Trop. Anim. Prod. Invest. 21 (1): 40 – 49 (2018)
ISSN: 1115-2540
http://animalsci.agric.ui.edu.ng/TAPI/index.php/tapijournal/index

ORIGINAL RESEARCH ARTICLE

Effect of Different Levels of Xylanase-Amylase-Protease® (XAP) Enzyme supplementation in Acha fed Broiler chickens

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ABSTRACT

This study evaluated the synergistic effect of varying levels of xylanase-amylase-protease® (XAP) supplementation on the growth performance, carcass characteristics and economics of production of broiler chickens fed acha - based diets. Acha grains were used as replacement for maize such that basal diets were formulated; maize-soybean (T_1) and acha-soybean (T_2) to serve as positive and negative controls, respectively. Furthermore, XAP® was supplemented into the acha-based diest at 250, 500 and 750 mg/kg levels to constitute treatments T_3, T_4 and T_5 respectively. A total of 120 day-old Abor-Acre broiler chicks were randomly assigned to the five treatments with 24 birds each in a completely randomized design (CRD). Each treatment was further divided into three replicates of eight (8) birds each. All chicks were managed under the same experimental conditions for 49 days. Data were collected on the respective parameters. Results showed significant ($P<0.05$) differences among treatments in all growth parameters (except the feed conversion ratio). Final body weight, weight gain, feed intake and feed conversion ratio were improved by XAP supplementation. Feed intake was enhanced for birds fed acha with or without enzyme supplementation. Cost per kg gain, cost of feed consumed per bird and weekly cost of feed were significantly ($P<0.05$) influenced by dietary treatments. The XAP enzyme combinations improved the carcass yield (73.12 – 75.85%) of broiler chickens. Relative weights for major cuts like back, breast and thigh were significantly ($P<0.05$) affected by dietary treatments. Significant ($P<0.05$) differences were observed among treatments for GIT weight and length (except for ilium length). In all cases the acha diet with 250 mg/kg XAP supplementation appeared superior in most parameters compared with other treatment groups. This study concludes that 250 mg XAP enzyme supplementation should be included into Acha based diet for optimum growth performance, carcass yield and cost effectiveness of broiler production.

Keywords: Carcass, economics, fortification, grains, growth

INTRODUCTION

In the past decades, expansion of the poultry industry has gradually resulted in increasing challenges such as global demand for animal protein and provision of safe products (Awati *et al*., 2014). With a growing world population, there is increased pressure to grow cheaper, bigger and larger birds while maximizing feed utilization, as feed cost is known to be the highest single cost of production (Barletta, 2010). With these pressures and teeming global human population, dietary modifications including feed additive supplementations are currently being considered (Awati *et al*., 2014). Proven benefits of feed enzymes include improved feed efficiency, reduced feed costs, improved digestion and absorption of nutrients, improved uniformity within flocks and better maintenance of gut health (Barletta, 2010).

Enzymes were first used in the poultry industry in the 1980s and are now widely used to improve their performance and make feed cost savings. With current high ingredient prices, poultry producers are pressured to increase productivity without compromising product safety. Environmental pressures on waste output from animal production facilities have also encouraged the increased use of enzymes. High commodity prices can result in the inclusion of lower cost raw materials in diets that increase the complexity of the diet and can result in more anti-nutritional factors, which can negatively affect birds' performance. Increased use of such low cost mixed diets has spurred the use of carbohydrases (xylanase and/or amylase) as well as protease in poultry feeds over the last 5 to 10 years.

According to Awati *et al*. (2014), enzymes are categorized based on the substrates they target and mixed poultry diets due to their complexity of substrates may benefit from multiple enzyme activities. One of such enzyme combinations is a mixture of xylanase, amylase and protease (XAP) activities. Exogenous xylanase targets the soluble and insoluble arabinoxylans in cell walls (Barletta, 2010). These arabinoxylans can trap nutrients in the cell walls and the soluble fractions can also induce viscosity in the gut which results in reduced digestion of nutrients and a reduced passage rate of feed through the gut (Barletta, 2010). The use of exogenous xylanase has two main benefits; firstly, releasing encapsulated nutrients such as starch and protein from the cells and secondly, reducing the viscosity of the digesta, both leading to improvement in digestibility (Choct, 2006; Mirzaie *et al*., 2012). The breakdown of non-starch polysaccharides by xylanase also have beneficial effects on the gut micro flora by creating conditions that encourage beneficial bacteria through reduction in viscosity and production of small oligomers that are used by the beneficial bacteria in the lower gut (Bedford, 2000).

Exogenous amylase is used to increase the hydrolysis of starch and improve starch digestibility which results in more energy being released for the birds (Barletta, 2010). Exogenous proteases are used to increase the hydrolysis of proteins in the feed, including hydrolysis of proteinaceous anti-nutrients such as trypsin inhibitors (Caine *et al*., 1998), resulting in improved digestibility of protein and amino acids (Yu *et al*., 2007). Previous studies on XAP have demonstrated improvements in the nutritive value of the diet. The workers have demonstrated incremental improvements in energy digestibility when dietary carbohydrases (xylanase and amylase; XA) were used with or without protease (Romero *et al*., 2013a). Romero *et al.* (2013b) analyzed four digestibility studies compared the effects of XA or XAP in maize based diets with or without distillers dried grains with solubles (DDGs). A meta-analysis of the four studies showed that XA increased ileal digestible energy and apparent metabolizable energy (AMEn) by 77 and 67 kcal/kg respectively, whereas XAP increased them by 98 and 93 kcal/kg feed respectively. In addition, XAP increased protein and ileal amino acid digestibility. Romero and Ravindran (2011a and b) also demonstrated significant improvements in crude protein as well as fat and starch digestibilities with XAP combination. According to Bundgaard *et al*. (2012), the use of XAP also possesses some environmental benefits such as reducing about 5% of the greenhouse gas emissions from poultry production sites. Increased digestibility following XAP supplementation leads to improved growth and feed efficiency.

Maize (*Zea mays*), also called corn, is believed to have originated in central Mexico. Maize contains approximately 72 % starch, 8-10 % protein, and 4 % fat, supplying an energy density of 365 Kcal/100 g and is grown throughout the world. It is estimated that in 2012, the total world production of maize was 875,226,630 tons (FAO, 2012) with the United States, China, and Brazil harvesting 31, 24, and 8% of the total production of maize, respectively. Maize can be processed into a variety of food and industrial products, including starch, sweeteners, oil, beverages, glue, industrial alcohol, and fuel ethanol (Ranum *et al*., 2014). As the ethanol industry absorbs a larger share of the maize crop, higher prices for maize will intensify and demand competition could affect maize prices for animal and human consumption. These over dependence on maize utilization and competition between human and animal demand for maize have resulted in the search for alternative feed ingredients which are locally available (Ukim *et al*., 2013; Ozung *et al*., 2016). Acha grain is considered as one of the promising alternatives to maize (Dachi *et al*., 2014).

Acha (*Digitaria exilis*) commonly called black fonio is an indigenous cereal of West Africa dating back to 7,000 years (Dachi *et al*., 2014). *Digitaria exilis* belongs to the family *Graminae,* tribe - *Poaceae* and closely related to the wild species - *Digitaria longiflora.* In Nigeria, acha is mainly grown in Plateau, Bauchi, Kebbi, Taraba, Kaduna and Niger States where it serves as staple food for man (Dachi *et al*., 2014). The presence of anti-nutrients such as phytate has been a major limiting factor to the extensive utilization of acha as a plant resource (Azeke *et al*., 2011). Anuonye *et al*. (2010) also reported that acha grain is of low toxicity with moderate amounts of anti-nutrients.

Presently, there is paucity of published information on the use of XAP in improving acha utilization by broiler chickens. This research therefore evaluated the synergistic activity of three levels of XAP supplementation on the growth and carcass characteristics of broiler chickens fed acha-based diets.

MATERIALS AND METHODS

Location of study

This study was conducted at the Poultry unit of the University of Calabar Teaching and Research Farm. Calabar is located in Southern Nigeria, which falls between latitude $45^0 58^I$N and longitude $8^0 12^I$E of the Equator with mean annual rainfall between 1,260 and 1,280mm, average temperature between 25 and 30^0C with a relative humidity of 55-99% and an elevation above sea level of 99 meters (NMA, 2018).

Test ingredients

The test ingredients used in this study were Acha (*Digitaria exilis*). The unpolished whole Acha (*Digitaria exilis*) grains were purchased from Bogoro Local Government Area, Bauchi State, Nigeria. Thereafter, the grains were cleaned by picking the chaffs and stones. Xylanase-amylase-protease enzyme (Axtra® XAP), a product of Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK was procured from Agrited Nigeria Ltd. Axtra® XAP has fixed ratios (10:1:25) of xylanase (2,000 xylanase units/kg XAP), amylase (200 amylase units/kg XAP) and protease (5,000 protease units/kg; XAP).

Experimental diets

Two basal broiler starter and finisher mashes (Table 1) were formulated to provide the required nutrients according to NRC (2012) requirements. The maize-basal diet - standard diet served as the positive control, while the acha basal diet without XAP® enzyme acted as negative control. The acha diets were formulated in one batch then subdivided into 4 experimental diets, with three diets containing XAP at three levels (250, 500 and 750 mg/kg of acha diet) each. The five experimental treatments were as follows:

T_1 Maize-soybean diet – positive control

T_2 Acha-soybean diet – negative control

T_3 Acha-soybean diet plus supplemental XAP at 250 mg/kg

T_4 Acha-soybean diet plus supplemental XAP at 500 mg/kg

T_5 Acha-soybean diet plus supplemental XAP at 750 mg/kg

Management of experimental birds

On arrival, glucose was added to the drinking water as anti-stress for the chicks. One hundred and twenty (120) day-old Abor-Acre broiler chicks were used in this study. The birds were randomly distributed after weight equalization into the five experimental treatments consisting of 24 chicks each. Each treatment was further subdivided into three replicates of eight (8) birds. The chickens were raised on a deep litter floor using wood shavings as litter material. Brooding, which lasted for 14 days was by means of electric bulbs as source of heat placed under a hover. Temperature of the brooding room was controlled by either reducing or increasing the electric bulbs' heights after reading the thermometer. Birds were vaccinated against Newcastle disease on the third day intra ocularly; Lasota on the 14th and 28th days; infectious bursal disease (Gumboro) on the 12th and 19th days. Birds were controlled against coccidiosis from the 14th - 21st days using prococ (coccidiostat). Anti-chronic respiratory disease (CRD) drug was used to protect birds from 18 days of age for 7 days and later at 30 days of age for 7 days. Vitamins (vitalyte) were administered at intervals, especially before and after each vaccination. The experiment lasted for 7 weeks. The study was carried out in accordance with the code of Ethics for animal experiments as stated in http://ec.europa.eu/environment/chemicals/lab_animals/legislation_en.htm.

Data collection

To evaluate the potential value of acha as a feed ingredient as well as the efficacy of XAP® supplementation on acha utilization, data were collected on the growth performance, carcass characteristics and economics of production of broiler chickens. The field trial lasted for 56 days.

Statistical analysis

Data collected were subjected to a one-way analysis of variance (ANOVA) in a completely randomized design according to the methods of Steel and Torrie (1980). Carcass and internal organs (at the 8th week) were expressed as percentage of live weight to obtain relative weight values. Significant means were separated using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Growth performance characteristics of broilers fed acha – based diets

The result of the growth performance of broilers fed acha-based diet supplemented with XAP is presented in Table 2. Final body weight was significantly ($P < 0.05$) influenced by dietary treatments.

Table 1: Gross composition of experimental diets (%)

	Starter diets		Finisher diets	
Ingredient	**Maize-based**	**Acha-based**	**Maize-based**	**Acha-based**
Maize	49.25	0.00	50.00	0.00
Acha	0.00	49.25	0.00	50.00
Soybean meal	35.00	35.00	28.75	28.75
Fish meal	2.00	2.00	2.00	2.00
Wheat offal	7.00	7.00	10.00	10.00
Bone meal	3.50	3.50	3.00	3.00
Salt	0.25	0.25	0.25	0.25
PKC	2.00	2.00	5.00	5.00
Vit-Min Premix	0.25	0.25	0.25	0.25
Palm oil	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values				
Crude Protein (%)	22.51	23.99	20.85	22.35
ME (Kcal/kg)	3100.40	3177.53	3041.75	3120.05
*Determined values				
Crude protein (%)	23.36	23.41	19.65	20.58

*Determined values were obtained from triplicate samples per dietary treatment.

Birds fed 250 mg of XAP in acha-based diet had numerically higher final body weight that was statistically similar to the values recorded for birds on 500 mg and 750 mg of XAP in acha-based diet, while birds fed maize-based diet had the least values (1657.53 g). The range of values 1657.53 – 2345.44 g obtained in this study were comparable with the 2155 g earlier reported by Dafwang (2006) and were within the range reported by Omojola *et al*. (2014), Afolayan *et al*. (2014) and Uchegbu *et al*. (2010) who reported 1557.50 – 2212.50 g, 1764 – 2820.37 g and 1939.10 – 2022.08 g, respectively for broilers at 8 weeks. The final weight obtained showed that birds on diet supplemented with XAP in each of the feeding regime were significantly ($P < 0.05$) higher compared with birds fed maize - based diets. Average weekly body weight was significantly ($P < 0.05$) influenced by dietary treatments. Average feed intake was significantly ($P < 0.05$) influenced by dietary treatments. Birds fed 250 mg of XAP consumed the highest feed (862.25 g) while those fed maize-based diet consumed the least (704.88 g). The lower weight gain of birds in the control group could be due to several factors such as low feed intake (Melansho *et al*., 1987). High ambient temperature has been shown to affect feed intake and efficiency (Mashly *et al*., 2004). Dietary proteins and amino acid content of the feed, particle size and dietary energy levels can also affect feed intake. As energy levels increases, birds satisfy their energy needs by decreasing feed intake.

The results of the present study showed that broiler chickens fed XAP supplemented diets had better performance in terms of weight gain. Earlier studies (Aksaka and Bilal, 2002; Lan *et al*., 2002) showed that broiler chickens fed diets supplemented with enzymes had improved FCR due to better feed utilization. Similarly, results of this study agreed with the findings of Bozkurt *et al*. (2006) who reported that the growth rate and FCR of broilers fed low Phosphorus diets containing enzyme were comparable or even better than those obtained for broilers fed standard diets. These results also agreed with those reported by (El-Tazi *et al*., 2009) which indicated that the body weight gain and feed intake were significantly improved by addition of enzyme to broiler diets. On the other hand, the results contradicted the findings of Wilson *et al*. (1999) who reported that feed consumption decreased due to addition of enzymes since birds fulfilled their nutrients requirement by taking less amount of feed.

The improvement in growth performance of broilers fed XAP supplemented diets could be attributed to the improvement in essential amino acids and metabolizable energy as

Table 2: Growth performance and economics of production of broilers fed acha – based diets with XAP enzyme (0 – 8 weeks)

Parameters	Treatments					
	Maize-based	Acha-based	250mg XAP	500mg XAP	750mg XAP	SEM
Initial weight (g)	39.00	39.00	39.00	39.00	39.00	0.00
Final weight (g)	1657.53^{b}	2133.33^{a}	2345.44^{a}	2099.70^{a}	2100.89^{a}	72.89
Av.wkly wt. gain (g)	231.22^{b}	299.19^{a}	329.49^{a}	294.39^{a}	294.56^{a}	10.41
Av. weekly feed intake (g/bird)	704.88^{b}	790.20^{a}	862.25^{a}	805.41^{a}	858.66^{a}	22.44
FCR	3.07	2.65	2.62	2.74	2.93	0.14
Cost/kg feed (₦)	209.66	327.16	327.21	327.26	327.31	0.00
Cost/kg gain (₦)	643.36^{b}	866.66^{a}	856.45^{a}	895.36^{a}	958.84^{a}	38.18
Cost of feed consumed/bird (₦)	1034.49^{c}	1809.65^{b}	1974.96^{a}	1845.05^{ab}	1967.34^{ab}	48.75
Weekly feed cost (₦)	147.78^{c}	258.52^{b}	282.14^{a}	263.58^{ab}	281.05^{ab}	6.96

^{abc} Means with different superscripts on the same row differ significantly (P<0.05)
SEM = Standard error of mean, XAP = xylanase - amylase- protease ® Enzyme

reported in an earlier study (Attia *et al*., 2001) or due to overall increased utilization of nutrients. In another study, Oluyinka *et al*. (2008) reported that the combination of XAP has been shown to impart beneficial effects on broiler performance. Cowieson and Adeola (2005) concluded that supplementation of XAP improved performance and nutrient digestibility when compared to a negative control diet. Additionally, results from a study conducted by Olukosi *et al*. (2007) showed that XAP supplementation increased final body weight as well as reduced FCR compared to a negative control diet. It is widely accepted that XAP supplementation beneficially influences broiler performance through increased nutrient digestibility.

The Economic implication of supplementing XAP (Table 2) showed that all the economic indices examined apart from cost per kg of feed were significantly (P < 0.05) influenced by dietary treatments. Although, birds fed 750 mg XAP had numerically higher cost per kg gain. It was further observed that 250 mg of XAP also posted higher cost of feed consumed per bird. These values were statistically similar with the values obtained for birds fed 500 mg and 750 mg of XAP which differ (P < 0.05) from acha – based diet control while maize – based diet had the least.

Carcass characteristics of broilers fed acha – based diets

Table 3 shows the prime cuts and organ weights of broilers fed the dietary treatments. Live weight, dressed weight, dressing percentage, prime cuts (back, breast and thigh) and organ (liver, full gizzard, empty gizzard, lungs, proventriculus, pancreas, oesophagus and trachea) weights were significantly (P < 0.05) influenced by dietary treatments. Live weight ranging from 1783.00 – 2217g were obtained in this study which was higher (P < 0.05) for birds fed acha with 500 mg XAP compared to birds fed the maize – based diet. Values for live weight obtained in this study were lower than that (2740.00 – 3023.33 g) reported by Ukim *et al*. (2017) for broilers fed graded levels of acha grains but comparable to that (1557.50 – 2212.50 g) reported by Omojola *et al*. (2014) for broilers fed Sesame/Soybean based diets supplemented with or without microbial phytase. Live weight obtained for XAP supplemented diets are comparable to those (1760 – 2020 g and 1996.82 – 2072.93 g) reported by Afolayan *et al*. (2014) and Ndelekwute *et al*. (2014) for broilers fed African locust bean and Acetic acid-treated diets respectively. Dressed weight ranging from 1267.00 – 1650.00 g were obtained in this study which was higher (P < 0.05) for birds fed acha with 500 mg and 750 mg XAP compared to those fed maize – based diet. Values for dressed weight obtained in this study for birds fed 500 mg of XAP is comparable to that (1593 – 1970 g) reported by Ademola *et al*. (2014) for broilers fed *Gliricidia sepium* leaf meal supplemented with enzymes, while the values for the other groups were lower than this range. Other workers like Vojtech *et al*. (2014) however reported lower dressed weight (1106 – 1380g) for broilers fed Serine protease. The variations in results could be attributed to the duration of experiments as well as type of diets in which the birds were exposed to in the separate studies. Dressing percentage (73.36 – 75.85%) was higher ($P < 0.05$) in birds fed acha with 750 mg XAP than those fed maize-based diet. Dressing percentage in this study was higher than the range (66.89 – 68.98 %) reported by Ukim *et al*. (2014). However, values obtained in this study are comparable or even higher in some treatments than the range (71.30 – 73.10 %) reported by Vojtech *et al*. (2014) for broilers fed graded levels of acha grains and Serine protease. This result showed that the carcass yield of broilers was not negatively affected when fed acha – based diet with or without enzyme supplementation. Birds on the maize – based diet had higher ($P < 0.05$) values for back and breast cut weights while birds fed acha – based diet with 500 mg XAP had the least. Birds fed acha – based diet with 500 mg of XAP had numerically higher drumstick and shank and the least for neck. Prime cuts values obtained in this study were not consistent with previous reports (Omojola *et al*., 2014). The variations may be attributed to the age of the birds at slaughter (56 days old broiler chickens).

Table 3: Carcass characteristics of broiler chickens fed acha – based diets with XAP enzyme

	Treatments					
Parameters	Maize-based	Acha-based	250 mg XAP	500 mg XAP	750 mg XAP	SEM
Live weight (g)	1783.00^{b}	1967.00^{ab}	1983.00^{ab}	2217.00^{a}	2000.00^{ab}	94.30
Dressed weight (g)	1267.00^{b}	1450.00^{ab}	1450.00^{ab}	1650.00^{a}	1517.00^{a}	70.30
Dressing %	71.06^{b}	73.72^{ab}	73.12^{ab}	74.42^{ab}	75.85^{a}	1.27
Prime cuts (relative weight,%)						
Back	14.73^{a}	14.18^{ab}	14.13^{ab}	12.59^{b}	13.82^{ab}	0.50
Breast	15.75^{a}	14.23^{ab}	14.12^{ab}	12.59^{b}	14.22^{ab}	0.73
Drumstick	10.96	10.46	10.35	11.21	10.40	0.38
Thigh	12.08^{ab}	11.34^{b}	12.26^{ab}	12.38^{a}	12.06^{ab}	0.28
Wings	8.65	8.48	8.55	8.57	8.59	0.31
Neck	5.58	5.57	5.54	5.08	5.47	0.25
Shank	4.00	4.13	3.61	4.05	3.64	0.21
Head	2.26	2.53	2.25	2.34	2.33	0.16

^{abc} Means with different superscripts on the same row differ significantly ($P<0.05$)
SEM = Standard error of mean; XAP = xylanase - amylase- protease® Enzyme

Table 4: Relative weight of internal organs of broilers fed acha – based diets with XAP enzyme

	Treatments					
Parameters (% LW)	Maize-based	Acha-based	250 mg XAP	500 mg XAP	750 mg XAP	SEM
Heart	0.43	0.46	0.36	0.43	0.36	0.05
Liver	1.79^{a}	1.82^{a}	1.76^{ab}	1.55^{bc}	1.46^{c}	0.07
Full gizzard	2.84^{a}	2.46^{ab}	2.00^{b}	1.98^{b}	2.57^{ab}	0.19
Empty gizzard	2.05^{a}	1.63^{abc}	1.38^{b}	1.57^{bc}	1.92^{ab}	0.14
Spleen	0.13	0.09	0.12	0.09	0.14	0.02
Lungs	0.48^{ab}	0.39^{c}	0.52^{a}	0.44^{abc}	0.42^{bc}	0.03
proventriculus	0.51^{ab}	0.46^{ab}	0.56^{a}	0.37^{b}	0.47^{ab}	0.05
Pancreas	0.24^{ab}	0.32^{a}	0.17^{b}	0.22^{ab}	0.16^{b}	0.04
Abdominal fat	1.49	1.56	1.05	0.80	1.99	0.51
Oesophagus	0.19^{a}	0.15^{ab}	0.15^{ab}	0.16^{ab}	0.13^{b}	0.02
Crop	0.38	0.29	0.29	0.23	0.24	0.06
Gall bladder	0.11	0.12	0.10	0.11	0.08	0.02
Trachea	0.16^{a}	0.11^{b}	0.09^{b}	0.09^{b}	0.10^{b}	0.02

^{abc} Means with different superscripts on the same row differ significantly ($P<0.05$)
SEM = Standard error of mean, XAP = xylanase - amylase- protease ® Enzyme

Table 5: GIT morphometry of broiler chickens fed acha – based diets with XAP enzyme

Parameters	Treatments					SEM
	Maize-based	Acha-based	250 mg XAP	500 mg XAP	750 mg XAP	
Intestinal weight						
GIT Weight (g)	126.22^{b}	248.24^{a}	247.37^{a}	231.00^{a}	204.13^{a}	19.47
Duodenum (g)	10.19^{b}	3.10^{c}	14.19^{a}	2.90^{c}	3.79^{c}	1.88
Jejunum (g)	12.32^{a}	4.25^{b}	4.43^{b}	3.06^{b}	3.05^{b}	1.71
Ilium (g)	41.96^{a}	24.37^{ab}	29.21^{ab}	23.93^{ab}	14.77^{b}	5.45
Caecum (g)	11.13^{a}	8.56^{ab}	5.83^{b}	6.71^{ab}	4.94^{b}	1.50
Intestinal Length						
Duodenum (cm)	20.67^{a}	16.67^{ab}	14.07^{bc}	15.33^{abc}	10.38^{c}	1.84
Jejunum (cm)	28.00^{a}	20.67^{b}	19.33^{b}	18.67^{b}	15.67^{b}	2.21
Ilium (cm)	114.70	146.30	142.00	128.30	125.30	10.77
Caecum (cm)	32.70^{ab}	38.00^{a}	32.70^{ab}	32.30^{ab}	27.30^{b}	2.80
pH						
Gizzard	6.33	5.67	6.00	6.00	6.00	0.42
Proventriculus	6.00	5.67	5.33	6.00	6.00	0.21
Duodenum	6.00^{b}	6.67^{a}	5.00^{c}	6.00^{b}	6.00^{b}	0.15
Jejunum	6.00	6.00	5.67	6.00	6.00	0.39
Crop	6.00	6.00	6.33	6.33	6.00	0.33
Ilium	6.00	6.00	5.67	6.00	6.00	0.30
Caecum	7.33	7.33	7.00	6.33	6.00	0.45

^{abc} Means with different superscripts on the same row differ significantly (P<0.05)
SEM = Standard error of mean, XAP = xylanase - amylase- protease ® Enzyme

Relative organ weight of broilers fed acha – based diets

Table 4 revealed that the relative organ weights (liver, full gizzard, empty gizzard, lungs, proventriculus, pancreas, oesophagus and trachea) were significantly (P < 0.05) influenced by dietary treatments. Birds on maize – based diet recorded higher values for full gizzard, empty gizzard, oesophagus and trachea compared to those on acha – based diets with or without enzymes. The numerically higher, but non – significant (P>0.05) difference heart weight obtained for acha – based diet compared with those on maize – based diets and acha - based diet with enzyme could be an indication that acha – based diet could maintain the normal circulatory function in broilers. The lower gizzard weight in acha fed birds indicated that digestive process was not impaired by the utilization of acha. Supplementation of acha – based diets with XAP at 250 mg and 500 mg appeared to produce numerically lower abdominal fat deposition in birds. The relative organ weights observed were within the ranges previously reported (Odoemelam *et al*., 2017). The small weights for the digestive organs of birds fed with XAP diets is an indication of the better feed efficiency observed as the time taken for digestion activities will be reduced leading to better nutrient utilization. Relative spleen weight (0.09 – 0.14%) obtained in this study were lower than the range reported by Aguihe *et al*. (2016) and Odoemelam *et al*. (2017) respectively for broilers fed dietary Scent leaf, garlic and antibiotics and those fed Maxigrain enzyme supplemented cassava peel meal based diets. The lower relative spleen weight in acha – based diets without supplementation and those supplemented 500 mg of XAP could be an indication that immune functions of the birds were not compromised but enhanced by enzyme supplementation. The improvements in the parameters in this study conform to the earlier assertion of Iyayi and Davis (2005) and Adeola and Olukosi (2008) that enzymes supplementation improve performance, carcass and organ characteristics of broiler chickens.

GIT morphometry of broilers fed acha – based diets

The result of the effect of dietary treatments on the gastrointestinal tract morphometry (Table 5) revealed that there were significant (P < 0.05) effects of dietary treatments on the GIT and intestinal segments. The significant lower values obtained in birds fed acha with or without enzyme further confirmed that XAP supplementation had no negative effects on total GIT weight. Birds on acha – based diet with or without enzyme had heavier GIT weight, while the least weight was obtained in those fed maize – based diet. Weight of the jejunum, ilium and caecum were numerically lower for birds on 750 mg of XAP while duodenum, jejunum, ilium and caecum were heavier in those fed maize – based diet. Birds on maize – based diet had the longest duodenum and jejunum lengths, while those on 750 mg of XAP had the shortest duodenum length. Results for GIT pH indicated significant ($P < 0.05$) difference by dietary treatments on the acidity and alkalinity of the duodenum of the birds (Table 5). The pH of the duodenum was highest for acha without enzyme, while those with 250 mg of XAP had the least. The gizzard, proventriculus, jejunum and ilium were statistically similar ($P > 0.05$) for the treatment groups.

CONCLUSION AND RECOMMENDATION

From the results of this study, acha – based diet supplemented with 250 mg of XAP for broiler chickens showed positive responses in growth rate, weight gain, feed intake and feed conversion ratio under the same environmental conditions as compared to those supplemented with 500, 750 mg, acha and maize – based diets. This study therefore recommends that for optimum performance, 250 mg XAP should be supplemented in acha- based diet for broiler chickens.

CONFLICT OF INTEREST

The authors wish to declare that there was no conflict of interest in the design, execution, analysis and documentation of findings in this study.

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