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Performance and Nutrient Utilization of Growing Rabbits Fed Graded Levels of Raw Bambara Groundnut [*Vigna subterranean* (L.) *Verdc*] Offal Diets

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Abstract: Performance and nutrient utilization of growing rabbits (N = 30) fed graded levels of raw Bambara groundnut [*Vigna subterranean* (L.) *Verdc*] offal (BGO) diets were determined in a Completely Randomized Design (CRD). There were five treatments each replicated three times with two rabbits per replicate. The inclusion levels of BGO in the diets were 0, 5, 10, 15 and 20%. Measurements were live weight, weight gain, feed and nutrient intakes, feed conversion ratio, feed cost and carcass quality. Also measured were nutrients voided, nutrient retention and apparent digestibility coefficient of nutrients. Results showed that 15% BGO diet improved daily weight gain (19.16 g), final live weight (1.18 kg), feed conversion ratio (2.56) and lowered cost per kg live weight gain (Naira 76.55) of rabbits than other diets. Increased level of BGO in the diets resulted in a significant ($p<0.05$) decrease in total feed cost. Rabbits fed 20% BGO diet had higher CP (18.92 g) and CF (11.31 g) intakes, significantly ($p<0.05$) higher faecal DM (98.58 g), OM (88.97 g) and faecal nitrogen (0.04 g) than rabbits fed other diets. The diet of 20% BGO also depressed coefficient of apparent digestibility of ether extract (85.28%), CF (65.80%), crude ash and NFE (89.54%) compared to other diets. It was concluded that growing rabbits could be fed diets containing up to 15% BGO to enhance daily weight gain and reduce feed cost, which would not adversely affect nutrient intake, coefficient of apparent digestibility and nutrient utilization.

Key words: Bambara groundnut offal, performance, nutrient utilization, rabbits

INTRODUCTION

The advantage of rabbits in Nigeria as source of animal protein has been identified (Amaefule *et al*., 2004). Domestic rabbit is raised as a cheap source of meat for reasons of economy of feeding, high prolificacy (Cheeke, 1986) and small body size that makes it suitable for backyard rearing and easy consumption by a family. Rabbits could be produced using inexpensive and renewable resources such as garden "wastes" and by-products of grains (Lukefahr, 2009).

Rabbits are able to thrive on non-conventional feedstuffs (Omole, 1982; 1988) with their utilization of large forage diets limited as a result of post gastric fibre digestion in the caecum (Belenguer *et al*., 2008). Caecal microorganisms are able to convert nutrients leaving the small intestine to volatile fatty acids (VFAs), gases (CH_4, CO_2, H_2), ammonia and compounds incorporated into microbial cells. As such, rabbits require concentrate feed, although they could manage high crude fibre levels (14-25%) in the diet (Adegbola *et al*., 1985).

Raw Bambara Groundnut Offal (BGO) is a by-product (sieviate) of local milling of bambara groundnut seeds to obtain flour for human consumption. Raw seeds are usually crushed with a local mill, sieved to remove the seed coat, then the decorticated seeds milled and sieved several times (2-4 times depending on the efficiency of the machine) to obtain chaff-free powdery flour. BGO contains about 18-21% CP (Ezuoke, 2003; Amaefule and Iroanya, 2004; Amaefule and Osuagwu, 2005), 5.29-6.43% CF and 12.44 MJ/kg GE (Ezuoke, 2003; Amaefule and Iroanya, 2004; Ukpabi *et al*., 2008). The offal has no industrial and other uses as at now (Amaefule and Osuagwu, 2005; Ukpabi *et al*., 2008) but could constitute an environmental hazard if not properly disposed. The feeding of rabbits with diets containing BGO could be one of the strategies towards achieving sustainable rabbit production in the rural and peri-urban areas, as the producers of BGO and small-scale rabbit farmers could be encouraged to keep and feed rabbits with it.

There are scientific reports of feeding toasted (Onyimonyi and Onukwufor, 2003; Ani, 2008) and raw (Amaefule and Osuagwu, 2005) bambara groundnut offal to pullets in which 5% BGO replaced part of soybean meal and maize in the diet. Also, Amaefule and Iroanya (2004) reported that 10% raw BGO replaced part of soybean meal and maize in broiler diet without adverse effect on performance. In another report, Ukpabi *et al*. (2008) indicated that diets containing raw BGO should be supplemented with lysine and methionine to improve broiler feed conversion ratio, apparent digestibility coefficient of CP and reduce feed cost.

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The nutritive value of complete diets is usually determined through digestibility assays, using *in vivo* method (faecal digestibility) as one of the techniques (Peiretti *et al*., 2007). The present study had the objective to determine the performance and nutrient utilization of growing rabbits fed graded levels of raw Bambara Groundnut Offal (BGO) diets.

MATERIALS AND METHODS

Experimental site: The study was conducted at the Rabbit Unit of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike. Umudike is located within the humid tropical zone of Nigeria and bears the coordinates of 5° 28^1 North and 7° 31^1 East, at an altitude of 122 m above sea level (NRCRI, 2009). The rabbits used for the study were obtained from the University Farm while feedstuffs were purchased from local dealers at Umuahia, Abia State, Nigeria.

Experimental rabbits and their management: The rabbits were housed in a 3-tier rabbit cage that had a total of 15 hutches (5 hutches per tier). The cages were located inside the rabbit building equipped with vents and windows for proper ventilation. Each hutch unit (with dimensions: 100 cm x 40 cm x 40 cm), which accommodated two rabbits was partitioned with wooden plank and wire mesh and was also fitted with aluminum drinkers and feeders (15 cm x 10 cm x 10 cm). There were six rabbits per treatment and two rabbits per replicate.

Thirty hybrid (Chinchilla x New Zealand) growing rabbits of mixed sexes (15 males and 15 females) were used. Two rabbits (male and female) were housed in a hutch unit. The rabbits were fed the experimental diets (Table 1) and water *ad libitum* throughout the experimental period. Equal quantities (25 g) each of fresh *Panicum maximum* and *Centrocema pubescens* were also provided (Amaefule *et al*., 2005) since rabbits require forage for normal metabolism. The rabbits were given coccidiostat and dewormed with Piperazine^R before the start of the experimental feeding.

Experimental diets: Five diets were formulated using graded levels of raw Bambara Groundnut Offal (BGO). The inclusion levels were 0, 5, 10, 15 and 20% in diets shown in Table 1. The BGO replaced part of maize offal in the diets that were also fortified with bone meal, vitamin premix and common salt (NaCl).

Experimental design and data collection: The experimental design was Completely Randomized Design (CRD) with model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} = General observation μ = Overall mean

T_i = Treatment effect e_{ij} = Experimental error

The rabbits were offered the experimental diets and water *ad libitum* and any leftover feed was recorded each day. They were weighed individually at the start of the experiment and subsequently on a weekly basis, usually in the morning hours (8.00-9.00 am local time). Weight gain was determined by subtracting initial live weight from final weight, Feed Conversion Ratio (FCR) as feed intake divided by weight gain and protein

Table 1: Percentage composition of diets of graded levels of raw bambara groundnut offal diets fed to growing rabbits

Feedstuffs	0%	5%	10%	15%	20%
Bambara groundnut offal	0.00	5.00	10.00	15.00	20.00
Local fish meal	2.00	2.00	2.00	2.00	2.00
Maize offal	54.50	49.50	44.50	39.50	34.50
Soybean meal	10.00	10.00	10.00	10.00	10.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Palm kernel meal	20.00	20.00	20.00	20.00	20.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Vitamin premix*	0.25	0.25	0.25	0.25	0.25
Common salt (NaCl)	0.25	0.25	0.25	0.25	0.25
Total (%)	100.00	100.00	100.00	100.00	100.00
Calculated composition					
CP (%)	17.14	17.44	17.44	18.04	18.34
ME (MJ/kg)	10.94	10.94	10.93	10.93	10.92
Crude fibre (%)	8.03	8.04	8.04	8.04	8.04
Lysine (%)	0.89	0.93	0.97	1.01	1.05
Methionine (%)	0.33	0.33	0.34	0.35	0.35
Avail. Ca (%)	0.89	0.89	0.89	0.89	0.89
Available P (%)	0.39	0.39	0.39	0.39	0.39
Ca: P ratio	2.28	2.28	2.28	2.28	2.28

*Vitamin premix supplied: Vitamin A 200000 IU, Vit. D_3 400000 IU, Vit. E 8.00 g, Vit. K_3 0.04 g, Vit. B_{12} 0.32 g, Vit. B_2 0.96 g, Vit. B_6 0.56 g, Vit. C 2400 mg, Folic acid 0.16 g, Biotin 8.00 mg, Choline 48 g, Ca pantothionate 1.60 g, Mn 16.00 mg, Fe 8.00 mg, Zinc 7.20 g, Copper 0.32 g, Iodine 0.25 mg, Cobalt 36.00 mg, Selenium 16.00 mg, BHT 32.00 g

efficiency ratio as weight gain divided by protein intake. Cost per kg live weight gain was calculated as FCR x cost per kg feed (Ukachukwu and Anugwa, 1995).

The rabbits were fasted for 12 h, weighed, stunned and slaughtered (bled by cutting the jugular vein) to determine carcass and organ characteristics. The dressed weight (slaughter weight minus blood, head, tail, pelt, intestine and internal organs) was expressed as a percentage of the slaughter weight (warm dressed percentage) while the internal organs were also expressed as a percentage of the dressed weight.

Digestibility study: Two rabbits per replicate were transferred to a metabolism cage (100 cm x 40 cm x 40 cm) and fed the experimental diets *ad libitum* for five days (preliminary period) to enable the rabbits get used to the environment. The quantity of feed consumed was recorded. They were weighed individually at the end of the 5th day, fasted for 24 h and thereafter given 90% of their *ad libitum* feed intake for 7 days. At the end of the 7th day, the rabbits were fasted again for 24 h. Faeces were collected each day plus that from the last 24 h fasting, oven dried at 60^{o}C and stored in a deep freezer from where they were collected for proximate analysis.

Chemical and data analyses: The proximate composition of BGO, diets and faecal samples were determined according to methods of AOAC (1990). The data collected were subjected to Analysis of Variance (ANOVA) as described by Steel and Torrie (1980) and differences among treatment means separated using Duncan's Multiple Range Test (Duncan, 1955). Data in percentages were subjected to Arcsine transformation before ANOVA.

RESULTS AND DISCUSSION

The proximate composition of Bambara Groundnut Offal (BGO) and diets of graded levels of BGO is presented in Table 2. The BGO used in this study had a CP content of 19.22% which was 8.59% higher than a CP content of 17.70% earlier reported by Amaefule and Osuagwu (2005) and 13.06% higher than 17.00% reported by Ani (2008). The differences in proximate composition of the BGO could be attributed to differences in variety of seeds and effect of processing (extent of sieving to obtain the flour for human consumption). The Crude Fibre (CF) content of the BGO diets were considered normal given that rabbits could tolerate high dietary fibre levels in the diet (Adegbola *et al*., 1985).

Performance: The performance of growing rabbits as influenced by diets of graded levels of BGO is presented in Table 3. Growing rabbits fed 20% BGO diet consumed 3.34, 2.29, 8.03 and 4.31% significantly ($p<0.05$) more feed than those fed 0, 5, 10 and 15% BGO diet, respectively. But this increased feed intake could not result in increased growth rate (weight gain) and improved feed conversion ratio. Rather, the increased feed intake of rabbits fed 20% BGO diet resulted in crude protein consumption that was 12.44, 12.67, 27.42 and 24.31% significantly ($p<0.05$) higher than those of rabbits fed 0, 5, 10 and 15% BGO diet, respectively. We could not assume that the increased protein intake was due to the increase in the CP content of the diets with increase in the level of BGO (Table 1) since the difference between the highest (18.34%) and lowest (17.14%) was only 7% CP. Rabbits fed 15% BGO diet had significantly ($p<0.05$) higher protein efficiency ratio than those fed 0, 5 and 20% BGO diets.

Table 2: Proximate composition of raw bambara groundnut offal and raw bambara ground based concentrate diets (% DM Basis)

Composition	BGO	0%	5%	10%	15%	20%
Dry matter (%)	86.10	90.90	90.18	91.34	90.24	89.78
Organic matter (%)	84.10	82.05	80.23	81.69	80.64	81.03
Crude protein (%)	19.22	15.63	15.40	13.64	13.65	17.23
Crude fibre (%)	5.40	9.30	9.95	9.75	10.15	10.30
Ether extract (%)	2.36	2.55	2.70	3.85	3.70	2.25
Crude ash (%)	2.00	8.85	9.95	9.65	9.60	8.75
Nitrogen free extract (%)	57.12	54.57	52.18	54.45	53.14	50.99

BGO = Bambara groundnut offal

Table 3: Performance of growing rabbits fed graded levels of raw bambara groundnut offal diets

Parameters	0%	5%	10%	15%	20%	SEM
Initial live weight (g)	89.50	102.08	91.67	108.33	100.40	9.21
Final live weight (kg)	0.78	0.82	0.93	1.18	0.93	0.13
Daily weight gain (g)	12.39	12.76	14.99	19.16	14.72	2.26
Daily feed intake (g)+	48.64^{b}	49.17^{b}	46.28^{b}	48.15^{b}	50.32^{a}	2.57
FCR++	3.93	3.85	3.09	2.51	3.42	1.93
Daily protein intake (g)+	7.60^{b}	7.58^{b}	6.30^{c}	6.57^{c}	8.68^{a}	1.23
Protein efficiency ratio++	1.63^{b}	1.68^{b}	2.38^{ab}	2.92^{a}	1.70^{b}	0.86
Cost per kg feed (Naira)	32.61	31.81	30.88	29.90	29.00	-
Total feed cost (Naira)	1109.51	1082.56	1050.26	1017.96	985.58	-
Cost per kg weight gain (Naira)	128.16	135.53	96.95	76.55	111.64	18.50

^{a,b}Means in the same row with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean. + = Concentrate only, ++ = Concentrate and forage

It could be observed that the daily feed intake and weight gain of growing rabbits recorded in this study were lower than the feed intake (96-130 g) and daily weight gain (34.50-39.00 g) obtained by Eiben *et al.* (2008) and Volek and Marounek (2008) probably due to differences in breed of rabbits, diet composition and environment. However, the two performance indices compared favourably with the results of Aderinola *et al.* (2008) with varying levels of *Centrocema pubescens* or *Calapogonium mucunoides* in the savanna zone of Nigeria. It has been reported by Carabano *et al.* (2008) that daily weight gains of rabbits are relatively slower after weaning and as such, the higher weight of gut maintenance on total requirements could increase significantly the relative needs for certain essential and non-essential amino acids with advanced stage of growth. This could have influenced the rate of gain of rabbits in this study since they were weaned rabbits. The performance of our growing rabbits could also have been influenced by anti-nutritional substances that may be contained in the raw BGO diets (Soetan and Oyewole, 2009), especially protease (trypsin) inhibitor (Aletor and Fetuga, 1987).

Increase in the level of BGO in the diets numerically decreased cost of one kg of feed and consequently reduced total feed cost but could not significantly ($p>0.05$) influence feed cost per kg live weight gain of the rabbits. However, this reduction in feed cost is likely to increase a farmer's income and profit from rabbits fed especially 15% raw BGO diets. This observation had earlier been made by Amaefule and Osuagwu (2005) that the inclusion of raw BGO in the diet of pullets considerably reduced the feed cost.

Carcass and organ characteristics: Rabbits fed graded levels of raw BGO diets had no significant ($p>0.05$) differences in their percent warm dressed weight, heart, kidney, liver and spleen (Table 4). The warm dressed weight (hot carcass yield) obtained in this study compared favourably with those of Marguenda *et al.* (2008) and Pinheiro *et al.* (2008). A consideration of the liver, which had no pathological lesions and also not enlarged, suggests that the anti-nutritional substances that raw BGO may have contained were well handled and or tolerated by the rabbits.

Nutrient intake and utilization: Rabbits fed 20% BGO diet had significantly ($p<0.05$) higher CP and lower EE intakes than rabbits fed 10 or 15% BGO diet (Table 5). Also faecal CP, CF, crude ash and Nitrogen Free Extract (NFE) outputs were significantly ($p<0.05$) higher with rabbits fed 20% BGO diet than those fed 0, 10 or 15% BGO diets.

There were no significant ($p>0.05$) differences among the rabbits fed BGO diets in DM and OM intakes, faecal output, DM and OM retention and digested N as percentage of N intake. However, 20% BGO diet significantly increased faecal DM and OM (Table 6) while 15% BGO diet increased DM intake as percentage of live body weight over that of rabbits fed 0% BGO (control) diet.

Rabbits fed 0 and 20% BGO diets had similar N intake and digested N, while those fed 15% BGO diet had significantly ($p<0.05$) lower value for the two indices. Faecal N output of rabbits fed 5, 10, 15 and 20% BGO diets were similar but significantly ($p<0.05$) higher than the N output of growing rabbits fed control diet (Table 6). It was observed that the differences in N intake could have resulted in the same pattern of differences in digested N, suggesting that N retention in rabbits may be related to N intake. Carabano *et al.* (2008) had reported that caecal microbiota is able to use non-protein compounds and also that caecotrophy

Table 4: Carcass and organ characteristics of growing rabbits fed graded levels of raw bambara groundnut offal diets

Parameters	0%	5%	10%	15%	20%	SEM
Warn dressed weight (%)	62.50	60.98	61.27	67.62	58.98	3.22
Heart (%)	0.66	0.59	0.44	0.64	0.44	0.08
Kidney (%)	0.78	0.84	0.76	0.66	0.76	0.07
Liver (%)	3.95	4.06	4.45	3.91	4.38	0.31
Spleen (%)	0.23	0.27	0.26	0.16	0.23	0.12

SEM = Standard Error of Mean

Table 5: Nutrient intake and faecal nutrient output of growing rabbits fed graded levels of raw bambara groundnut offal diets

Nutrient intake (g)	0%	5%	10%	15%	20%	SEM
Crude protein	17.50^{a}	16.17^{ab}	13.53^{b}	13.46^{b}	18.92^{a}	0.99
Ether extract	2.85^{ab}	2.84^{ab}	3.82^{a}	3.65^{a}	2.47^{b}	0.25
Crude fibre	10.41	10.45	9.67	10.01	11.31	0.67
Crude ash	9.91	10.45	9.57	9.47	9.61	0.66
Nitrogen free extract	61.09	54.79	54.00	52.40	56.04	3.79
Faecal Output (g)						
Crude protein	0.74^{b}	1.39^{ab}	0.95^{b}	0.99^{b}	2.53^{a}	0.50
Ether extract	0.14	0.17	0.16	0.16	0.35	0.66
Crude fibre	0.99^{b}	1.44^{b}	1.09^{b}	1.13^{b}	3.86^{a}	0.54
Crude ash	0.71^{b}	1.08^{ab}	0.69^{b}	0.77^{b}	2.23^{a}	0.43
Nitrogen free extract	1.68^{b}	1.99^{b}	1.85^{b}	1.80^{b}	5.48^{a}	0.84

^{a,b}Means in the same row with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean

Table 6: Nutrient retention of growing rabbits fed graded levels of raw bambara groundnut offal diets

Indices	0%	5%	10%	15%	20%	SEM
Live weight (kg)	0.78^{b}	0.82^{ab}	0.88^{ab}	1.10^{ab}	1.16^{a}	0.10
Feed intake (g)	111.95	105.00	99.17	98.60	109.80	6.96
Faecal output (g)	6.53	11.83	5.28	6.61	21.29	4.99
Dry Matter (DM) intake (g)	101.76	94.69	90.58	88.98	98.58	6.33
Faecal DM (g)	4.23^{b}	6.07^{b}	4.73^{b}	4.85^{b}	14.44^{a}	2.33
DM retention (g)	97.53	88.62	85.85	84.13	84.14	6.64
DM intake as % of live weight	13.05^{a}	11.55^{ab}	10.29^{ab}	8.09^{b}	8.50^{ab}	1.43
Organic Matter (OM) intake (g)	91.85	84.24	81.01	79.51	88.97	5.67
Faecal OM (g)	3.52^{b}	4.99^{b}	4.05^{b}	4.08^{b}	12.23^{a}	1.91
OM retention (g)	88.33	79.25	76.96	75.43	76.74	5.59
Nitrogen (N) intake (g)	2.80^{a}	2.59^{ab}	2.16^{b}	2.15^{b}	3.03^{a}	1.72
Faecal N (g)	0.12^{b}	0.22^{ab}	0.15^{ab}	0.16^{ab}	0.40^{a}	0.80
Digested N (g)	2.66^{a}	2.36^{ab}	2.02^{b}	1.99^{b}	2.62^{a}	1.79
Digested N as % of intake	95.00	91.51	93.12	92.56	87.22	3.25

^{a,b}Means in the same row with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean

Table 7: Coefficient of apparent nutrient digestibility of growing rabbits fed graded levels of raw bambara groundnut offal diets

Nutrient digestibility (%)	0%	5%	10%	15%	20%	SEM
Dry matter	95.84	93.59	94.77	94.55	85.35	2.50
Organic matter	96.17	94.08	95.00	94.87	86.23	2.45
Crude protein	95.77	91.40	93.01	92.64	86.63	3.23
Ether extract	95.09^{a}	94.01^{a}	95.51^{a}	95.62^{a}	85.83^{b}	2.41
Crude fibre	90.49^{a}	86.22^{a}	88.73^{a}	88.71^{a}	65.88^{b}	5.16
Crude ash	92.84^{a}	89.67^{ab}	92.79^{a}	91.87^{a}	76.80^{b}	4.34
Nitrogen free extract	97.25^{a}	96.37^{a}	96.75^{a}	96.56^{a}	90.22^{b}	1.82

^{a,b}Means in the same row with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean

contributes to improve N digestion and retention in rabbits. According to Llorente *et al.* (2007), endogenous N (e.g. digestive enzymes, mucoproteins, urea) could be a source of protein for microorganisms in the gut and in rabbits may represent about 64% of the total ileal protein flow. However, this contribution could be variable and mainly influenced by DM intake, diet composition, fibre type and levels of anti-nutritional substances in the diet (Carabano *et al.*, 2008). These factors stated above could have influenced the nutrient retention values obtained with rabbits fed graded levels of BGO diets in this study.

Coefficient of apparent (total tract) digestibility of DM, CP, EE, CF, crude ash and NFE of rabbits fed 0, 5, 10 and 15% raw BGO diets were not significantly ($p>0.05$) different from each other (Table 7). At the same time, 20% BGO diet significantly ($p<0.05$) reduced coefficient of apparent digestibility of EE, CF and NFE compared to other diets. These digestibility results suggest that 15% was the optimum level of inclusion of raw BGO, above which apparent digestibility could be adversely affected. Coefficient of apparent digestibility values obtained in this study were higher than those reported by Peiretti *et al.* (2007) with mixed feed of increasing levels of False flax seeds using male and female rabbits, although the breed or hybrid was not stated. Our results were also higher than those obtained by Zeweil *et al.* (2008) with New Zealand white rabbits fed *Nigella* seed meal as source of protein in the diet and comparable with the digestibility coefficients reported by Iyeghe-Erakpotobor and Esievo (2010) for growing rabbits fed soybean cheese waste meal diet and lablab hay.

Conclusion: The conclusion from this study was that growing rabbits could be fed diets containing up to 15% BGO to enhance daily weight gain and reduce feed cost, which would not adversely affect carcass quality and organ characteristics, nutrient intake, coefficient of apparent digestibility and nutrient utilization.

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REFERENCES

Adegbola, J.A., E.U. Tibi and D.C. Adogwa, 1985. Feed intake and digestibility in rabbits on all forage plus concentrate and all concentrate diet. J. Anim. Prod. Res., 5: 15-16.

Aderinola, O.A., O.O. Ojebiyi, T.A. Rafiu, J.A. Akinlade and L.O. Adepoju, 2008. Performance evaluation of growing rabbit fed diets containing varying levels of *Centrocema pubescens* or *Calapogonium mucunoides* in the Savanna zone of Nigeria. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 525-528.

Aletor, V.A. and B.L. Fetuga, 1987. Pancreatic and intestinal amylase (EC 3.2.1.1) in the rat fed haemaglutinin extract. II. Evidence of impaired dietary starch utilization. J. Anim. Physiol. Anim. Nutr., 57: 113-117.

Amaefule, K.U. and C.O. Iroanya, 2004. Replacement of soybean meal and maize offal with bambara groundnut offal in broiler diets. Nig. Agric. J., 35: 133-142.

Amaefule, K.U. and F.M. Osuagwu, 2005. Performance of pullet chicks fed graded levels of raw bambara groundnut [*Vigna subterranean* (L.) *Verdc*] offal diets as replacement for soybean meal and maize. Livestock Research for Rural Development (LRRD) 17: 5. http://www.cipav.org.co/lrrd17/05/amae17036.htm.

Amaefule, K.U., F.C. Iheukwumere and C.C. Nwokoro, 2005. Performance, nutrient digestibility and carcass characteristics of rabbits fed graded dietary levels of boiled pigeon pea seed (*Cajanus cajan*). Livestock Research for Rural Development (LRRD) 17: 4. http://www.cipav.org.co/lrrd17/04/amae17051.htm.

Amaefule, K.U., C.C. Nwokoro and F.C. Iheukwumere, 2004. The effect of feeding graded levels of raw pigeon pea seed (*Cajanus cajan*) meal on the performance, nutrient retention and carcass characteristics of weaner rabbits. Nig. J. Anim. Prod., 31: 194-199.

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

AOAC, 1990. Official methods of Analysis. Association of Official Analytical Chemists, Washington DC., USA.

Belenguer, A., M. Fondevila, J. Balcells, L. Abecia, M. Lachica and M.D. Carro, 2008. *In vivo* and *in vitro* study of caecal fermentation pattern and methanogenesis in rabbits. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 535-540.

Carabano, R., M.J. Villamide, J. Garcia, N. Nicodemus, A. Llorente, S. Chamorro, D. Menoyo, P. Garcia-Rebollar, A.I. Garcia-Ruiz and J.C. de Blas, 2008. New concepts and objectives for protein-amino acid nutrition in rabbits. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 477-490.

Cheeke, P.R., 1986. Potentials of rabbit production in tropical and subtropical agricultural systems. J. Anim. Sci., 63: 1581-1586. http://jas.fss.org/egi/reprint/63/5/1581.pdf.

Duncan, D.B., 1955. Multiple range and multiple F-tests: A Biometric Approach, 11: 1-42.

Eiben, C., T. Gippert, K. Godor-Surmann, B. Podmaniczky and K. Kustos, 2008. Influence of dietary protein reduction and enzyme and/or amino acid supplementation on fattening performance of rabbits. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 637-642.

Ezuoke, O.C., 2003. Biochemical, haematological and nutritional evaluation of raw and toasted bambara groundnut by-product using rabbits. Final Year Project Report, College of Animal Science and Animal Health, Michael Okpara University of Agriculture, Umudike, pp: 15-16.

Iyeghe-Erakpotobor, G.T. and L.O. Esievo, 2010. Performance of growing rabbits fed soybean cheese waste meal diets and lablab hay. Nig. J. Anim. Prod., 37: 173-183.

Llorente, A., M.J. Villamide, A.I. Garcia, S. Chamorro and R. Carabano, 2007. Prediction de la digestibilite ileale azotee par methods *in vitro*. In: Proc. 12th Journees Recherche Cunicole, 2007 November, le Mans, France, pp: 93-96.

Lukefahr, S.D., 2009. Role of organic rabbit farming for poverty alleviation. MEKARN M.Sc. 2008-10, Miniprojects, pp: 1-11.

Marguenda, I., R. Carabano, P. Garcia-Rebollar, M. Fragkiadakis, L. Sevilla, S. Vadillo and N. Nicodemus, 2008. Effect of dietary type and level of fibre on carcass yield and its microbiological characteristics. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 1387-1392.

National Root Crops Research Institute (NRCRI) Umudike, 2009. Metrological Data and Information from NRCRI Weather Station.

Omole, T.A., 1982. The effect of level of dietary protein on growth and reproductive performance of rabbits. J. Appl. Rabbit Res., 5: 83-88.

Omole, T.A., 1988. Alternative to Feed Formulation: Presidential Task Force on Alternative Feed Formulation, Abuja.

Onyimonyi, A.E. and J.O. Onukwufor, 2003. Effects of toasted bambara groundnut (*Voandzeia subterranean* (L.) Thouras) waste on performance of growing pullets. In: Proc. 28th Conf., Nig. Soc. Anim. Prod., 28: 237-239.

Peiretti, P.G., P.P. Mussa, G. Meineri and G. Perona, 2007. Apparent digestibility of mixed feed with increasing levels of false flax (*Camelina sativa* L.) seeds in rabbit diets. J. Food Agric. Environ., 5: 85-88.

Pinheiro, V., S.R. Silva, J.A. Silva, D. Outor-Monteiro and J.L. Mourao, 2008. Growth and carcass characteristics of rabbits housed in open-air or standard systems. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 1421-1424.

Soetan, K.O. and O.E. Oyewole, 2009. The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds: A review. Afr. J. Food Sci., 3: 223-232.

Steel, R.G. and J.H. Torrie, 1980. Principles and Procedures of Statistics. MacGraw Hill Book Co., New York, USA.

Ukachukwu, S.N. and F.O.I. Anugwa, 1995. Biometrics of feeding raw or heat treated soybeans to broilers. Nig. J. Anim. Prod., 22: 137-140.

Ukpabi, U.H., K.U. Amaefule and O.M. Amaefule, 2008. Performance of broilers fed raw bambara groundnut [*Vigna subterranean* (L.) *Verdc*] offal diets supplemented with lysine and or methionine. Int. J. Poult. Sci., 7: 1177-1181.

Volek, Z. and M. Marounek, 2008. White lupin (Cv. Amiga) seeds as a protein source in diet for growing rabbits: Effect on growth performance, digestibility of nutrients and carcass traits. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 831-836.

Zeweil, H.S., M.H. Ahmed, M.M. El-Adawy and B. Zaki, 2008. Evaluation of substituting Nigella seed meal as a source of protein for soybean meal in diets of New Zealand white rabbits. In: Proc. 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 863-868.