carcass characteristics and internal organ weights of broiler chicken fed raw and enzyme blend treated red sorghum diets are shown in Table 11. The carcass characteristics show no significant difference across the dietary treatments. Broiler chickens fed on diet supplemented with 0.8g/kg recorded highest live, bled, plucked, dressed weights and dressed weight percentage. The dressing percentage ranged from 62.48% in control to 67.24% in diet supplemented with 0.80g/kg and were not significantly ($P > 0.05$) affected by the dietary treatments. Birds on diet supplemented with 0.8g/kg of enzyme had the least head (27.25g) and shank (37.75g) weights and were not significantly ($P > 0.05$) by the dietary treatments. The percentage live weights of the liver, pancreas, heart, kidney and abdominal fat were not significantly ($P > 0.05$) affected across the treatment groups. Birds on the control diet recorded heaviest liver and kidney weights. There was a significant ($P < 0.05$) differences in the lungs, gizzard and proventriculus weights among the treatment groups. Birds fed the control diet recorded relative highest lungs (0.34%) and gizzard (1.32%) weights. Birds on diet supplemented with 0.5g/kg of enzyme blend recorded the highest proventriculus weight (0.27%). There were no significant ($P > 0.05$) differences in the lengths and weights of large and small intestines across the treatment groups. Birds fed on diet containing 0.2g/gk recorded heaviest large intestine weight (0.11%) while those on control diet recorded longer large intestine length (7.25cm). Birds fed diet containing 0.5g/kg enzyme recorded heaviest small intestine weight (1.53%) while those on the control diet recorded longest small intestine length (130.50cm).

Table 6: Carcass Characteristics and Internal Organ Weights of Broiler Fed Red Sorghum-based Diets Supplemented with Enzymes Complex

	Dietary Treatments					
Parameters	**T_1(0.0g/kg)**	**T_2(0.2g/kg)**	**T_3(0.5g/kg)**	**T_4(0.8g/kg)**	**T_5(1.10g/kg)**	**SEM**
Carcass Characteristics						
Live weight (g)	1703.10	1845.40	1748.30	1939.50	1888.00	124.10^{ns}
Bled weight (g)	1572.50	1714.80	1617.70	1808.80	1757.40	124.10^{ns}
Plucked weight (g)	1322.40	1464.70	1367.60	1558.80	1507.30	124.10^{ns}
Dressed weight (g)	1072.10	1214.40	1117.30	1308.50	1257.00	124.10^{ns}
% Dressed weight	62.48	64.49	63.54	67.24	66.31	2.62^{ns}
Head (g)	33.00	30.00	30.00	27.25	30.50	1.79^{ns}
Shank (g)	44.50	41.75	40.50	37.75	41.75	4.06^{ns}
Internal Organ Weights (% Live Weight)						
Liver	0.89	0.79	0.83	0.65	0.70	0.08^{ns}
Pancreas	0.09	0.12	0.12	0.13	0.08	0.02^{ns}
Heart	0.25	0.26	0.29	0.22	0.28	1.11^{ns}
Lungs	0.34^{a}	0.22^{b}	0.28^{ab}	0.19^{b}	0.23^{ab}	0.03^{*}
Kidney	0.30	0.22	0.27	0.19	0.23	0.05^{ns}
Gizzard	1.32^{a}	1.02^{ab}	1.20^{ab}	0.80^{b}	1.01^{ab}	0.10*
Proventriculus	0.24^{ab}	0.24^{ab}	0.27^{a}	0.15^{b}	0.20^{ab}	0.02*
Abdominal fat	0.46	0.44	0.70	0.50	0.55	0.12^{ns}
Large intestinal weight	0.10	0.11	0.09	0.10	0.06	0.01^{ns}
Large intestine length (cm)	7.25	7.00	6.75	6.75	5.75	0.72^{ns}
Small intestine weight	1.30	1.17	1.35	1.14	1.00	0.17^{ns}
Small intestine length (cm)	130.50	122.25	119.75	120.50	117.50	8.00^{ns}
Caeca weight	0.18	0.21	0.19	0.23	0.19	0.03^{ns}
Caeca length (cm)	12.75	11.75	12.00	11.75	11.25	0.70^{ns}

Means within the same row with different superscript differs significantly (P>0.05)*; SEM: Standard Error Mean

Print ISSN: 2517-276X
Online ISSN: 2517-2778
Website: https://bjmas.org/index.php/bjmas/index
Published by European Centre for Research Training and Development-UK

DISCUSSION

Proximate Profile of Raw Red Sorghum Grain

The proximate composition observed in the current study varied from those reported by Mohammed *et al*. (2019). The Dry Matter, Crude Protein and Crude fiber were higher; while the Moisture, Ether Extract, and Nitrogen Free Extract were low. The variation observed in proximate composition could be due to differences in proximate contents among Sorghum varieties in different region and climate. Variation in nutrient composition of Cereal grains have been reported by Jinyoung *et al*. (2016); and NRC, (2012). Similarly, Markus *et al*. (2016) have also reported variation in chemical composition and characteristics of cereal grains from different genotype.

Growth Performance of Broiler Chickens Fed Raw and Enzyme Treated Diets

Feed intake and growth performance of broiler chickens at starter stage (1 - 4 weeks)

The results of the present study showed that enzyme (Kingzyme®) supplementation to Red Sorghum-based diet did not significantly ($P > 0.05$) improve performance at starter stage of growth. This is in agreement with the report by Hajati (2010) who reported no significant ($P > 0.05$) effect on growth performance of broiler chickens fed enzyme (Endofeed W®: Xylanase and β-glucanase) treated corn-soybean based diet for 28 days. Similar report has been made by Sanaa *et al*. (2014) that Multi-enzyme (Optizyme-P5) supplementation had no significant effect on body weight and body weight gain of broiler breeder hens. Similarly, Torres *et al*. (2013) and Selle *et al*. (2010b) has reported no significant ($P > 0.05$) difference in performance parameters of birds fed on Sorghum during the period of 1 – 14 days of age; and among grain type (Sorghum and Wheat) on feed intake and weight gain at 14 days' period respectively.

Contrary, the performance parameters recorded in the current study was however higher than the values reported by Bulus *et al*. (2014) who recorded significant difference in performance of broiler chickens fed Yellow and White guinea corn respectively. This could be attributed to the essential role of the enzyme on digestion and feed utilization. This conforms to Garcia *et al*. (2008) who reported that Endofeed® improved body weight gain of birds. The higher FCR could be due to inherent anti-nutrient present in the principal energy source; Medugu *et al*. (2010) has reported high FCR for high and low tannin sorghums respectively. Based on the FCR in the current study, it is tentative that enzyme (KINGZYME®) did not exert any influence on FCR. Also, Sanaa *et al*. (2014) reported significant ($P < 0.05$) increase in body and body weight gain and improved FCR for broilers fed sorghum grains and enzymes (Allzyme®) supplementation. Similar report has been made by Bulus *et al*. (2014) for broilers fed two varieties of guinea corn and millet. Shakaouri *et al*. (2009) also reported that the addition of enzymes (Xylanase and β-glucanase) increases 28-day weight gain in broilers fed wheat-based diets but did not alter growth rates of birds offered Sorghum based diets. Figueiredo *et al*. (2012) reported significant ($P < 0.05$) deference in body weight of broilers fed wheat-based diet supplemented with commercial xylanase for 28 days.

The lower feed intake of birds fed the control diet could be due to the presence of tannin. Studies has shown that tannin causes decrease feed consumption in animals; bind dietary protein and digestive enzymes to form complexes that are not readily digestible; decrease palatability and reduce growth rate (Habtamu and Nigussie, 2014). This adverse effect of tannin consequently has a corresponding effect on the average daily weight gain, total weight gains and the final weight of the birds and other experimental animals. This implies that birds fed raw Red Sorghum-diets are expected to exhibit these factors. This finding agrees with the report by Ibitoye *et al*. (2012) who observed low feed intake in broilers fed diet containing white guinea corn. The total feed intake ($P > 0.05$) conform with the report by Govil *et al*. (2017), that the feed intake of broilers fed low energy diet supplemented with carbohydrase enzymes (Xylanase 50g/ton, manannase 50g/ton and amylase 40g/ton) was not statistically influenced.

The findings on total feed intake however contradict the report by Ibrahim *et al*. (2012) that inclusion of β-glucanase enzyme in Sorghum-diet significantly ($P < 0.05$) decrease total feed intake and improved weight gain and feed conversion ratio of broilers. The least total weight gain observed in the control could be due to increased level of soluble non-starch polysaccharide and tannin. Hajati (2010) stated that ingestion of high levels of soluble non-starch polysaccharides increase digesta viscosity and reduce digestibility and absorption. Tannin decrease feed intake and palatability, bind dietary protein and digestive enzymes to form complexes and reduces growth rate (Habtamu and Nigussie, 2014). The mortality rate of the birds was not significantly ($P > 0.05$) affected by the dietary treatment. Hence, it indicates that the diet was not lethal as to compromise the survival of the birds. The variation in the result of the present study and some other existing reports could be due to differences in dietary ingredients, source of enzyme and level of inclusion.

Feed intake and growth performance of broiler chickens at finisher stage (5 - 8 weeks)

The result of this study showed that the performance of broilers chickens fed raw and enzyme treated Red Sorghum-based diet was not significantly ($P > 0.05$) affected. This is consistent with Amerah *et al*. (2017) who reported no significant ($P > 0.05$) difference in the performance of broiler chickens fed corn/soy diets supplemented with enzymes (Xylanase, amylase and protease) during finisher phase. The total weight gains improved (not significantly) over the control. Cowieson *et al*. (2010) reported that the feed intake of broiler fed low energy diet supplemented with carbohydrase enzyme was not significantly affected. This could be due to improved feed utilization resulting from enzyme supplementation. Exogenous enzyme has the capacity to increase the efficiency of digestion by breaking down anti-nutritional factors (fibers, phytate and non-starch polysaccharides) or improve digestibility of many ingredients which remains low because of a lack of the enzyme needed for breaking down the complex nutrient present in plant-based feeds. Cowieson and Adeola (2005) reported 14% improvement in weight gain after supplementing enzyme cocktail (Xylanase, amylase, protease and phytase) in broilers fed nutritionally marginal diets. Jose *et al*. (2009) also reported improvement in body weight gain of broilers after supplementation of carbohydrases (Xylanase and amylase) in negative control diets.

Also, Avila *et al*. (2012) and Zeng *et al*. (2015) reported that supplementation with NSP-degrading enzymes (Xylanase and β-glucanase and phytase) to broiler diets increased their body weight. The FCR recorded in the current study was lower compared to 2.94 reported by Medugu *et al*. (2010) for broilers fed high tannin Sorghum. Zhang *et al*. (2014) also reported that supplementation of multicarbohydrase enzyme did not affect feed intake of broilers but their weight gain which indicate improved feed efficiency. However, the result of the current study contradicts Bulus *et al*. (2014) who reported significant ($P > 0.05$) in performance of broilers fed two varieties of guinea corn and millet as a replacement for maize. This could be due to variation in the principal feed ingredients, enzyme type, complex and levels of inclusion.

Carcass Characteristics and Internal Organ Weights of Broiler Chickens

The result of the current study indicated that the carcass characteristics of the birds were not significantly ($P > 0.05$) affected across the dietary treatments. The result is consistent with Torres *et al.* (2013) who reported no significant ($P > 0.05$) difference in carcass weights of broiler chicken fed sorghum-based diets. Ahmed *et al.* (2011) observed that replacement of maize by 100, 75, 50, 25 and 0% sorghum in broiler diet had no significant effect on carcass traits. Mahmood *et al.* (2017) reported that carcass traits of broilers chickens fed diet supplemented with exogenous enzyme was not significantly affected.

However, all other internal organ weights were not significantly ($P > 0.05$) affected except the lungs, kidney and gizzard. Ahmed *et al.* (2011) reported that no significant effect was observed in liver and abdominal fat weights in broiler chickens fed graded levels of sorghum in replacement for maize. Birds raised on the enzyme treated diet showed significant ($P < 0.05$) reduction in gizzard weight over the control. The significant ($P < 0.05$) higher weight of gizzard observed in the birds fed control diet is indicative of its better muscle development which may have effect on the particle size of digesta and nutrient absorption. The gizzard value obtained in this study is similar to (1.30 %) carcass weight reported by Hajati (2010) for broiler chickens fed enzyme treated diet. The value for proventriculus obtained in this study was higher than the range reported by Hajati (2010) for broiler chickens. The significant ($P < 0.05$) observed on the weights of lungs, gizzard and proventriculus are consistent with Kokozyniski *et al.* (2017) who reported variation in internal organ weight of rabbits fed alternative source of protein in the tropics. Birds fed the control diet recorded relative higher lungs, liver and kidney weights. This could be due to the presence of toxic factor in the diet. Higher weights of these organs usually arise due to increase in metabolic rate in an attempt to convert toxic factors to non-toxic metabolites.

CONCLUSION

Based on the findings of the study, it can be concluded that red sorghum, due to its high tannin profile, protein structure and isopeptide formation do not respond to exogeneous enzyme activity. The use of enzyme in Red sorghum as a supplement to enhance digestibility do not confer performance difference.

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