African Journal of Biotechnology Vol. 11(56), pp. 11991-11997, 12 July, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.4106
ISSN 1684–5315 ©2012 Academic Journals

Full Length Research Paper

Effects of raw bambara nut (*Voandzeia subterranea* l) waste and enzyme complex on growth performance and apparent nutrient retention in broiler chickens

A. O. Ani*, O. D. Omeje and L. C. Ugwuowo

Department of Animal Science, University of Nigeria, Nsukka, Nigeria.

Accepted 15 June, 2012

The effects of graded levels of raw bambara nut (*Voandzeia subterranea* L) waste and supplementary enzyme (Roxayzme G) on performance of broiler chicks were investigated. One hundred and twenty 14-day old unsexed commercial broiler chicks (Anak strain) were randomly divided into eight groups of 15 birds each. The groups were randomly assigned to eight energetic (9.24 to 11.68 MJ of ME/kg) and nitrogenous (21.12 to 22.12% crude protein) diets in a 4 × 2 factorial arrangement involving four levels (0, 10, 15 and 20%) of raw bambara nut waste and 2 enzyme levels (0 and 0.02%). Each treatment was replicated three times with five birds per replicate. Results show that increasing levels of raw bambara nut waste in the diets increased ($P < 0.05$) average daily feed intake and feed cost per kg weight gain, but decreased ($P < 0.05$) final body weight, average daily weight gain, feed conversion efficiency and protein efficiency ratio. Increasing raw bambara nut waste levels also depressed ($P < 0.05$) nutrient absorption as evidenced by significant reduction in the retention of dry matter, nitrogen, crude fibre, ether extract, nitrogen-free extract and gross energy. However, supplementation with enzyme improved ($P < 0.05$) final body weight and average daily weight gain at 0% raw bambara nut waste level, feed conversion ratio at the 10, 15 and 20% raw bambara nut waste levels, and reduced average daily feed intake and feed cost per kg weight gain at all the raw bambara nut waste (RBW) inclusion levels. Enzyme supplementation also improved ($P < 0.05$) the retention of dry matter at the 0, 15 and 20% raw bambara nut waste levels, nitrogen at 0% raw bambara nut waste level, ether extract and nitrogen-free extract at 0 and 20% raw bambara nut waste levels, and gross energy at 10 and 20% raw bambara nut waste levels. There was no incidence of chicks' mortality in all the treatments. The results of the study indicate that 10% raw bambara nut waste can be included in enzyme supplemented broiler starter diet without adverse effects on broiler chicks and also to reduce cost of production.

Key words: Raw bambara nut waste, enzyme, diets, broiler chicks, growth performance.

INTRODUCTION

The problem of protein deficiency in Nigeria is evidenced by the fact that an average Nigerian consumes about 10 g per day of the minimum daily protein intake of 35 g recommended by Food and Agricultural Organization (FAO, 1997). Ani and Adiegwu (2005) had attributed the low protein intake to low level of animal protein production and high cost of animal products, and suggested the intensification of the production of highly reproductive animals with short generation intervals such as poultry, pigs and rabbits (Fielding, 1991; Serres, 1992; Smith, 2001). However, the major factor militating against intensive animal production in Nigeria is the high cost of feed and feed ingredients, especially the conventional energy and protein feed ingredients like maize, soybean cake and groundnut cake. The ever-increasing cost of poultry feeds with the attendant increase in the cost of chicken and eggs shows that there is need to explore the use of alternative feed ingredients that are cheaper and locally available. One of such alternative feed ingredients is bambara nut (*Voandzeia subterranea* L) waste.

*Corresponding author. E-mail: austinani2011@yahoo.com.

Bambara nut is widely cultivated in the Northern and Southern States of Nigeria where the seeds are processed into flour and consumed as moi moi (Enwere, 1998). The processing of the seeds into flour results in the production of the waste which contains 16.40% crude protein (Okeke, 2000). Bambara nut waste has been used in the feeding of poultry and rabbits (Okeke, 2000; Ani and Okafor, 2004; Ani, 2006, Ani, 2008). However, its use in the feeding of monogastric animals is limited by the presence of such antinutritional factors, as protease inhibitors, haemaglutinins, tannins, cyanogenic glycosides and flatulence factors in the raw bean (Doku and Karikari, 1981; Ensminger, 1996; Enwere, 1998). Besides antinutritional factors, another limitation is its high fibre content. 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 Roxazyme G, 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 (Choct and Annison, 1992; Bedford et al., 1992; Acromovic, 2001). The present study was therefore conducted to determine the effects of graded levels of raw bambara nut waste and supplementary enzyme (Roxazyme G) on the growth performance of broiler chicks.

MATERIALS AND METHODS

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

Formulation of experimental diets

Eight energetic [9.24 to 11.67 MJ/kg metabolizable energy (ME)] and nitrogenous [21.14 to 22.08% crude protein (CP)] experimental diets containing five raw bambara nut waste levels (0, 10, 15 and 20%) and two enzyme levels (0 and 0.02%) were formulated with the feed ingredients. The percentage composition of the diets is presented in Table 1.

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 unsexed commercial broiler chicks (Anak strain) were randomly divided into eight groups of 15 birds each. The groups were randomly assigned to eight energetic (9.24 to 11.68 MJ of ME/kg) and nitrogenous (21.12 to 22.12% crude protein) diets in a 4 × 2 factorial arrangement involving four levels (0, 10, 15 and 20%) of raw bambara nut waste (RBW) and two enzyme levels (0 and 0.02%). Each treatment was replicated three times with five birds per replicate placed in 2.6 × 3 m deep litter pens of fresh wood shavings. Kerosene stoves placed under metal hovers for 14 days provided heat. Feed and water were supplied *ad libitum* to the birds from 14 to 42 days of age. The birds were subjected to standard broiler management procedure.

Measurement of growth parameters

At the beginning of the experiment, chicks in each replicate were weighed together. Feed intake was determined daily by the weigh-back technique. Live weights were recorded weekly for each replicate.

Parameters calculated

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. Protein efficiency ratio was 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. Mortality record was kept on daily basis. The chicks were vaccinated against New Castle disease in the first and third weeks and against Gumboro disease in the second and fourth weeks. Prophylactic treatment against coccidiosis with Embazin forte at two weeks of age was also given to the birds.

Apparent nutrient retention by broiler chicks

During week four of the experiment, a seven-day excreta collection from three chicks per treatment (one per replicate) was carried out to determine the apparent retention of the proximate components. Apparent nutrient retention (C) can be defined as follows: Quantity of nutrient in the feed consumed (A) - quantity of nutrient in the faeces voided (B) divided by the quantity of nutrient in the feed consumed (A) multiplied by 100, that is (C = A - B / A ×100). Apparent total tract retention (ATTR) can be calculated as follows: Quantity of the feed consumed (A) - quantity of faeces voided (B) divided by the quantity of the feed consumed (A) multiplied by 100, that is (C = A - B / A × 100). During this period, birds were housed individually in metabolism cages and weighed quantity of feed (90% of the daily feed intake) was offered to each bird daily. The birds were allowed two days to adjust to the cage environment before droppings were collected. Daily feed consumption was recorded as the difference between the quantity offered and the quantity left after 24 h. Faecal droppings were collected from separate cages in detachable trays placed beneath the wire mesh floor of the cages, oven-dried and weighed over a seven day period. At the end of the collection period, all faecal samples from each bird were bulked and preserved in sealed polythene bags until they were required for analysis.

Proximate and statistical analyses

Samples of the eight experimental diets and excreta samples were analyzed for their proximate compositions at the Nutrition Laboratory, Department of Animal Science, University of Nigeria, Nsukka. The samples were analyzed according to AOAC (1990) methods (No. 1230) as follows: The ether extract was determined by extracting the diet with ethyl ether placed in a designed container. The solvent is dripped through the sample, a process

Table 1. Ingredients and nutrient composition of experimental diets (% as fed basis).

Ingredient/diet	Raw bambara nut level (%)							
	0		10		15		20	
	Enzyme level (%)							
	0	0.02	0	0.02	0	0.02	0	0.02
Raw bambara waste	0.00	0.00	10.0	10.0	15.0	15.0	20.0	20.0
Groundnut cake	20.8	20.8	20.0	20.0	19.15	19.15	18.25	18.25
Fish meal	1.8	1.8	1.0	1.0	0.85	0.85	0.75	0.75
Palm kernel cake	5.2	5.18	6.8	6.78	7.8	7.78	8.8	8.78
Soybean meal (44% CP)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Wheat offal	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Bone meal	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	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
Roxazyme G2	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02
Total (%)	100	100	100	100	100	100	100	100
Calculated composition								
CP (%)	22.08	22.08	22.01	22.00	22.12	21.12	21.14	21.14
Crude fibre (%)	4.02	4.02	5.98	5.98	6.97	6.97	7.96	7.96
Energy (MJ/kg ME)	11.67	11.67	11.05	11.05	10.02	10.02	9.24	9.24
Determined composition								
Dry matter (%)	92.36	91.78	92.20	91.62	92.70	92.79	88.64	89.75
Crude protein (%)	24.65	23.93	23.01	23.93	23.42	23.20	23.61	23.67
Crude fibre (%)	4.37	4.28	5.11	4.87	6.35	7.02	7.84	7.85
Ether extract (%)	5.41	5.56	5.07	5.10	5.01	5.66	4.28	5.25
Ash (%)	7.10	7.30	8.40	6.80	6.86	6.94	8.03	7.48
Nitrogen –free extract (%)	50.83	50.71	50.61	50.92	51.06	49.97	44.92	45.50

that removes fat and other soluble substances. Results obtained using this procedure is quantitative, rather than qualitative in nature. The crude protein was determined using the Kjeldahl's digestion procedure. The sample is digested in hot, concentrated sulphuric acid, which converts all the carbon containing compounds to carbon dioxide, and nitrogen is trapped and subsequently measured and expressed as percentage. The rationale behind this procedure is that all proteins contain nitrogen. The crude fibre was determined by boiling (refluxing) the sample (of which fat has been extracted from) in a weak acid solution, filtrating and boiling in a weak solution of alkali, and filtering and drying; the residue remaining is the crude fibre. The dry matter was determined by drying the samples in an oven at 100°C for 24 h or more, depending on the nature of the product being dried. The inorganic minerals were estimated by the ash value, which is determined by burning the sample at a temperature of 350 to 600°C until nothing is left but metallic oxides or contaminants such as rocks and soil. The nitrogen-free extract was determined by summing up the products of all the above mentioned procedures and subtracting from 100. It is not determined using a laboratory procedure. It is an estimate of the readily available carbohydrates. Gross energy of feed and faecal samples was determined in a Parr oxygen adiabatic bomb calorimeter. Data collected were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) as described by Steel and Torrie (1980). Significantly different means were separated using Duncan's New multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Proximate composition and energy content of raw bambara nut waste

The proximate composition and gross energy content of RBW is presented in Table 2 as follows: moisture, 10.2%; CP, 18.30%; crude fibre (CF), 20%; ether extract (EE), 5.36%; nitrogen-free extract (NFE), 41.640% and 16.74 mJ of gross energy (GE).

The proximate values obtained in the present study (Table 2) seem to differ from the values (9.50 and 9.00% moisture, 16.19 and 17.00% CP, 21.00 and 26% CF, 4.00 and 5.00% EE, 3.50 and 2.50% ash, 53.31 and

Table 2. Proximate composition and gross energy content of raw bambara nut waste.

Parameter	Value
Dry matter (%)	89.80
Crude protein (%)	18.30
Crude fibre (%)	20.00
Ether extract (%)	5.36
Ash (%)	4.50
Nitrogen –free extract (%)	41.64
Gross energy (MJ/kg)	16.74

40.50% NFE) reported by Okeke (2000) and Ani (2007), respectively. The observed difference may have resulted from the varieties of seeds used and from the processing method (milling and sieving) adopted. Differences in proximate compositions of legumes and oil seeds have been attributed to differences in the varieties of seeds used (Amaefule and Obioha, 1998; Ani and Okorie, 2006).

Performance of broiler chicks

Table 3 shows the effects of dietary RBW and supplementary enzyme on performance and mortality of broiler chicks. There were significant differences (P < 0.05) among treatments in final body weight (FBW), average daily weight gain (ADWG), average daily feed intake (ADFI), feed conversion ratio (FCR) and protein efficiency ratio (PER). Chicks fed the control diet (0% RBW) had significantly (P < 0.05) higher FBW and ADWG, and lower ADFI than chicks fed 10, 15 and 20% RBW diets (with or without enzyme supplementation). The highest (P < 0.05) ADFI and FCR, and the lowest (P < 0.05) PER were recorded at the 20% RBW level (without enzyme supplementation). Chicks fed 10% RBW diet (with enzyme supplementation) had significantly (P < 0.05) higher FBW and ADWG than chicks fed 15 and 20% RBW diets. Chicks fed 0% RBW diet (with or without enzyme supplementation) had lower (P < 0.05) FCR than chicks fed 15 and 20% RBW diets. There were significant (P < 0.05) interactions between RBW and enzyme levels in FBW, ADWG, ADFI and FCR. Enzyme supplementation improved (P < 0.05) FBW and ADWG at 0% RBW level, FCR at the 10, 15 and 20% RBW levels, and reduced ADFI at all RBW inclusion levels. There was no incidence of chicks' mortality in all the treatments.

The marked effect of RBW inclusion on nutrient composition was a progressive increase in crude fibre content from 4.28% at the 0% RBW inclusion level to 7.84% at the 20% RBW level (Table 2). Feed intake also increased with the increase in RBW levels. The present finding contradicts earlier reports (Apata and Ojo, 2000; Ajaja et al., 2003). The increase in feed intake may be attributed to the fibrous and bulky nature, coupled with the low nutrient (energy) content of the RBW containing diets. This seems to corroborate the report of Pond et al. (1974) that feed consumption and the quantity of feed required per kg of gain in pigs increased with increase in the dietary fibre. They attributed such increase to the bulky nature and low total digestible nutrient of the feed. However, the feed intake of birds that consumed enzyme supplemented diets decreased significantly (P < 0.05). Ritcher et al. (1995) and Samarasinghe et al. (2000) had reported a similar observation. As shown in Table 4, ADGW, FBW, feed efficiency and PER decreased with increasing RBW levels. A similar observation had earlier been reported (Apata and Ojo, 2000). The depression in performance at the 15 and 20% RBW levels may be attributed to the anti nutritional factors (ANFs) present in raw bambara nut waste (Doku and Karikari, 1981; Apata and Qloghobo, 1994; Ensminger et al., 1996). Besides ANFs, the high fibre content of the 15 and 20% RBW diets may have contributed to the depressed performance. 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, FBW, feed conversion ratio and PER. A similar improvement in chicks' performance had been reported (Agbede et al., 2002; Shakouri and Kermanshashi, 2004). According to Broz et al. (1994) and Zobell et al. (2000), 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 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 (Bedford, 1997; Gunal and Yasar, 2004).

Apparent nutrient retention (% of intake) of nutrients by broiler chicks

Table 4 shows the effect of graded levels of RBW and supplementary enzyme inclusion levels on apparent retention (% of intake) of nutrients by broiler chicks. There were significant (P < 0.05) differences among treatments in the apparent retention of dry matter (DM), nitrogen, crude fibre (CF), ether extract (EE), nitrogen-free extract (NFE) and gross energy (GE). Birds fed 20% RBW diet (with or without enzyme supplementation) had significantly (P < 0.05) lower retention of DM, nitrogen, CF, NFE and GE than birds fed 0% RBW diet. Birds fed 15% RBW diet (with or without enzyme supplementation) had significantly (P < 0.05) lower retention of nitrogen and GE than birds on control diet. The NFE retention

Table 3. Effect of dietary graded levels of raw bambara nut waste and supplementary enzyme on growth performance chickens from 14 to 42 days of age.

Parameter	Raw bambara nut level (%)								SEM
	0		10		15		20		
	Enzyme level (%)								
	0	0.02	0	0.02	0	0.02	0	0.02	
Initial body weight (g/bird)	370.77	370.77	380.00	370.00	370.77	360.77	390.	370.77	2.43
Av. final body weight (g/bird)	1490.77^{b}	1610.77^{a}	1340.77^{cd}	1400.00^{c}	1230.77^{e}	1270.77^{de}	1200.54^{e}	1260.00^{e}	27.76
Av. weight gain (g/bird/day)	40.00^{b}	44.29^{a}	34.29^{cd}	36.90^{c}	30.71^{ef}	32.50^{de}	28.93^{f}	31.79^{def}	1.01
Av. feed intake (g/bird/day)	64.29^{c}	51.45^{e}	68.28^{b}	58.57^{d}	60.43^{d}	69.71^{b}	74.14^{a}	67.86^{b}	1.04
Feed conversion ratio (g feed/g gain)	1.61^{e}	1.39^{e}	1.99^{cd}	1.59^{e}	2.27^{b}	1.86^{d}	2.56^{a}	2.13^{bc}	0.08
Protein efficiency ratio (g protein intake/g gain	2.84^{ab}	3.17^{a}	2.18^{bc}	2.59^{abc}	1.96^{cd}	2.32^{bcd}	1.65^{d}	1.95^{cd}	0.10
Mortality (%)	-	-	-	-	-	-	-	-	-

$^{a,b,c..f}$Means on the same row with different superscripts are significantly (P < 0.05) different. SEM, Standard error of the mean.

of birds fed 10 and 15% RBW diets (with or without enzyme supplementation) was significantly (P < 0.05) higher than that of birds fed 20% RBW (with or without enzyme supplementation). There were significant (P < 0.05) RBW × enzyme interactions in DM, nitrogen, EE, NFE and GE retention. Enzyme supplementation significantly (P < 0.05) improved the retention of DM at the 0, 15 and 20% RBW levels, nitrogen at 0% RBW level, EE and NFE at 0 and 20% RBW levels, and GE at 10 and 20% RBW levels.

Increase in RBW levels beyond 10% had adverse effect on nutrient absorption as evidenced by the significant depression in the retention of DM, nitrogen, CF, EE, NFE and GE. Similar depression in nutrient digestibility had been reported in rabbits (Jokthan et al., 2006) and in broiler chicks (Abdelsamie et al., 1983). Kass et al. (1980) and Fielding (1991) attributed such depression in apparent nutrient digestibility to higher rate of passage of digester in animals fed on high fibre diets. Fibre tends to limit the amount of intake and the retention of the available energy by birds, and contributes to excessive nutrient excretion (Kung and Grueling, 2000). Besides fibre, anti-nutritional factors such as protease inhibitors, tannins and haemaglutinins may have contributed to the observed depression in nutrient digestibility and retention. This agrees with the reported findings of Osho (1989) and 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, enzyme supplementation of the RBW diets improved nutrient retention. This corroborates earlier reports (Ikegami, 1990; Francesch et al., 1994) that enzymes improved the digestion and absorption of nutrients. Perhaps enzymes might have helped to reduce the viscosity of the encapsulated nutrients to enhance nutrient uptake and absorption as reported by Toibipont and Kermanshashi (2004).

Cost implication of feeding graded levels of raw bambara nut waste and supplementary enzyme to broiler chicks

Table 5 shows the cost implication of feeding graded levels of raw bambara nut waste and supplementary enzyme to broiler chicks. There were significant differences (P < 0.05) among treatments in cost of daily feed intake, total feed intake and feed cost per kg weight gain. Chicks fed 10, 15 and 20% RBW diets (without enzyme supplementation) had significantly (P < 0.05) lower costs of daily and total feed intakes than birds on control diet. The feed cost per kg weight gain of chicks fed 20% RBW diets (with or without enzyme supplementation) was significantly (P < 0.05) higher than that of birds fed 0, 10 and 15% RBW diets. There were significant RBW × enzyme interactions in costs of daily and total feed intakes and in feed cost per kg weight gain. Enzyme supplementation reduced (P < 0.05) costs of daily and total feed intakes and feed cost per kg weight gain at all RBW inclusion levels. The cost of daily

Table 4. Effect of dietary graded levels of raw bambara nut waste and supplementary enzyme on apparent retention of nutrients by broiler chickens from 14 to 42 days of age.

Parameter	Raw bambara nut level (%)								SEM
	0		10		15		20		
	Enzyme level (%)								
	0	0.02	0	0.02	0	0.02	0	0.02	
Dry matter (%)	68.00^{b}	74.99^{a}	67.75^{b}	71.88^{ab}	56.38^{c}	68.20^{b}	47.73^{d}	58.200^{c}	1.79
Nitrogen (%)	60.87^{b}	66.62^{a}	53.09^{cd}	57.58^{bc}	49.33^{de}	50.21^{de}	46.23^{e}	49.34^{de}	1.40
Crude fibre (%)	66.34^{ab}	68.00^{a}	60.34^{bcd}	65.40^{abc}	60.00^{cd}	62.95^{bc}	55.19^{d}	56.52^{d}	2.02
Ether extract (%)	67.72^{b}	71.72^{a}	65.90^{b}	66.76^{b}	65.81^{b}	66.41^{b}	58.67^{c}	65.22^{b}	1.08
Nitrogen- free extract (%)	56.21^{c}	60.00^{a}	55.21^{c}	59.01^{ab}	54.36^{c}	56.60^{bc}	46.34^{e}	51.46^{d}	0.93
Gross energy (%)	72.83^{ab}	75.30^{a}	64.26^{c}	70.80^{b}	63.32^{c}	66.24^{c}	57.70^{d}	66.63^{c}	1.18

$^{a,b,...e}$Means on the same row with different superscripts are significantly (P < 0.05) different. SEM, Standard error of the mean.

Table 5. Cost implication of feeding graded levels of raw bambara nut waste and supplementary enzyme to broiler chicks.

Parameter	Raw bambara nut level (%)								
	0		20		30		40		SEM
	Enzyme level (%)								
	0	0.02	0	0.02	0	0.02	0	0.02	
Feed cost per kg (₦)	51.13	51.82	46.46	47.16	44.44	45.14	42.49	43.19	-
Cost of average daily feed intake (₦/kg)	3.99^{a}	3.18^{b}	3.17^{b}	2.76^{d}	3.10^{b}	2.70^{d}	3.15^{b}	2.93^{c}	0.04
Cost of average total feed intake (₦/kg)	92.04^{a}	89.13^{b}	88.82^{b}	77.34^{d}	86.75^{b}	76.38^{d}	88.21^{b}	82.06^{c}	1.13
Feed cost per kg weight gain (₦)	82.32^{de}	72.03^{f}	92.46^{c}	74.98^{ef}	100.88^{b}	83.96^{d}	108.92^{a}	92.14^{c}	2.47

$^{a,b,c..f}$Means on the same row with different superscripts are significantly (P < 0.05) different. SEM = Standard error of mean.

feed intake and the cost of total feed intake decreased with increasing RBW levels, while feed cost per kg weight gain increased with increasing RBW levels. The observed increase in feed cost per kg weight gain may be attributed to increase in ADFI, poor feed conversion efficiency and utilization, and poor growth rate of chicks that consumed diets containing high levels of RBW. Nevertheless, enzyme supplementation significantly (P < 0.05) reduced feed cost per kg weight gain. Reduction in feed cost per kg weight gain of chicks fed enzyme-supplemented diets had earlier been reported (Mikulshi et al., 1998; Ajaja et al., 2003). The observed reduction in feed cost per kg weight gain of chicks that consumed the enzyme- supplemented diets may probably be due to reduction in ADFI, improved feed efficiency and utilization, and improved ADWG of the chicks.

Conclusion

It is evident from the results obtained in this study that raw bambara nut waste can be included in enzyme supplemented broiler starter diets at 10% level without adverse effects on broiler chicks and to enhance cost reduction of feed per kg weight gain.

REFERENCES

Abdelsamie RE, Ranaweera NP, Nana WE (1983). The influence of fibre content and physical texture of diet on performance of broilers in the tropics. Poult. Sci. 24:383-390.

Acromovic T (2001). Commecial application of enzyme technology for poultry production. World Poult. Sci. J. 57:225-242

Agbede JO, Ajaja K, Aletor VA (2002). Influence of Roxazyme G. supplementation on the utilization of sorghum dust-based diets for broiler chicks. Proc. 25th Ann. Conf. Nig. Soc. for Anim. Prod (NSAP), March 17-21, 2002, Fed. Univ. of Tech. Akure, Nig. pp.105-108.

Ajaja K, Agbede JO, Aletor VA (2003). Influence of Roxazyme G supplementation on utilization of wheat offal or rice bran by broilers. Proc. 8th Ann. Crop. Anim Sci. Ass. of Nig. (ASAN) Sept 16th –18th Fed. Univ. Tech, Minna, Nigeria. pp. 32-34.

Amaefule KU, Obioha FC (1998). The substitution of pigeon pea seed (*Cajanus cajan*) for groundnut cake and maize in broiler finisher rations. Nig. J. Anim. Prod., 28(1): 31-39.

AOAC (1990). Association of Official Analytical Chemists. Official Methods of Analysis 15th ed. Washington, D.C. p.1230.

Ani AO, Okafor IC (2004).Nutritional evaluation of raw bambara groundnut waste(*Voandzeia subterranea* L) waste for weaner rabbits.Proc.29th Ann. Conf. Nig. Soc. For Anim. Prod.(NSAP), March 21st-25th,2004,Usman Danfodiyo Univ. Sokoto, Nigeria pp.183-186.

Ani AO, Adiegwu LI (2005). The feeding value of velvet beans (*Mucuna pruriens*) to weaner rabbits. Proc.30th Ann. Conf. Nig. Soc. For Anim. Prod. (NSAP), March 20th-24th, 2005, Univ. Nigeria, Nsukka, Nigeria pp.186-189.

Ani AO (2006). Effect of toasted bambara groundnut (*Voandzeia subterranea* L) waste on haematol. carcass and organ characteristics of growing rabbits. Proc.31st Ann. Conf. Nig. Soc. For. Anim. Prod.

(NSAP), March 12th-15th, 2006, Bayero Univ. Kano, Nigeria pp.341-345.

Ani AO, Okorie, AU (2006). The efficacy of two-stage cooking as a method of Detoxifying castor oil bean (*Ricinus communis* L) meal for livestock feeding. J. Sustain. Agric. Environ. 8(1):14-22.

Ani AO (2008). Effect of graded levels of toasted bambara groundnut (*Voandzeia subterranea* L) waste on performance of growing rabbits. Nig. J. Anim. Prod. 35(2):202-209.

Apata DF, Ologhobo AD (1994). Biochemical evaluation of some Nigerian legume seeds. Food Chem. 49:33-38.

Apata DF, Ojo V (2000). Efficacy of the *Trichoderma viride* enzyme complex in broiler starters fed cowpea testa based diets Proc.25th Ann. Conf. Nig. Soc. for Anim. Prod. (NSAP), March 19th –23rd, 2000.Michael Okpara Univ. Agric. Umudike, Nigeria pp.132-134.

Bedford MR, Smith CH, Veldman M, Versteng A, Beynene AC (1992). Dietary carboxymethylcellulose with high instead of low viscocity reduces macronutrient digestion in broiler chicken. J. Nutr. 127:483-487.

Bedford MR (1997). Reduced viscosity of intenstinal digesta and enhanced nutrient digestibility in chickens given exogenous enzymes. In*:* Enzymes in Poult. Swine nutrition. IDRC Publication p.145.

Broz J, Oldale P, Perrin-Voltz AH (1994). Effects of *Trichordemer viride* enzyme complex on performance of broiler chickens receiving pelleted diets. Arch. Geflugelk. 58:182-185.

Choct M, Annison G (1992). Anti-nutritive effect of wheat pentosans in broiler chickens. Role of viscosity and gut microflora. Brit. Poult. Sci. 33:821-834.

Doku JA, Karikari OO (1981). Tropical Grasses. Legume Bull. 31:20-27.

Duncan DB (1955). New Multiple Range Test*.* Biometrics 11:1-42.

Ensminger ME, Oldfield JE, Heinemann WN (1996). Feeds and Nutrition*.* The Ensminger Publishing Coy; Clovis California, USA pp.324-366.

Enwere NJ (1998). Foods of Plant Origin*.* Afro-Orbis Pub. Ltd. Nsukka, Nigeria p.301.

FAO (1997). Food and Agriculture Organization. Production Year Book, 50: 118-122.

Fielding D (1991). Rabbits. The Tropical Agriculturalist. Macmillan Education Ltd. London. p. 106.

Francesch M, Perez-Vendrell A M, Estave-Garcia E, Brufau J (1994). Effect of cultivar, pelleting and enzyme addition on nutritive value of barley in poult. diets. Br. Poult. Sci. 35(2):259-272.

Gunal M, Yasar S (2004). Performance and some digesta parameters of broiler chickens given low or high viscosity wheat-based diets with or without enzyme supplementation. Turk. J. Vet. Anim. Sci. 28:323-327.

Ikegami S (1990). Effect of viscous indigestible polysaccharides on pancreatic secretion and digestive organs in monogastrics. J. Nutr. 120:253-366.

Jokthan GE, Alawa JP, Adeyinka IA, Adamu AM (2006). The effect of fibre sources, on the performance of young rabbits. Nig. J. Anim. Prod. 33(2)192-196.

Kass ML, Van Soest PJ, Pond WG, Lewis B, McDowell RE (1980). Utilization of dietary fibre from alfalfa by growing swine. 1 Apparent digestibility of diet components in specific segments of the gastro intestinal tract*.* J. Anim. Sci. 50:175-191.

Kung P, Grueling HT (2000). Enzyme supplementation of a poultry diet containing rye and wheat. Br. J. Nutr. 62:139-149.

Marquardt RR (1997). Enzyme enhancement of the nutritional value of cereals: role of viscous water-soluble, nonstarch polysaccharides in chick performance. In: Enzymes in Poult. Swine Nutrition. IDRC Publication p.154.

Mikulshi D, Jankoweki J, El-Soud SBA, Farugh A, Abou-Zeid AE (1998). Effect of feeding enzyme supplemented triticale-barley diets on broiler chicken. Egypt Poult. Sci. J. 19:607-618.

Okeke DP (2000). Replacement of soybean meal with bambara waste (*Voandzeia subterranea*) in broiler diets. M.Sc. Thesis Dept. Anim. Sci. Univ. Nigeria, Nsukka.

Osho SM (1989). Soya bean processing for household use in food crops production, utilization and nutrition. Mbah BN and Nnanyelugo DO (editors), Dotom publishers ltd. Ibadan. pp. 68-78.

Pond WG, Lowrey RS, Manner JH (1974). Effects of crude fibre level on ration digestibility and performance in growing finishing swine. J. Anim. Sci. 21:692-699.

Richter G, Lemser A, Muller A (1995). Is enzyme feeding beneficial in broiler feeding? Lohnt sich der Einsatz von Enzymen in der Broilermast Muhle + Mischfutter technik. 131(39):546-547. In: Poult. Abst. 21:5.

Samarasinghe K, Messikommer R, Wenk C (2000). Activity of supplementation enzymes and their effect on nutrient utilization and growth performance of growing chickens as affected by pelleting temperature. Arch. Anim. Nutr. 53:45-58.

Shakouri MD, Kermanshahi H (2004). Effect of enzyme supplementation in wheat and trickle based diets on broiler performance. In: Proceedings of the Annual Conference of the British Society of Animal Science, Univ. York, York, UK, 5-7 April, 2004 p.273.

Serres H (1992). Manual of Pig Production in the Tropics. CAB International, Wellington pp.14-50.

Smith AJ (2001). Poultry. The Tropical Agriculturalist. Revised ed. Macmillan Education Ltd. London pp. 1-11.

Steel RGD, Torrie JH (1980). Principles and Procedures of Statistics. A Biometric Approach (2nd ed.). McGraw-Hill Publishers, New York p.633

Toibipont K, Kermanshahi H (2004). Effect of levels of tallow and NSP degrading enzyme supplements on nutrient efficiency of broiler chickens. In: Proceedings of the Annual Conference of the British Society of Animal Sci. Univ. York, York, UK, 5-7 April, 2004 p.273.

Zobell BI, Chock M, Freed RD (2000). Inhibition of nutrient digestion by wheat Pentosans. Br. J. Nutr. 67:123-132.