The effect of feeding toasted Bambara nut (*Vigna subterranea* (L) *verdc*) offal and supplementary enzyme on performance of broiler chicks

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The objectives of the study were to evaluate the performance, cost implications and haematological traits of feeding varying dietary levels of toasted bambara nut offal (TBO) (0, 10, 15 and 20%) with supplementary enzyme, 2 enzyme levels, (0 and 0.02%) to one hundred and twenty 14-day old mixed sex commercial broiler chicks (Anak strain) that were randomly divided into eight treatment groups of 15 birds each. Feed intake increased significantly (P<0.05) while final body weight, daily weight gain, total weight gain, feed efficiency and protein efficiency ratio decreased (P<0.05) with increasing levels of TBO in the diets. The costs of daily and total feed intakes and feed cost per kg gain increased significantly (P<0.05) with increasing levels of the diets. Mean cell haemoglobin (MCH), mean cell haemoglobin concentration, (MCHC) and mean cell volume (MCV) were not significantly (P>0.05) affected. Significant (P<0.05) differences existed among treatments in haemoglobin concentration (Hb), packed cell volume (PCV), red blood cell count (RBC) and white blood cell count (WBC). Based on the results obtained in the study, it was concluded that up to 10% toasted bambara nut offal can be included in enzyme supplemented broiler starter diet without adverse effects on the performance and haematological indices of broiler chicks.

Keywords: Anak strain, cost implication, feed intake, haematological indices, red blood cell count

A major problem of poultry in the under developed countries today, apart from the incidence of disease, is that of high cost of feeds, arising from high cost of feed ingredients (Adeniji and Balogun 2002) due to competition among animal, human and industry over the use of cereal and legumes (feed ingredients). This problem has tended to reduce the rate of expansion of the poultry industry, thereby resulting in the deficiency of animal protein in the diet of the average Nigerian (Ani and Adiegwu 2005). One of the efforts made to reduce the high cost of feeds with subsequent reduction in the cost of poultry product was the utilization of cheap and readily available alternative feedstuffs. Research on the use of cheap industrial by-products and unconventional feedstuffs at different levels of dietary inclusion for poultry has been intensified in the last few decades to determine their efficacy in terms of growth and productivity (Din et al. 1979, cited by Adeniji and Balogun 2002). Bambara nut *Vigna subterranean (L) Verdc* offal stands out as one of the cheap non-conventional feedstuffs. It is widely cultivated in the Northern and Southern States of Nigeria (Ani and Omeje 2011). Earlier report (Onyimonyi and Ugwu 2007) had shown that Bambara nut is widely grown in Nigeria and annual production has progressively increased over the years due to increasing consumption. The seeds are milled into flour, processed and consumed as *moimoi* (Enwere 1998). Bambara nut offal is the waste from the milling of Bambara nut. It contains 18.30% crude protein, 20% crude fibre, 5.36%

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ether extract, 41.64% nitrogen-free extract, 10.2% moisture, and 16.74Mj of gross energy (Ani and Omeje 2007). Bambara nut offal has no direct use for humans; hence, it has been used in feeding of poultry and rabbits (Ani 2006; Ani 2007; Ani and Omeje 2007, Ani et al. 2012). However, a major factor limiting the use of Bambara nut offal in the feeding of animals especially the monogastric animals is the presence of anti-nutritional factors such as protease inhibitors, haemagluinnins, tannins, cyanogenic glycoside and flatulence factors in the raw bean (Doku and Karikari 1981; Ensminger et al. 1996; Enwere 1998). The Bambara nut offal used in the present study was therefore processed by toasting to reduce or eliminate the adverse effect of these anti-nutrients and to improve the digestibility of the bambara nut offal based diets, by making some of the nutrients more available (Akande and Fabiyi 2010). Besides the anti-nutritional factors, another limitation to the use of bambara nut offal is its high fibre content (Ani 2007). Poultry cannot fully utilize high fibre diets because they lack the digestive framework to handle highly fibrous diets. It has been shown that the problem of high dietary fibre can be solved by dietary inclusion of enzymes. Enzymes not only improved the utilization of diets containing cereals and legume such as barely, wheat, bambara nut, oats etc, especially for poultry, but also had a positive impact on the quality of the environment through reduced output of excreta and pollutants such as phosphate and nitrogen, including ammonia (Nelson 2005). The reports of Acamovic (2001) and Bedford et al. (1992) revealed that enzymes increased digestibility of feed ingredients and reduced the incidence of weight losses which could be attributed to the presence of non-starch polysaccharides (NSPs) in the diet. The enzyme being considered in this study is Roxazyme G®, an enzyme complex derived from *Trichoderma viride* pers. 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 (Choct and Annison 1992; Bedford et al. 1992; Acamovic 2001). Dierick and Decuypere (1996) reported improvements in both *in vitro* and *in vivo* digestibility. The present study was therefore conducted to determine the effects of dietary inclusion of toasted bambara nut offal and Roxazyme G® (exogenous enzyme) on the growth performance and haematological indices of broiler chicks.

Materials and method

The study was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka, Nigeria. Toasted bambara nut offal and other feed ingredients used in the study were procured from Nsukka and Enugu in Enugu State, Nigeria.

Processing of Bambara nut offal

Bambara nut offal (BNO) used in the formulation of the experimental diets was processed by toasting for 30 minutes at 100^0C. The toasting involved adding about 5kg BNO in an open cast-iron dry pan already set over fire. The BNO was steadily stirred to prevent it from sticking to the pan and from burning until it turned brownish and produced a sweet-smelling aromatic odour (Udensi et al. 2004; Ani 2006; Oyeagu et al. 2015a). At this point, the toasted bambara nut offal (TBO) was removed from the cast-iron pan and spread out to cool before incorporating it into the diets.

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

TBO level (kg)	0		10		15		20	
Enzyme level (kg)	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02
Treatments	1	2	3	4	5	6	7	8
Ingredients								
Maize	51.20	51.20	41.20	41.20	36.20	36.20	31.20	31.20
TBO	0.00	0.00	10.00	10.00	15.00	15.00	20.00	20.00
GNC	20.80	20.80	20.00	20.00	19.15	19.15	18.25	18.25
Fish meal	1.80	1.80	1.00	1.00	0.85	0.85	0.75	0.75
PKC	5.20	5.18	6.80	6.78	7.80	7.80	8.80	8.78
SBM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Wheat offal	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Bone meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
VMP	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total (kg)	100	100	100	100	100	100	100	100
Calculated nutrients								
CP (%)	22.08	22.08	22.01	22.01	22.12	22.12	22.02	22.02
CF (%)	4.02	4.02	5.98	5.98	6.97	6.97	7.96	7.96
ME (kcal/kg)	2950	2950	2945	2945	2930	2930	2925	2925
Cost (₦)	6928.50	6928.50	6237.30	6248.94	5934.44	5934.44	5615.80	5627.44
Chemical composition								
Ash (g/kg)	10.55	10.57	8.58	8.60	7.49	7.50	7.95	7.80
Oil (g/kg)	0.48	0.50	0.79	0.80	0.98	1.00	0.98	1.02
Fibre (g/kg)	4.37	4.28	5.07	5.10	5.01	5.66	5.96	6.08
Crude protein (g/kg)	24.56	23.93	23.01	23.93	23.42	23.32	23.51	23.57
Gross energy (MJ/kg)	11.89	12.09	11.67	12.43	12.38	12.36	12.80	12.88
Nitrogen-free extract (g/kg)	50.93	50.81	50.71	50.92	51.16	50.09	45.92	46.50

TBO=Toasted bambara nut offal. GNC=Groundnut cake. PKC=Palm kernel cake. SBM=Soybean meal. VMP=Vitamin mineral premix. CP=Crude protein. CF=Crude fibre. ME=Metabolizable energy. 1USD=₦198.

Animals and management

The experiment was carried out in accordance with the provisions of the Ethical Committee on the use of animals and humans for biomedical research of the University of Nigeria, Nsukka (2006). One hundred and twenty 14-day old broiler birds were randomly divided into 8 groups of 15 birds each. The groups were randomly assigned to 8 diets containing 11.67-12.24MJ of ME/Kg and 21.14-22.08 g/kg crude protein diets in a 2 x 4 factorial arrangement involving four levels (0, 10, 15 and 20 kg) of TBO and 2 enzyme levels

(0 and 0.02 kg). The ingredient composition (kg) of the diets is presented in Table 1.

Each treatment was replicated 3 times with 5 birds per replicate placed in 2.6m x 3m deep litter pens of fresh wood shavings. Feed and water were supplied *ad libitum* to the birds from 14 to 42 day of age. A general flock prophylactic management strategy and routine vaccinations were administered as and when due. Day 1 – intra ocular (New castle disease vaccine), Week 2 – Gumboro (Gumboro disease vaccine), Week 3 – Lasota (New castle disease vaccine), Week 4 – Gumboro (Gumboro disease vaccine), Week 5 – fowl pox (fowl pox vaccine), and Week 6 – Lasota (New castle disease vaccine). Some drugs were administered to the birds via water for prevention of some diseases. Vitalyte was used according to the dosage provided on the packet for appetite booster and energy supply. It also provided the birds with some vitamins. Keprosyril was used according to the prescribed dose on the packet for antibiotics related disease, Embazin fort was also used based on the prescribed dose on the packet for coccidiosis and intestinal infections.

Measurement of growth parameters

At the beginning of the experiment, chicks in each replicate were weighed individually and subsequently on a weekly basis. Feed intake was determined daily by the weigh-back technique.

Feed conversion ratio was calculated from the data on live weights and feed intakes as quantity (g) of feed consumed per unit (g) weight gained over the same period. Feed cost per kg gain and protein efficiency ratio were also calculated as weight gain (g) divided by protein consumed (g) over the same period. All measurements were taken between 8.00 am and 12.00 noon.

Blood collection and evaluation

During week four of the experiment, three birds were randomly selected from each treatment group (one bird per replicate) and blood samples were collected from their wing veins with sterile needles. The blood samples were collected in properly labeled sterilized bottle containing EDTA (Ethylene diamine tetra-acetic acid) for haematological analysis. Packed cell volume (PCV) and haemoglobin concentration (Hb) were determined by the methods described by Lamb (1991). Red blood cell (RBC) and total white blood cell (WBC) counts were estimated using the haemocytometer, while mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were calculated according to Mitruka and Rawnsley (1977).

Proximate analyses

Experimental diets were analyzed for their proximate components according to the methods of AOAC with procedure number 1230 (1990). The proximate analysis is presented in Table 1.

Statistical design

Data collected were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) for 2 x 4 factorial arrangement as outlined by Steel and Torrie (1980) using Statistical Package for the Social Sciences (SPSS 2003), windows version 17.0. Significantly, different means were separated using Duncan's New Multiple Range Test (Duncan, 1955) option of the package.

Results and discussion

Performance of broiler chick fed graded levels of TBO with supplementary enzyme

Table 2 shows the effects of dietary toasted bambara nut (TBO) offal and supplementary enzyme on growth performance of broilers.

The effects of treatments on final body weight, daily feed intake, daily weight gain, total weight gain, feed conversion ratio and protein efficiency ratio were significant (P<0.05). Birds on treatment 2 (0 kg TBO diet + 0.02 kg enzyme) and treatment 4 (10 kg TBO diet + 0.02 kg enzyme) had significantly (P< 0.05) higher final body weight values than birds on other treatments. Birds fed treatments 7 and 8 (20 kg TBO diet with and without enzyme, respectively) had the lowest (P< 0.05) final body weight.

Table 2: Performance of broiler chicks fed graded levels of TBO with supplementary enzyme

TBO level (kg)	0		10		15		20		SEM
Enzyme level (kg)	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	
Treatments	1	2	3	4	5	6	7	8	
Parameters									
Initial body weight (kg)	0.51^{a}	0.56^{a}	0.57^{a}	0.55^{a}	0.54^{a}	0.54^{a}	0.55^{b}	0.58^{b}	0.26
Final body weight (kg)	1.39^{ab}	1.46^{a}	1.37^{b}	1.45^{a}	1.35^{b}	1.36^{b}	1.28^{d}	1.30^{d}	0.14
Daily feed intake (g)	78.10^{c}	70.50^{d}	80.90^{c}	71.30^{d}	86.30^{c}	80.90^{b}	92.20^{a}	90.30^{ab}	2.08
Daily weight gain (g)	28.80^{ab}	33.50^{a}	28.00^{ab}	36.30^{a}	26.10^{b}	31.10^{ab}	28.70^{ab}	31.30^{ab}	1.21
Total weight gain (kg)	0.88^{ab}	0.90^{a}	0.79^{bc}	0.90^{a}	0.81^{b}	0.82^{b}	0.73^{c}	0.72^{c}	0.03
FCR (g feed/g gain)	2.71^{bc}	2.10^{c}	2.89^{b}	1.96^{cd}	3.31^{a}	$2.61b^{c}$	3.39^{a}	2.89^{b}	0.06
PER (g protein intake/g gain)	3.05^{ab}	3.38^{a}	2.10^{bc}	2.91^{ab}	1.89^{c}	2.26^{bc}	1.69^{c}	2.00^{bc}	0.11

a,b,c,d; Mean values in a row with different letter superscripts are significantly (p<0.05) different. SME= Standard error of the mean. TBO=Toasted bambara nut offal. FRC=Feed conversion ratio. PER=Protein efficiency ratio.

The average daily feed intake (ADFI) value of birds on treatment 7 (20 kg TBO + 0 kg enzyme) was significantly (P<0.05) higher than the ADFI value of birds on other treatments. Birds fed treatments 2 (0 kg TBO diet + 0.02 kg enzyme) and treatment 4 (10 kg TBO diet + 0.02 kg enzyme) had the lowest (P< 0.05) ADFI. Treatment 2 (0 kg TBO diet + 0.02 kg enzyme) and treatment 4 (10 kg TBO diet + 0.02 kg enzyme) fed birds had higher (P< 0.05) average daily weight gain (ADWG) values than birds on other treatments while treatment 5 (15 kg TBO diet + 0 kg enzyme) fed birds had the lowest value on ADWG. Result revealed that, birds on treatments 1, 3, 6, 7 and 8 had similar (P>0.05) ADWG values. The total weight gain values of treatment 2 (0 kg TBO diet + 0.02 kg enzyme) and treatment 4 (10 kg TBO diet + 0.02 kg enzyme) fed birds were higher (P< 0.05) than treatments 3, 5, 6, 7 and 8 fed birds. Birds on treatments 7 and 8 (20 kg TBO diet with and without enzyme, respectively) had the least (P< 0.05) total weight gain values which were similar to that of birds on treatment 3 (10 kg TBO diet without enzyme). Treatment 5 (15 kg TBO diet + 0 kg enzyme) and treatment 7 (20 kg TBO diet + 0 kg enzyme) fed birds had higher (P< 0.05) feed conversion ratio (FCR) values than birds on other treatments. Treatment 2 (0 kg TBO diet + 0.02 kg enzyme) and treatment 4 (10 kg TBO diet + 0.02 kg enzyme) fed birds had similar FCR values and these were the least and the best. Birds fed treatment 2 (0 kg TBO diet + 0.02 kg enzyme) had similar PER values with birds fed treatments 1 (0 kg TBO diet + 0 kg enzyme) and 4 (10 kg TBO diet + 0.02 kg enzyme) and this was significantly (P< 0.05) higher than the PER values of birds fed other treatments. Treatments 1 (0 kg TBO diet + 0 kg enzyme) and 4 (10 kg TBO diet + 0.02 kg enzyme) had significantly (P< 0.05) higher PER values than birds fed treatments 5 (15 kg TBO diet + 0 kg enzyme) and 7 (20 kg TBO diet + 0 kg enzyme). There were significant (P<0.05) interactions between TBO and enzyme levels in FBW, total weight gain, ADFI and FCR. Enzyme supplementation improved (P<0.05) FBW and total weight gain at the 10 kg TBO inclusion level; reduced (P<0.05) ADFI at the 0, 10 and 15 kg TBO inclusion levels and decreased (P<0.05) FCR at all the TBO inclusion levels. The results (Table 2) obtained in the present study revealed that birds fed treatment 4 (diet containing 10 kg TBO with supplementary enzyme) had lower feed intake, higher growth rate and better efficiency of feed conversion and utilization than other treated birds. Evidently, their performance was comparable to that of birds on the control diets (0 kg TBO diets with and without enzyme supplementation).

Interestingly, the results obtained in the present study are in line with earlier reports (Ghazi et al. 2002; Yu et al. 2007; Hajati et al. 2009) which showed that birds fed high fibre diets containing cereals and legumes with supplementary enzyme had comparable growth performance with those on control diet. Observation from the result (Table 2) showed that feed intake increased with increase in TBO levels in the diets. However, this observation contradicts earlier reports (Apata and Ojo 2000; Ajaja et al. 2003; Alam et al. 2003). The increase in feed intake may be due to the fibrous and bulky nature of the TBO-containing diets. Earlier report (Pond et al. 1974 cited by Ani et al. 2012) showed that feed consumption and the quantity of feed required per kg of gain in pigs increased with increase in the dietary fibre. Such increase was attributed to the bulky nature and low total digestible nutrient of the feed. The marked effect of enzyme supplementation was a significant (P<0.05) decrease in the feed intake of birds that consumed enzyme supplemented diets. Richter et al. (1995), Samarasinghe et al. (2000) and Oyeagu et al. (2015a) reported similar observation and stated that, the decrease in feed intake by the addition of enzyme could be attributed to the fact that those birds that consumed less amount of feed were able to fulfill their nutrient (energy) requirement. Enzymes have been shown to increase the digestibility of fibrous diet by disrupting the plant cell walls, and by reducing the viscosity of the gut contents, thereby enhancing nutrient absorption (Choct and Annison 1992; Bedford et al. 1992; Acamovic 2000). Table 2 shows that beyond 10 kg TBO inclusion level, final body weight, daily weight gain, total weight gain, efficiency of feed utilization (as shown by FCR) and protein efficiency ratio decreased significantly. This is in line with earlier reports (Apata and Ojo 2000; Ani et al. 2012). The low performance observed at the 15 and 20 kg TBO inclusion levels may be due to the presence of anti-nutritional factors (ANFs) in toasted bambara nut offal as reported by Apata and Qloghobo (1994) and Ensminger et al. (1996). Besides ANFs, the high fibre content of the 15 and 20 kg TBO diets (Table 2) may have contributed to the depressed performance (Rad and Keshavarz, 1976 as cited by Khan et al. 2006; Ani 2007). High dietary fibre is known to limit the amount of the energy available to the birds and correspondingly contributes to excessive nutrient excretion (Kung and Grueling 2000; Santos Jr. et al. 2004). However, enzyme supplementation improved final body weight, average daily weight gain, efficiency of feed utilization (as shown by FCR) ratio and protein efficiency ratio. A similar improvement in chicks' performance had been reported (Agbede et al. 2002; Shakouri and Kermanshashi 2004; Oyeagu et al. 2015a). According to Zobell et al. (2000); Buchanan et al. (2007), exogenous enzymes compliment the digestive enzymes of poultry by hydrolyzing the non-starch polysaccharides (NSPs) in cereals and vegetable proteins, thereby decreasing gut viscosity, and thus improved nutrient absorption. Bedford (1997) and Gunal and Yasar (2004) had also reported that 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 digestive tract.

Cost of feeding dietary levels of toasted Bambara nut waste and supplementary enzyme to broiler chicks

Table 3 shows the cost of feeding dietary levels of toasted Bambara nut offal and supplementary enzyme to broiler chicks. There was a clear margin in the production costs of diets containing toasted bambara nut offal (TBO) with supplementary enzyme. Feed cost per kg decreased as the levels of TBO increased in the diets. The costs of average daily feed intake and average total feed intake and feed cost per kg gain were significantly (P<0.05) affected by dietary treatments. The cost of total feed intake was reduced significantly (P<0.05) at the 10 kg TBO inclusion level with supplementary enzyme only when compared to the control diet (0 kg TBO diet without enzyme supplementation). However, feed cost per kg gain increased with increasing levels of TBO in the diets. The observed increase in feed cost per kg gain may be due to increase in average daily feed intake, poor feed efficiency, and poor growth rate of chicks that consumed diets containing high levels of TBO.

Table 3: Cost implication of feeding graded levels of TBO with supplementary enzyme to broiler chicks

TBO level (kg)	0		10		15		20		SEM
Enzyme level (kg)	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	
Treatments	1	2	3	4	5	6	7	8	
Parameters									
Feed cost per kg of feed (₦)	69.29	69.40	62.37	62.49	59.23	59.34	56.16	56.27	-
Cost of daily feed intake (₦)	5.41^{a}	4.90^{ab}	5.05^{ab}	4.44^{b}	5.11^{ab}	4.80^{ab}	5.46^{a}	5.08^{ab}	0.13
Cost of total feed intake (₦)	147.80^{a}	140.08^{bc}	141.80^{bc}	138.56^{c}	149.20^{a}	143.20^{b}	149.60^{a}	141.30^{bc}	0.87
Feed cost per kg weight gain (₦)	159.00^{c}	149.21^{d}	168.92^{b}	148.00^{d}	176.50^{a}	175.70^{a}	178.00^{a}	175.93^{a}	2.41

a,b,c,d; Mean values in a row with different letter superscripts are significantly (p<0.05) different. SME= Standard error of the mean. TBO=Toasted bambara nut offal. 1USD = ₦198.

Interestingly, birds that consumed the diets supplemented with enzyme had significantly (P<0.05) reduced costs of daily feed intake, total feed consumed and feed cost per kg gain as opposed to those that consumed the diets without supplementary enzyme. Mikulshi et al. (1998), Ajaja et al. (2003) and Ani et al. (2012) had reported similar observation and attributed such reduction in cost to reduced average daily feed intake, improved feed efficiency and utilization, and improved average daily weight gain of the chicks. Incidentally, birds fed dietary treatment 4 (10 kg TBO + 0.02 kg enzyme) produced the least cost of feed per kg gain as compared to the control (0 kg TBO diet without enzyme supplementation). A saving of this magnitude will be of great benefit to the farmer, since feed alone accounts for over 70% of the recurrent expenditure in poultry production (Atteh 2002; Adebayo et al. 2002; Kehinde 2006). The inclusion of exogenous enzyme in poultry feed not only reduces the cost of production, it also allow ability of diet formulation, ensures better litter quality and good health of birds, all which will have positive impact on total production cost (Costa et al. 2008). Earlier reports (Alam et al. 2003; Khan et al. 2006) had also shown that the supplementation of broiler diets with exogenous enzyme resulted in improved feed utilization and profit maximization.

Haematological parameters

Data on the haematological traits of the experimental birds are presented in Table 4. Although there were no significant (P>0.05) differences among treatments in mean cell haemoglobin (MCH), mean cell volume (MCV), and mean cell haemoglobin concentration (MCHC) values, significant (P<0.05) differences existed between treatments in haemoglobin (Hb) concentration, white blood cell (WBC), packed cell volume (PCV) and red blood cell count (RBC) values.

Table 4: Haematological parameters of broiler chicks fed graded levels of TBO with supplementary enzyme

TBO level (kg)	0		10		15		20		SEM
Enzyme level (kg)	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	
Treatments	1	2	3	4	5	6	7	8	
Parameters									
Haemoglobin (g/dl)	8.70^{ab}	9.50^{a}	8.00^{b}	9.18^{a}	7.15^{bc}	8.40^{ab}	6.25^{c}	8.09^{b}	0.29
White Blood Cell ($10^3/mm^3$)	13.15^{b}	15.15^{a}	12.40^{bc}	14.10^{ab}	11.60^{c}	13.40^{b}	10.84^{c}	12.69^{bc}	0.34
Packed Cell Volume (%)	26.10^{b}	28.50^{a}	24.00^{bc}	28.03^{a}	21.50^{c}	25.20^{b}	18.80^{d}	22.67^{c}	0.53
Red Blood Cell ($10^6/mm^3$)	4.35^{ab}	4.75^{a}	4.00^{b}	4.70^{a}	3.57^{bc}	4.20^{ab}	3.12^{c}	4.05^{b}	0.11
Mean Cell haemoglobin (pg)	20.03^{a}	20.40^{a}	20.00^{a}	20.10^{a}	20.03^{a}	19.97^{a}	20.02^{a}	21.04^{a}	0.42
Mean Cell volume (μm^3)	60.10^{a}	60.19^{a}	59.88^{a}	60.09^{a}	60.00^{a}	60.03^{a}	59.19^{a}	60.06^{a}	0.67
Mean Cell Haemoglobin Conc. (%)	33.30^{a}	34.00^{a}	32.95^{a}	33.80^{a}	33.00^{a}	33.15^{a}	33.29^{a}	33.90^{a}	1.02

a,b,c,d; Mean values in a row with different letter superscripts are significantly (p<0.05) different. SME= Standard error of the mean. TBO=Toasted bambaranut offal.

The values of Hb, WBC, PCV and RBC decreased significantly ($P<0.05$) at the 15 and 20 kg TBO inclusion levels, especially for treatments 5 and 7 (15 and 20 kg TBO diets with 0 kg enzyme respectively). The observed decrease in Hb, WBC, PVC and RBC with increase in the level of TBO in the diet may be as a result of the destruction of the red blood cells by the anti-nutritional factors (ANFs) and perhaps other toxicants that could have remained in the processed Bambara nut offal. Ani and Omeje (2011) had made similar suggestion. Ani and Okorie (2005) had observed a similar reduction in the PCV of broiler chicks fed diets containing high levels of castor oil bean meal and attributed such reduction to the presence of toxicants in the dietary castor bean meal. Earlier report (Jacob et al. 1968) had shown that cyanide induces the detachment of 'haem' from haemoglobin, thus resulting in impaired erythropoiesis. It also binds to haemoglobin to form cyanomethaemoglobin thereby impeding its oxygen carrying capacity. The resultant effect is the inactivation of cytochrome oxidase and inhibition of oxidative phosphorylation in red blood cells thereby leading to ineffective oxygen utilization. In such a condition, there could be an impairment of cellular respiration that would lead to tissue necrosis, especially of the brain, liver, and heart (Borron and Baud 2005). Erythropoietin is known to be produced in the liver, kidney and bone marrow. Damage to the liver, kidney and bone marrow will therefore affect the production and effective use of erythropoietin due to impaired erythropoiesis (Rebar, 2005). Experimental work by Liener (1986) also revealed that lectins, either intact or partially digested may themselves enter the circulatory system to cause tissue or organ damage. The observed reduction in the values of Hb, WBC, PCV and RBC at the 15 and 20 kg TBO levels could therefore, suggest a relative blood dilution and lower efficiency of cellular oxygen transportation (Ani and Omeje 2011). Reduction in the value of Hb, WBC, PCV and RBC of the birds that consumed the 15 and 20 kg TBO diets might be due to low nutrient availability and utilization. This condition, coupled with the adverse effects of the toxicants in the TBO could have been enough to make the treated birds vulnerable to attacks by some pathogens. Schalm et al. (1975) as cited by Ani and Omeje (2011), reported that leucocytes exercise their function as free macrophages in the tissue in defense against microbial agents. Monocyctes for instance have the ability for phagocytosis or pinocytosis. However, the inclusion of enzyme in some of the diets helped to reverse the adverse effect of TBO on the haematological trait. The non-significant ($P> 0.05$) differences observed among treatments in MCV, MCH and MCHC are similar to that observed by Ani and Omeje (2011).

Conclusion

It can be concluded from the results obtained in this study that toasted Bambara nut offal can be included in enzyme supplemented broiler starter diets at 10 kg level without adverse effects on the performance, haematological indices and feed cost per kg weight gain of birds.

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