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Nutritional value of dietary raw bambara nut offal fortified with enzyme (Natuzyme®) on the performance of broiler chickens

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Abstract

Nutritional value of dietary raw bambara nut offal fortified with enzyme (Natuzyme®) on the performance of broiler chickens were investigated. Two hundred and fourty (240), unsexed one day-old commercial broiler chicks (Marshal Strain) were randomly divided into eight groups of 30 birds each. The groups were randomly assigned to eight iso-caloric and iso-nitrogenous diets in a 2 × 4 factorial arrangement involving four levels (0, 10, 20 and 30 %) of raw bambara nut offal and 2 enzyme levels (0 and 0.025 %). Each treatment was replicated three times with ten birds per replicate. There were significant differences (P < 0.05) among treatments in AFW, ADWG, ADFI, FCR and PER. Chickens fed 10 % BGO without Natuzyme® had higher (P < 0.05) FBW, ADWG and ADFI than chickens fed 0, 20 and 30% BGO diets. Least (P<0.05) ADFI and better FCR was recorded on broiler chickens fed control diet and 20 % BGO with enzyme. respectively. Addition of enzyme improved (P < 0.05) AFW and ADWG at 20 and 30 % BGO level. Significantly (P<0.05) higher AFW, ADWG and ADFI revealed that inclusion level of BGO at 10 % did not pose any deleterious effects on the birds. There were significant (P < 0.05) differences among treatments in the digestibility of dry matter (DM), crude protein, crude fibre (CF), ether extract (EE) and nitrogen-free extract (NFE). There was no interaction (P>0.05) between enzyme and BGO across the dietary treatments. Significant (P < 0.05) differences were observed in all the blood profile parameters observed across the dietary treatments except eiosinophil concentration. It was concluded that up to 30 % BGO can be included in enzyme supplemented broiler finisher diet without adverse effects on the performance, nutrients digestibility and blood profile of broiler finisher chickens

Keywords: Bambara groundnut offal, Natuzyme®, finisher, broiler, growth

Introduction

\Feed remains the most important cost of animal production (Kehinde *et al.,* 2006). The need for feed ingredients, which will reduce the cost of production, is the basis for most new ingredients that are been utilied in livestock feed and production research. This is because man and his livestock are in competition for basic ingredients and such ingredients are not usually produced in sufficient quantities locally (Omojola and Adesehinwa, 2007). The use of agro-industrial by-products in feed reduces the cost of feed as they attract little pricing (Onyimonyi, 2003). One of such readily available agro-industrial by-products in Nigeria is Bambara groundnut offal, a waste product from the milling of Bambara groundnut seed. The development of the offal as an alternative energy and protein source could contribute to solving the problem of high cost of poultry feed and could provide a better avenue for its disposal which may constitute an environmental nuisance. Bambara groundnut offal contains 17.90- 21.16% crude protein, 5.29 – 21.50% crude fiber and 12.44 MJ/kg gross energy (Onyimonyi and Okeke, 2007). However, anti-nutritional factors such as tannins, protease inhibitors, cyanogenic glycosides, flatulence factors and haemagglutinins

have been reported in raw Bambara (Ensminger *et al.,* 1996). Anti- nutritional factors and high fiber content are limitations to the use of Bambara groundnut in poultry feeding. Poultry cannot fully utilize high fibre diets because they lack the digestive framework that can elaborately digest large amount of fibre. It becomes imperative, therefore, to incorporate exogenous enzymes into their diets in order to enhance the breakdown of the non-starch polysaccharides (NSPs) present in fibre. The enzyme being considered in this study is Natuzyme®, an enzyme complex derived from *Trichoderma viride,* with glucanase and xylanase activity. The enzyme has been shown to increase digestibility of fibrous feed ingredients by disrupting the plant cell walls, and by reducing the viscosity of the gut contents, thereby enhancing nutrient absorption (Acromovic, 2001). The present study was therefore conducted to determine the nutritional value of dietary raw bambara nut offal fortified with enzyme (Natuzyme®) on the performance of broiler chickens.

Materials and Method

Experimental site

The study was conducted at the Poultry Unit of the Livestock Section, Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State. Makurdi is located between latitude $7^0$44'N and longitude $8^0$21'E in the Guinea savanna zone of West Africa. The annual rainfall ranges between 6 - 8 months (March - October) and ranges from 508 to 1016 mm with a minimum temperature range of 24.20 ± 1.4^0C and maximum temperature range of 36.33 ± 3.70^0C. The relative humidity ranges between 39.50 ± 2.20% and 64.00 ± 4.80% (TAC, 2011).

Procurement and processing of feed ingredients

Feed ingredients such as maize, soybean meal and groundnut cake were purchased in Makurdi metropolis, Benue state, while micro ingredients were purchased from a reputable livestock office. Maize offal and Bambara nut offal were obtained as processed feed waste products at feed mill. All the ingredients were crushed with hammer mill using a sieve size of 5mm

Formulation of experimental diets

Eight iso-caloric metabolizable energy (ME) and iso-nitrogenous experimental diets containing four raw bambara nut offal levels (0, 10, 20 and 30 %) and two enzyme levels (0 and 0.025 %) were formulated with the feed ingredients. The percentage compositions of the diets are presented in Tables 1 and 2.

Experimental diets and design

Two hundred and forty (240), one-day old unsexed commercial broiler chicks (Marshal strain) were randomly divided into eight groups of 30 birds each. The groups were randomly assigned to eight dietary treatments in a 2 × 4 factorial arrangement involving four levels 0, 10, 20 and 30% of raw bambara groundnut offal (BGO) and two enzyme levels of 0 and 0.025 %. Each treatment was replicated three times with 10 birds per replicate and placed in 2.6 × 3 m deep litter pens of fresh wood shavings. Feed and water were supplied *ad libitum* to the birds throughout the experimental period. The birds were subjected to standard broiler management procedure.

Experimental birds and management

Deep litter poultry house was cleaned, fumigated, washed and disinfected with 1 % formalin solution prior to the arrival of the chicks. The feeders and drinkers were also disinfected 24 hours before the arrival of the broiler chicks. Disinfectant solution daily prepared and poured in the foot dip at the entrance to the pen for disease control. Charcoal stoves were used to maintain the required temperature for brooding, and

light was provided using 200 watt electric bulbs. Vaccines (Gomboro and Lasota) were administered and other health management practices were observed according to recommendation of the veterinary officer.

Table 1: Ingredients and calculated nutrient composition of experimental diets (kg as fed basis)

BGO Levels (%)	0		10		20		30	
Enzyme levels (mg)	0	250	0	250	0	250	0	250
Ingredients (kg)								
Maize	47.32	47.32	39.40	39.40	32.24	32.24	25.06	25.06
Soybean meal	20.07	20.07	18.48	18.48	16.81	16.81	15.15	15.15
Groundnut cake	20.06	20.06	18.47	18.47	16.81	16.81	15.14	15.14
BGO	0.00	0.00	10.00	10.00	20.00	20.00	30.00	30.00
Maize offal	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Bone meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Salt (Nacl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Palm oil	0.00	0.00	1.00	1.00	1.50	1.50	2.00	2.00
*Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100
Calculated analysis								
ME (kcal/kg)	2840	2840	2828	2828	2821	2821	2813	2813
Crude protein (%)	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Crude fibre (%)	5.73	5.73	4.82	4.82	5.42	5.42	6.03	6.03
Calcium (%)	1.38	1.38	1.38	1.38	1.38	1.38	1.39	1.39
Phosphorus (%)	0.73	0.73	0.72	0.72	0.70	0.70	0.68	0.68
Lysine (%)	1.22	1.22	1.27	1.27	1.31	1.31	1.35	1.35
Methionine (%)	0.86	0.86	0.72	0.72	0.73	0.73	0.74	0.74

*Premix per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E - 30,000IU, Vitamin K – 3,000mg Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg,Folic acid 2,000mg, choline 300,000mg,Iron 60,000mg, manganese 80,000mg, copper 25,000mg,Zinc 80,000mg cobalt 150mg, iodine 500mg, selenium 310mg, Antioxidant 20,000mg. BGO = bambara groundnut offal

Measurement of growth parameters

At the beginning of the experiment, chicks in each treatment replicate were weighed together to obtain average initial weight of 41.87 – 42.00. Feed intake was determined daily by the weigh-back technique. Live weights were recorded weekly for each replicate. Feed conversion ratio was calculated as quantity (g) of feed consumed per unit (g) weight gained over the same period. Protein efficiency ratio was also calculated as weight gain (g) divided by protein consumed (g) over the same period. Feed cost per kg weight gain was calculated by dividing per kg feed cost by gram of weight gain.

Nutrient digestibility

Nutrient digestibility evaluation was done at the end of week seven (7) and terminated at the end of week eight. Four birds per replicate group were selected and transferred into metabolic cages. A 3-days acclimatization period was allowed for the birds and the respective diets were offered *ad-libitum*. Daily feed intake and daily faecal output were recorded for 4 days. The

Table 2: Ingredients and calculated nutrient composition of experimental diets (kg as fed basis)

BGO Levels (%)	0		10		20		30	
Enzyme levels (mg)	0	250	0	250	0	250	0	250
Ingredients (kg)								
Maize	49.15	49.15	40.75	40.75	32.96	32.96	25.13	25.13
Soybean meal	15.65	15.65	14.10	14.10	12.50	12.50	10.91	10.91
Groundnut cake	15.65	15.65	14.10	14.10	12.50	12.50	10.91	10.91
BGO	0.00	0.00	10.00	10.00	20.00	20.00	30.00	30.00
Maize offal	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Bone meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Salt (Nacl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Palm oil	0.00	0.00	1.50	1.50	2.50	2.50	3.50	3.50
*Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100
Calculated analysis								
ME (kcal/kg)	2854	2854	2869	2869	2862	2862	2853	2853
Crude protein (%)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Crude fibre (%)	4.58	4.58	5.19	5.19	5.81	5.81	6.39	6.39
Calcium (%)	1.36	1.36	1.37	1.37	1.37	1.37	1.37	1.37
Phosphorus (%)	0.71	0.71	0.69	0.69	0.67	0.67	0.65	0.65
Lysine (%)	1.18	1.18	1.21	1.21	1.24	1.24	1.27	1.27
Methionine (%)	0.58	0.58	0.59	0.59	0.60	0.60	0.78	0.78

*Premix per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E - 30,000IU, Vitamin K – 3,000mg Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg,Folic acid 2,000mg, choline 300,000mg,Iron 60,000mg, manganese 80,000mg, copper 25,000mg,Zinc 80,000mg cobalt 150mg, iodine 500mg, selenium 310mg, Antioxidant 20,000mg; BGO = bambara groundnut offal

droppings were collected per replicate once daily at 8:00 am, weighed and dried in an oven at 70˚ C to constant weight. Dried excreta were bulked and ground. Experimental diets and faecal samples were used to determine their respective proximate constituent according to AOAC (2006).

Blood constituent evaluation

At the 8th week of the experiment, birds were fasted overnight so that the serum was cleared of excess fat and protein that could cloud the results. Three (3) birds per treatment replicate were selected for the evaluation of haematological indices and serum biochemical variables; care was taken to choose representative birds with respect to body weight compared to the group mean body weight. Two (2) mL of blood samples was collected from the birds that were slaughtered using a sharp and cleaned knife, during bleeding; the blood was drained into labelled sterile bottle containing ethylene diaminetetra acetic acid (EDTA) which serves as an anticoagulant. Haematological indices determined are packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC) and haemoglobin concentration (Hb). The improved Nuebaer Haemocytometer method described by Jain (1986) was used to estimate the red and white blood cells, haemoglobin were determined according to Jain (1986). PCV was determined using Wintrobe Microhaematocrit method (Dacie and Lewis, 1991). The determination of the distribution of the various blood cells was

done by Shilling method of differential leucocyte counts (Mitruka and Rawnsley, 1977) and mean corpuscular haemoglobin concentration (MCHC), mean corpuscular volume (MCV) and mean haemoglobin concentration (MHC) were computed according to Jain (1986).

A second set of anti-coagulant free bottle tubes were used to collect 3mls of blood sample from each bird for serum biochemical analysis. The blood was allowed to clot to obtain serum by allowing the blood sample to stand for 2 hours at room temperature and centrifuged using the High Speed Wintrobes Microhaematocrit for 10 minutes at 2000 rpm to separate the cells from the serum. Serum total protein, globulin and albumin were analysed using Sigma kits according to Benzie and Strain (1996).

Statistical analysis

All generated data were subjected to Analysis of Variance (ANOVA) using SAS (2008) software package and the means of the parameters which were significantly different ($P<0.05$) were separated using Duncan's Multiple Range Test (DMRT).

Results and discussion

Table 3 shows the effect of dietary BGO and supplementary enzyme on performance of broiler chickens. Average initial weight (AIW) ranged between 41.87 g to 42.00 g. There were significant differences ($P < 0.05$) among treatments in final body weight (AFW), average daily weight gain (ADWG), average daily feed intake (ADFI), feed conversion ratio (FCR) and protein efficiency ratio (PER). Chickens fed 10 % BGO without Natuzyme® had significantly ($P < 0.05$) higher FBW, ADWG and ADFI than chickens fed 0, 20 and 30% BGO diets (with or without enzyme supplementation). The broiler chickens fed 10 % and 20 % BGO with enzyme are significantly ($P<0.05$) similar in terms of FBW and ADWG. Significantly ($P<0.05$) least feed intake and better feed conversion ratio was recorded on broiler chickens fed control diet and 20 % BGO with enzyme, respectively. The highest ($P<0.05$) PER was recorded on broiler chickens fed 10 % BGO with enzyme while the least was recorded broiler chickens fed 30 % BGO without enzyme. There were significant ($P < 0.05$) interactions between BGO and enzyme levels in average final weight, average daily weight gain, average daily feed intake, FCR and PER.

Enzyme supplementation improved ($P < 0.05$) AFW and ADWG at 20 and 30 % while addition of enzyme significantly improved ADFI at 10 % BGO level. Addition of enzyme significantly improved FCR at 10 and 30 % BGO levels while addition of enzyme at 20 and 30 % BGO significantly increased PER. PER was significantly better with the increased level of BGO, this may indicate that gastrointestinal tract of the birds can handle the BGO up to 30 % level. Significantly ($P<0.05$) higher AFW, ADWG and ADFI revealed that inclusion level of BGO at 10 % did not pose any deleterious effects on the birds. This result is in line with that of Ani *et al*. (2012) who observed that raw bambara nut waste can be included in enzyme supplemented broiler starter diets at 10% level without adverse effects on broiler chicks. Also, Oyeagu *et al*. (2016) concluded that toasted Bambara nut offal can be included in enzyme supplemented broiler starter diets at 10 kg level without adverse effects on the performance. However, the depression in performance at the 20 and 30 % BGO levels may be attributed to the anti- nutritional factors (ANFs) present in raw BGO (Apata and Qloghobo, 1994; Ensminger *et al*., 1996). Besides ANFs, the high fibre content of the 20 and 30% BGO diets may have contributed to the depressed performance.

Table 3: Effect of feeding different levels of BGO and enzyme fortification on growth performance of broiler chickens

BGO Levels (%)	0		10		20		30	
Enzyme levels (mg/kg)	0	250	0	250	0	250	0	250
Parameters								
AIW (g)	41.90 ± 0.10	41.87 ± 0.13	41.90 ± 0.15	42.00 ± 0.00	41.87 ± 0.13	42.00 ± 0.00	41.90 ± 0.10	42.00 ± 0.00
AFW (g)	2605.09 ± 61.38^{bcd}	2655.56 ± 48.45^{bcd}	2865.74 ± 31.68^{a}	2772.22 ± 58.35^{ab}	2526.30 ± 65.86^{de}	2720.37 ± 41.86^{bc}	2388.89 ± 60.94^{e}	2587.89 ± 44.18^{cd}
ADWG (g)	40.68 ± 0.97^{bcd}	41.42 ± 0.82^{bcd}	44.82 ± 0.51^{a}	43.34 ± 0.93^{ab}	39.44 ± 1.05^{de}	42.51 ± 0.66^{abc}	37.25 ± 0.97^{e}	40.41 ± 0.70^{cd}
ADFI (g)	92.17 ± 0.39^{d}	98.11 ± 0.45^{bc}	102.26 ± 1.78^{a}	95.61 ± 0.29^{c}	96.98 ± 0.96^{bc}	96.90 ± 0.62^{bc}	99.18 ± 0.41^{b}	97.40 ± 1.18^{bc}
FCR	2.27 ± 0.06^{b}	2.37 ± 0.04^{bcd}	2.28 ± 0.02^{bcd}	2.21 ± 0.06^{a}	2.46 ± 0.09^{cd}	2.28 ± 0.02^{bcd}	2.66 ± 0.07^{d}	2.41 ± 0.07^{c}
PI	18.44 ± 0.08^{d}	19.62 ± 0.09^{bc}	20.45 ± 0.36^{a}	19.12 ± 0.05^{c}	19.40 ± 0.19^{bc}	19.38 ± 0.12^{bc}	19.84 ± 0.08^{b}	19.48 ± 0.24^{bc}
PER	2.21 ± 0.05^{ab}	2.11 ± 0.04^{abc}	2.19 ± 0.02^{abc}	2.27 ± 0.05^{a}	2.03 ± 0.07^{c}	2.22 ± 0.04^{ab}	1.88 ± 0.05^{d}	2.07 ± 0.06^{bc}
Feed cost/kg	332.94 ± 8.08^{ab}	359.45 ± 6.13^{a}	326.52 ± 2.48^{b}	327.54 ± 8.16^{b}	338.81 ± 13.85^{ab}	323.37 ± 3.27^{b}	347.37 ± 9.47^{ab}	326.84 ± 9.55^{b}

^{abcd} Means within each row with different superscripts are significantly different ($P< 0.05$). AIW = average initial weight; AFW = average final weight; ADWG = average daily weight gain; ADFI = average daily feed intake; FCR = feed conversion ratio; PI = protein intake; PER = protein efficiency ratio; FC/kg = feed cost per kilogram.

Table 4: Effect of feeding different levels of BGO and enzyme fortification on nutrient digestibility of broiler chickens

BGO levels (%)	0		10		20		30	
Enzyme levels (mg/kg)	0	250	0	250	0	250	0	250
Parameters (DM)								
Dry matter	97.10±0.34^{a}	96.65±0.57^{ab}	95.50±0.29^{b}	96.33±0.39^{ab}	95.51±0.34^{b}	95.82±0.25^{b}	95.95±0.33^{b}	95.85±0.09^{b}
Crude protein	96.66±0.45^{ab}	96.96±0.41^{a}	95.29±0.16^{c}	96.06±0.38^{abc}	95.90±0.36^{abc}	95.31±0.34^{c}	95.65±0.29^{bc}	95.35±0.03^{c}
Ether extract	95.88±0.28^{a}	96.32±1.17^{a}	96.87±0.27^{a}	96.40±0.57^{a}	96.86±0.34^{a}	97.83±0.38^{a}	92.76±1.28^{b}	93.60±0.21^{b}
Ash	95.49±0.43^{a}	91.51±1.64^{b}	92.79±0.32^{ab}	92.59±0.75^{b}	88.47±1.13^{c}	90.45±1.06^{bc}	91.27±0.83^{bc}	92.40±0.36^{b}
Crude protein	85.23±1.78^{b}	86.69±2.85^{b}	84.71±1.20^{b}	87.56±1.59^{ab}	87.81±1.37^{ab}	86.47±1.80^{b}	92.77±0.55^{a}	92.17±0.17^{a}

^{abc} Means within each row with different superscripts are significantly different (P< 0.05).

High dietary fibre is known to limit the amount of the energy available to birds and correspondingly contributes to excessive nutrient excretion (Kung and Grueling, 2000). However, enzyme supplementation improved ADWG, AFW, FCR and PER. A similar improvement in chicken's performance had been reported (Agbede *et al.,* 2002; Shakouri and Kermanshashi, 2004). According to Zobell *et al.* (2000), exogenous enzymes complement the digestive enzymes of poultry by hydrolyzing the non-starch polysaccharides (NSPs) in cereals and vegetable proteins, thereby decreasing gut viscosity, and thus improve nutrient absorption. Feed enzymes also have the ability to alter the bacterial population by digesting the long chain carbohydrate molecules utilized by some bacteria to colonize the tract, and this increases the quantity of protein amino acid digested in the pre caecal section of the tract (Gunal and Yasar, 2004). Significantly ($P<0.05$) higher feed cost per kg was recorded on broiler chickens fed control diets without enzyme. This may be due to cost of the conventional feed ingredients (maize, soybean meal and groundnut cake). The effect of graded levels of BGO and supplementary enzyme inclusion levels on nutrients digestibility of broiler chickens is shown in Table 4.

There were significant ($P < 0.05$) differences among treatments in the digestibility of dry matter (DM), crude protein, crude fibre (CF), ether extract (EE) and nitrogen-free extract (NFE). Birds fed 20 and 30 % BGO diet (with or without enzyme supplementation) had significantly ($P < 0.05$) lower nutrients digestibility of DM than birds fed 0% BGO diet without enzyme but were significantly similar to the birds fed 0 % BGO with enzyme. Birds fed 10 % BGO diet without enzyme supplementation and 20 % with enzyme supplementation had significantly ($P < 0.05$) lowest nutrient digestibility of crude protein compared to the control with and without enzyme. Broiler chickens fed 30 % BGO with and without enzyme recorded least ($P<0.05$) value of ether extract digestibility compared to other dietary treatments. Meanwhile, broiler chickens fed 30 % BGO with and without enzyme recorded highest ($P<0.05$) value of crude fiber digestibility. There was no interaction ($P>0.05$) between enzyme and BGO across the dietary treatments. Increase in BGO levels up to 30 % did not have adverse effect on nutrient absorption as evidenced by the significant similar in the digestibility of DM, CP, CF, EE and NFE. This result is not in line with the findings of Marquardt (1997) that ANFs in raw beans cause depression in nutrient digestibility, absorption and retention. The poor performance of chicks that consumed the RBW containing diets therefore, could be attributed to the high fibre content of RBW diets, poor nutrient absorption and retention, as well as to the ANFs present in RBW. However, none enzymatic effect may be due to the presence of other limiting factors and differences in accessibility or solubility of the substrate that suppress the enzyme potency. Leske and Coon (1999) observed that for an enzyme treatment to be effective, an adequate enzyme treatment to substrate ratio must be present in the diet and that a particular substrate in one ingredient may not exactly be the same as the one found in another ingredient. The substrates differ and the same substrate in different ingredients may respond differently to the enzyme treatment. Such differences arise from the location of the substrate in the ingredient matrix, the presence of other limiting factors and differences in accessibility or solubility. The effect of graded levels of BGO and supplementary enzyme inclusion levels on blood profile of broiler chickens is

Table 5: Effect of feeding different levels of BGO and enzyme fortification on blood profile of broiler chickens

BGO levels (%)	0		10		20		30	
Enzyme level (mg/kg)	0	250	0	250	0	250	0	250
Blood Indices								
PCV (%)	41.00±0.58^{abc}	26.30±0.88^{e}	43.00±2.89^{ab}	44.00±0.58^{a}	35.00±1.73^{d}	38.00±1.15^{cd}	43.00±1.15^{ab}	39.33±0.33^{bcd}
RBC x $10^{6/\mu l}$	5.67±0.09^{a}	4.57±0.09^{c}	5.67±0.20^{a}	5.30±0.11^{ab}	4.87±0.09^{bc}	5.00±0.17^{b}	5.27±0.09^{ab}	5.20±0.17^{b}
WBC x $10^{4/\mu l}$	2.70±0.17^{a}	1.70±0.06^{d}	2.40±0.12^{abc}	2.60±0.12^{ab}	2.00±0.12^{cd}	1.70±0.17^{d}	2.10±0.29^{bcd}	2.10±0.17^{bcd}
HB (g/dL)	13.67±0.20^{ab}	8.80±0.29^{d}	14.37±0.95^{a}	14.67±0.20^{a}	11.70±0.58^{c}	12.67±0.38^{bc}	13.37±0.38^{a}	13.17±0.09^{ab}
MCV (μm^3)	36.47±0.03^{b}	29.57±1.53^{c}	38.10±1.10^{b}	41.93±0.38^{a}	36.20±1.27	38.77±0.03^{ab}	41.67±1.70^{a}	38.07±0.78^{ab}
MCH (pg)	12.17±0.03^{b}	9.77±0.49^{c}	13.00±0.17^{ab}	14.00±0.12^{a}	12.10±0.70^{b}	13.13±0.67^{ab}	13.90±0.58^{a}	12.77±0.26^{ab}
Lymphocytes (%)	57.67±0.88^{a}	59.00±1.15^{a}	60.67±1.45^{a}	51.67±1.45^{b}	58.67±4.33^{a}	59.33±0.88^{a}	60.67±0.88^{a}	60.67±2.02^{a}
Heterophil (%)	38.00±0.58^{b}	37.00±0.58^{b}	36.67±1.45^{b}	45.00±1.15^{a}	36.00±1.73^{b}	38.00±1.15^{b}	37.00±1.73^{b}	36.00±1.73^{b}
Eosinophil (%)	0.67±0.67	1.00±0.00	2.00±0.00	1.33±0.33	1.33±0.88	1.00±0.58	1.00±0.58	2.33±0.33
Monocytes (%)	3.67±0.33^{a}	3.00±0.58^{ab}	1.00±0.00^{c}	2.00±0.00^{abc}	3.67±1.45^{a}	1.67±0.33^{bc}	1.33±0.33^{bc}	1.00±0.00^{c}
Total protein (g/dl)	3.81±0.09^{a}	3.41±0.14^{ab}	3.04±0.09^{b}	3.41±0.14^{b}	3.07±0.28^{b}	3.08±0.07^{b}	3.09±0.01^{b}	2.93±0.16^{b}
Albumin (g/dl)	1.37±0.04^{c}	1.53±0.03^{abc}	1.69±0.10^{a}	1.59±0.07^{abc}	1.60±0.12^{ab}	1.69±0.10^{ab}	1.52±0.02^{abc}	1.46±0.01^{bc}
Globulin (g/dl)	2.47±0.04^{a}	1.89±0.11^{b}	1.35±0.00^{b}	1.66±0.30^{b}	1.38±0.36^{b}	1.39±0.03^{b}	1.57±0.01^{b}	1.48±0.15^{b}

^{abcd}Means within each row with different superscripts are significantly different (P< 0.05). PCV = packed cells volume; WBC = white blood cells; RBC = red blood cells; Hb = Haemoglobin; MCV; mean corpuscular volume; MCH = mean corpuscular haemoglobin

shown in Table 5. Significant ($P < 0.05$) differences were observed on all the parameters observed across the dietary treatments except eiosinophil concentration. The differences ($P<0.05$) observed showed that all the parameter evaluated were similar across the dietary treatments with the control diet. This implied that BGO with and without enzyme can be used in broiler diet up to 30 % with or without enzyme to provide optimum nutrition.

All the value obtained in this study fall within the normal range reported by Talebi *et al*. (2005) on the comparative studies of haematological indices in four different broiler chicken strains (Ross, arbor acres, Cobb and Arian). The significant similarities obtained in all the parameter evaluated with the control showed that the processing technique which gave rise to BGO may have reduced its anti-nutritional factors and improve its energy and protein content which according to Cary *et al.* (2002) improves broiler chicken performance. This also confirmed that haematological traits, especially PCV and Hb were correlated with the nutritional status of the broiler chicken. This agreed with the findings of Adejumo (2004) and Oyawoye and Ogunkunle (1998) who stated that PCV is an index of toxicity in the blood and high levels usually suggest the presence of toxic factors which has adverse effect on blood formation. MCH is an indicator of the blood carrying ability of the RBC and the result obtained could suggest that the birds on all the dietary treatments were more efficient in performing respiratory function as observed by Longe and Fagbenro (1990). WBCs are known to fight against diseases hence, the result of this study indicated that birds on control diets have similar immunity status with the birds on BGO based diets with or without enzyme. Thus, animals with low white blood cell count are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytocis and have higher degree of resistance to diseases (Longe and Fagbenro-Byron, 1990). Consequently, the result obtained in this study suggests the nutritional adequacy of the test material. The leucocyte counts indicated that the birds were not stressed during the experiment either as a result of nutritional or environmental factors, since leucocyte responses are considered as better indicators of chronic stress (Alabi and Ayoola, 2010). Significant effect reported on lymphocytes, heterophil and monocytes in this study is in agreement with the findings of **Owosibo *et al.* (2013).** The result obtained indicated that the nutrients were adequately utilized by the broiler chickens and posed no problem to the birds. It explained why the birds were healthy, not anaemic and capable of withstanding stress. The significantly different MCV, MCHC and MCH in this study indicated that there was no negative effect of diets. The significant similarities recorded with the control and other dietary treatments in serum total protein, albumin and globulin showed that there was normal nutrients metabolism. This showed that the diets had better nutritional quality, good amino acid balance; thus, there was absence of muscle degeneration (liver damage caused by toxicity of dietary substances) on birds (Sola *et al.,* 2011; Soetal *et al.,* 2013). This was in line with the finding of Muhammad and Oloyede (2009) who stated that the values of albumin and globulin are normally low in the blood but becomes high when there is occurrence of liver damage by toxic substances. The values of total protein, albumin and globulin obtained in this study indicated that there was no negative interaction between the dietary BGO and enzyme. The result of interaction effect

showed that addition of enzyme at 0 % BGO significantly reduced RBC, WBC, Hb, MCV, MCH and globulin concentration. At 10 % level of BGO, addition of enzyme also increased MCV and heterophil concentration while lymphocytes concentration decreased. At 20 and 30 % levels of BGO, addition of enzyme decreased MCV and monocytes concentration respectively.

Conclusion

It was concluded that up to 30 % BGO can be included in enzyme supplemented broiler finisher diet without adverse effects on the growth performance, nutrients digestibility and blood profile of finisher broiler chickens.

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