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Effect of poultry litter with or without enzyme supplementation on the growth performance, nutrient digestibility and economy of rabbit production

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A 9-week feeding trial was carried out to evaluate the performance, nutrients digestibility and economics of production of rabbits fed poultry litter with or without nutrase xylase (exogenous enzyme) supplementation. 60 cross-breed rabbits with group mean weight (515 to 530 g) were randomly distributed to 10 dietary treatments at 6 rabbits to a treatment group in complete randomization. Results on chemical composition showed improvement in nutrient status of enzyme supplemented diets over diets not supplemented with exogenous enzyme. The better nutrient density in enzyme supplemented diets was manifested in performance response data as rabbits fed enzyme supplemented diets recorded higher weight gain over rabbits fed non-enzyme supplemented diets, except at 40% level of inclusion, which recorded no significant influence (P>0.05) between rabbits fed enzyme supplemented diet and non-enzyme supplemented diet. Apparent digestibility results showed improved nutrients digestibility by rabbits fed enzyme supplemented diets over those not supplemented with enzyme (P<0.05), except the dry matter digestibility that was statistically similar (P>0.05) at 0 to 20 and 30 to 40% poultry litter inclusion levels. Economics of production showed that enzyme supplementation gradually reduced the cost of feed ₦/kilogram weight gain (₦223.61 to 228.47) up to 30% poultry litter-based diets. Above this level, a loss was incurred as evidenced in the cost differential (₦25.08) and relative cost benefit/kilogram gain (-10.35%).

Key words: Nutrase xylase, digestibility, rabbits, litter, costs.

INTRODUCTION

In Nigeria, poultry production has witnessed remarkable growth in recent years, partly because of the relative reduction in feed cost occasioned by the use of non-conventional feed resources, which do not enter into human dietary pattern, and are of less demand as input resources by many agro-based industries (Oladunjoye and Ojebiyi, 2010; Leeson and Caston, 1996). For instance, the Nigeria poultry industry witnessed an expansion with domestic meat production from 172,000 metric tones in 1999 to 211,000 metric tones in 2005 (Alabi and Aruna, 2005). Although, the expansion has not translated to meeting the domestic consumption requirement of 63 g of animal protein per day per caput as recommended by FAO (1986). In the expansion drive and with intensification of poultry keeping, a lot of waste; poultry litter is generated, which often constitute menace and environmental hazard to the immediate community where the farm is sited. Records abound that poultry litter; a low-cost material, contains appreciable quantity of nutritive growth factors such as 16.5 to 25.00% crude

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protein (Adegbola et al., 1990; Owen et al., 2008; Ensmniger, 1977; Devendra and Rooghavan, 1978; Lamidi, 1995; Ogunsipe, 2011), minerals particularly calcium (Ca) and phosphorous (P) (Fontenot, 1990; Lamidi, 1995; Rhanjhan, 1990; Owen et al., 2008) and vitamin K and B12 or pro-vitamins (Muller et al., 1968), riboflavin (Lamoreux and Schumaucher, 1940) and fibre (Onimisi and Omage, 2006).

In spite of the nutritional potential of poultry litter, studies revealed that poultry litter do harbour some pathogenic organisms such as Salmonella, *E. coli*, Bacillus spp. (Clegg et al., 1995; Fontenot, 2000; Ogunsipe, 2011), which could impact negatively on feed utilization and physiological functions within the animal system. Also reported was the high fibre content (19.2 to 21.90%) (Onu et al., 2011; Onimisi and Omage, 2006), and the bio-deterioration activities of bacteria present in the litter (Onion et al., 1981), which could lower its digestibility. Therefore, for poultry litter to be safe as feed ingredient in livestock diet, processing of the litter becomes necessary to help destroy or make inactive the harmful pathogenic organisms, improve palatability and acceptability by the animals, and enhance the nutritive quality. The choice of nutrase xylase; an enzyme complex from *Bacillus subtilis*, and containing other active enzymes such as cellulase, xylanase, glucanase, amylase, pectinase and protease for this study was conceived with its roles to help breakdown long-chain polysaccharides into absorbable and utilizable forms, thus helping to improve metabolizable energy, nutrient retention, growth rate (weight gain), feed conversion rate, increase digesta passage rate, decreased viscosity of the intestinal tract and reduce sticky dropping (Friesen et al., 1992; Leeson and Proulx, 1995).

The thrust of this study was to evaluate the effect of poultry litter supplemented with exogenous enzyme on the growth performance, nutrient utilization and economic implications of growing rabbits.

MATERIALS AND METHODS

Experimental location

The right to conduct the study was given by the Research Committee of the Animal Production Unit, Agricultural Science Department, Adeyemi College of Education, Ondo, Ondo State, Nigeria. The study was carried out at the rabbit unit of the Teaching and Research Farm of Adeyemi College of Education, Ondo, Ondo State of the Southwestern part of Nigeria. Ondo is located between 07° 05^1 N, 04° 55^1 E with annual rainfall of between 1800 to 3600 mm, 54 to 91% relative humidity and mean daily temperature range of 22 to 35°C throughout the year.

Processing of test ingredient

Rice straw used as bedding material (litter) in the layer's battery cage system at the Poultry Unit of the Teaching and Research Farm, Adeyemi College of Education, Ondo was collected after a period of 8 months. Lime and super phosphate were added to the litter material to help keep the litter dry and friable, and to reduce the escape of ammonia. The choice of rice straw as the litter material was because of its water-absorbent ability, coarse nature and ability to decompose when attacked by microbes. At the end of the 8th month, the litter was packed using shovel and immediately dried. Drying temperature of between 80 and 90°C was maintained for 60 min to sterilize the litter, and not to damage or denature the protein in it. Heating helps to destroy potential pathogens, for example, *Anzona* spp. could be destroyed at 48°C for 30min, *Staphylococcus pullorum* at 63°C and *E. coli* at 70°C for 30 min (Messers et al., 1971). The litter was ground in a hammer mill into a meal suitable for incorporation and run over a magnet to remove any possible stray metal scraps.

Feed preparation

Ten experimental diets were formulated such that diet 1 which serve as the positive control contained 0% poultry litter without enzyme supplementation and diet 2 serving as negative control also contained 0% but with enzyme supplementation, while diets 3, 5, 7 and 9 have their maize grains replaced with poultry litter at 10, 20, 30 and 40%, respectively without enzyme supplementation. Diets 4, 6, 8 and 10 contained the same (10 to 40%) levels of poultry litter in place of maize grains with 200 mg nutrase xylase per kilogram weight of feed in each supplemented diet. The concentrate mixture was formulated to contain 16.05 to 16.31% crude protein and 2140.90 to 2536.64 kcal/ME/kg of feed (Table 1). The determined composition of the test diets and that of poultry litter (AOAC, 1995) are contained in Table 2.

Pre-experimental period and management of animals

A total of 60 weaned rabbits aged 7 and 8 weeks with similar group mean weight (516 to 530 g) were randomly distributed to ten dietary treatments replicated five times in a completely randomized design experiment. Cages made of bamboo splits with wire netting were constructed such that each compartment measures 210 × 180 × 120 cm to conveniently accommodate the six rabbits for each treatment group. The cages were raised 90 cm above the ground level and their stands immersed in insecticidal solution (Gammalin 20) to prevent crawling insects and other predators from getting to the rabbits. Other necessary housing conditions were observed to ensure adequate ventilation for the rabbits. Prior to the commencement of the experiment, the rabbits were treated against endo and ecto parasites by subcutaneous injection of Ivomec (0.2 ml/rabbit). Oxytetracyclin L.A; a broad spectrum anti-biotic was also administered at the rate of 0.2 ml/rabbit. Vitalyte and embazin forte were given orally in their drinking water. The feeds were served twice daily: in the morning at 8.00 am and at 4.00 pm in the afternoon, while clean water was supplied ad libitum throughout the experimental period.

The rabbits were individually weighed and their weights balanced after which they were randomly assigned to their group cages. The rabbits were made to undergo 14 days adaptation period. In the first seven days, the rabbits were fed commercial growers mash (guinea feed) containing 16% crude protein, and in the last seven days, the rabbits were fed their respective experimental diets but without any record taken. The purpose of this two phase adaptation period was to enable the rabbits acclimatize to the new environment and adjust to the new diets.

Digestibility of nutrients

Apparent digestibility of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract of the diets were carried out a

Table 1. Composition of experimental diets (g/100 g).

Ingredients	Diets									
	1	2	3	4	5	6	7	8	9	10
	Levels of inclusion (%) and enzyme supplementation									
	0 – E	0 + E	10 - E	10 + E	20 – E	20 + E	30 – E	30 + E	40 - E	40 + E
Maize	51.80	51.80	46.80	46.80	41.80	41.80	36.80	36.80	31.80	31.80
Poultry litter	-	-	10.00	10.00	20.00	20.00	30.00	30.00	40.00	40.00
SBM	12.00	12.00	12.00	12.00	11.00	11.00	9.00	9.00	8.00	8.00
Wheat offal	13.00	13.00	10.00	10.00	8.00	8.00	6.00	6.00	4.00	4.00
Fish meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Rice bran	14.00	14.00	9.00	9.00	7.00	7.00	6.00	6.00	4.00	4.00
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Palm oil	-	-	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	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	100	100
Calculated composition										
Crude protein (%)	16.31	16.31	16.26	16.26	16.31	16.31	16.05	16.05	16.10	16.10
ME/kcal/kg	2536.6	2521.8	2386.4	2437.9	2330.7	2386.1	2219.4	2295.1	2140.9	2247.4

-E denotes no enzyme supplementation; +E denotes with enzyme supplementation.

Table 2. Chemical composition of experimental diets (g/100 g).

Parameter	Diets											
	1	2	3	4	5	6	7	8	9	10	SEM	Sig
	Levels of inclusion (%) and enzyme supplementation											
	0 – E	0 + E	10 – E	10 + E	20 – E	20 + E	30 – E	30 + E	40 - E	40 + E		
Dry matter	88.65	89.34	88.27	88.85	87.73	88.54	87.31	87.90	87.13	87.58	0.63	NS
Crude protein	16.27	16.67	16.20	16.51	16.17	16.56	16.19	16.63	16.16	16.48	0.14	NS
Crude fibre	11.57[a]	11.13[a]	13.76[a]	12.53[a]	15.55[b]	13.29[a]	16.14[b]	14.05[a]	17.83[b]	14.84[ab]	2.01	*
Crude fat	4.32	4.39	4.41	4.42	4.45	4.45	4.48	4.49	4.45	4.48	0.04	NS
Ash	11.07	12.31	12.87	12.93	13.24	13.36	14.13	14.25	14.51	14.67	1.07	NS
NFE	45.42	44.84	41.03	42.46	38.32	40.88	36.37	38.48	34.18	37.11	3.47	NS
Energy (kcal/ME/kg)	2517.3	2548.2	2472.5	2501.5	2386.3	2420.1	2314.7	2393.4	2291.4	2347.1	71.57	NS

[ab]Means with different superscripts on the same row are significant (P<0.05).

week to the expiration of the experiment. Faeces were collected from each treatment group, bulked together, and 10% of the weight of each sample taken. The faecal samples were dried in air-circulation oven at 60°C, and were allowed to cool in glass desiccators to prevent the sample from absorbing moisture from the surrounding environment. The faecal samples were ground and analyzed (AOAC, 1995). Apparent nutrients digestibility were determined as:

$$\frac{\%\text{ nutrient in feed} \times \text{FI} - \%\text{nutrient in faeces} \times \text{FO}}{\%\text{ nutrient in feed} \times \text{FI}} \times 100$$

Where FI = Feed intake (on dry matter basis) and FO = faecal output (on dry matter basis).

Chemical analysis

The milled samples of poultry litter, faeces and experimental diets were analyzed for dry matter, crude protein, crude fibre, ash, ether extract and nitrogen free extract (AOAC, 1995), while the gross energy values of the feed and faeces were determined using Gallenkamp oxygen bomb calorimeter (AOAC, 1995).

Table 3. Chemical composition of poultry litter.

Parameter	Composition (%)
Moisture	12.34
Dry matter	87.66
Crude protein	20.41
Crude fibre	18.73
Crude fat	3.87
Ash	21.24
NFE	35.75
Energy (kcal/ME/kg)	1073.08
Phosphorous (P)	5.10 mg/kg
Calcium (Ca)	2.30 mg/kg

Economic analysis

Cost of feed per kilogram was calculated by taking the price of each ingredient to multiply the quantity (kg) of ingredients used in compounding each diet, then summed up to calculate the feed cost per kg. Cost of feed ₦/kg weight gain was calculated as the cost of feed ₦/kg multiplied by the average feed consumed, and then dividing by the average weight gain, while cost differential is the cost of feed ₦/kg weight gain of each test diet minus the cost of feed ₦/kg weight of control diet, and the % relative cost benefit/kg weight gain was calculated as cost differential divided by cost of feed ₦/kg weight gain of control diet multiplied by 100.

Data collection

Data were collected on daily feed intake and weekly weight changes. Feed intake was calculated as the difference between feed given and feed left over, while weight gain was determined as the difference in the weight of the rabbits from the preceding week. Feed conversion ratio was calculated by dividing the average feed intake by the average weight gain.

Statistical analysis

Data generated were subjected to a one way analysis of variance using SPSS 15 (2006) package. The treatment means were compared using the Duncan option of the same software.

RESULTS AND DISCUSSION

The results on the chemical composition of the experimental diets showed a crude protein (CP) range (16.16 to 16.67%), crude fibre (CF) (11.13 to 17.83%), crude fat (EE) (4.32 to 4.49%), ash (11.07 to 14.67%) and nitrogen free extract (NFE) (34.18 to 45.42%) (Table 3). The energy value was between 2386.29 and 2673.42 kcal/ME/kg across the various dietary treatments. The enzyme supplemented diets are of better nutrients density than the non-supplemented diets. The improved nutrient status of the supplemented diets over those non-supplemented could be due to the actions of the exogenous enzyme to help breakdown the complex polysaccharides into soluble and absorbable forms, thus releasing the lock up nutrients in the feed matrix to absorbable forms. In both cases (enzyme supplementation and non-enzyme supplementation), increased fibre content in the diets resulted in a gradual decrease in the metabolizable energy content of the diets (Table 2), while the total ash increased progressively as the total ash increases. This finding corroborates the works by Onu et al. (2004) that irrespective of enzyme supplementation, energy value of feed decreased with increased level of fibre. The dietary inclusion of poultry litter with or without enzyme supplementation up to 40% in rabbit's diet did not significantly alter the crude protein and crude fat, as the levels met the requirements for rabbit production (NRC, 1977; Champe and Maurice, 1993). The determined chemical composition of poultry litter as contained in Table 3 shows the dry matter (DM) content of 87.66% as against the values 91.80% observed by Onu et al. (2011) for sheep manure, 97.50% reported by Onimisi and Omage (2006) but similar to the 87.00% recorded by Owen et al. (2008). The 12.34% moisture content is agreeable with the previous works by Burdine et al. (1993), Ruffin and McCaskey (1991) and Owen et al. (2008) that for easy feeding and processing, and to avoid dustiness of feed, moisture content of feed should be between 12 and 25%.

The crude protein of 20.41% reported here is in line with the range of 19.40 to 21.18% previously reported by some researchers (Ogunsipe, 2011; Onu et al., 2011; Onimisi and Omage, 2006; Owen et al., 2008). The total ash (21.24%) was higher than the 17.50% reported by Onimisi and Omage (2006), 18.50% by Owen et al. (2008); but lower than the 32.80% observed by Onu et al. (2011) for sheep manure. Fibre is often used as a negative index to measure the nutritive value of any feed ingredients. The high fibre content (18.73%) in this study suggests that poultry litter of rice straw material is high in fibre, although, rabbits are known to be good fibre digesters because of the microbes present in the caecum. The 1073.08 kcal/ME/kg recorded in this study was however higher than the 621.41 kcal/ME/kg reported by Owen et al. (2008) but lower than the 1817.16 kcal/ME/kg for sheep manure (Onu et al., 2011). The two minerals determined; phosphorus (P) and calcium (Ca) had values 5.10 and 2.30 mg/kg, respectively. These values were similar to those obtained by Owen et al. (2008). The observed variations in the nutrient composition of poultry litter in this study and previous studies might be due to the type of feed consumed by animal, degree of contamination of excreta with bedding, type of bedding litter material used and the processing techniques adopted (Owen et al., 2008). Data on Table 4 showed similar feed intake (P>0.05) between rabbits on 0 to 10% poultry litter-based diets irrespective of enzyme addition or not and rabbits placed 40% poultry litter-based diet (P>0.05), although there appeared numerical increase in feed intake of rabbits fed non-enzyme

Table 4. Performance response of rabbits fed poultry litter-based diets with or without nutrase xylase enzyme supplementation.

Parameter	Diets											
	1	2	3	4	5	6	7	8	9	10	SEM	Sig
	Levels of inclusion (%) and enzyme supplementation											
	0 – E	0 + E	10 - E	10 + E	20 - E	20 + E	30 - E	30 + E	40 - E	40 + E		
Initial body weight (g)	528	516	525	518	525	520	530	515	530	528	5.59	NS
Final live weight (g)	1425.1^{a}	1566.1^{b}	1403.9^{a}	1510.3^{b}	1322.9^{a}	1528.3^{b}	1319.4^{a}	1501.5^{b}	1284.2^{a}	1353.9^{b}	89.63	*
Slaughter weight (g)	1366.9^{b}	1514.8^{b}	1343.4^{a}	1466.2^{b}	1250.4^{a}	1468.5^{b}	1236.6^{a}	1431.9^{b}	1210.9^{a}	1287.4^{a}	101.7	*
Fasting loss (%)	4.08^{b}	3.29^{a}	4.30^{b}	3.61^{a}	5.47^{d}	3.89^{ab}	6.27^{e}	4.64^{c}	5.70^{d}	4.92^{c}	0.92	*
Total feed intake (g)	3241.3^{a}	3219.5^{a}	3253.8^{a}	3178.1^{a}	3563.8^{c}	3291.2^{a}	3713.8^{d}	3332.0^{b}	3469.2^{b}	3454.2^{b}	168.97	*
Average feed intake/rabbit/d/g	51.4^{a}	51.1^{a}	51.6^{a}	50.5^{a}	56.7^{c}	52.3^{a}	58.9^{d}	52.8^{a}	55.0^{b}	54.9^{b}	2.41	*
Total weight gain g	897.7^{a}	1051.0^{c}	877.7^{a}	1005.5^{b}	800.5^{a}	1011.1^{b}	787.5^{a}	989.3^{b}	756.1^{a}	824.8^{a}	100.3	*
Average weight gain/rabbit/d/g	14.3^{ab}	16.6^{c}	13.9^{ab}	15.9^{b}	12.7^{a}	16.0^{c}	12.5^{a}	15.7^{b}	11.9^{a}	13.1^{a}	1.35	*
Feed conversion ratio	3.62^{b}	3.09^{a}	3.71^{c}	3.19^{a}	4.43^{d}	3.25^{ab}	4.74^{e}	3.33^{ab}	4.64e	4.17d	0.58	*

^{abcde}Means with different superscripts on the same row are significant (P<0.05).

supplemented diets over the diets supplemented with exogenous enzyme.

The increased feed intake by rabbits fed non-enzyme supplemented diets over the enzyme supplemented diets might be due to the low energy value in the non-enzyme supplemented diets (Table 2). All enzyme supplemented diets recorded higher significant weight (P<0.05) over the non-enzyme supplemented diets, except at 40% poultry litter inclusion, where no significant influence (P>0.05) exists in the slaughter weight, feed intake and weight gain of rabbits fed with or without enzyme supplementation. Enzymes had been reported to improve weight gain with less feed consumption in monogastrics (Onu et al., 2011; Khan et al., 2006; Fasiullah et al., 2010; Nian et al., 2011). Feed conversion ratio showed improved nutrient utilization (P<0.05) in all enzyme supplemented diets over the non-enzyme supplemented diets. This finding agreed with the reports by Nian et al. (2011), Onu et al. (2011) and Oladunjoye and Ojebiyi (2010) that enzyme supplementation has positive effect on feed conversion or efficiency. Apparent digestibility results (Table 5) showed improved nutrients digestibility in all enzyme supplemented diets over those diets not supplemented, except the dry matter digestibility that were similar (P>0.05) in rabbits fed 0 to 20% poultry litter-based diets with or without enzyme supplementation, and among rabbits placed on 30 and 40%-based poultry litter diets (P>0.05) irrespective of enzyme addition. The negative control diet showed better significant (P<0.05) or numerical value over other test diets, except in crude fat and ash digestibilities.

The implication therefore is that when a diet is enzyme supplemented, more nutrients are released for animal use than when not supplemented with enzyme. The findings from this study revealed that all enzyme supplemented diets improved nutrients digestibility and utilization as evidenced in the feed conversion ratio and weight gain of the experimental rabbits. The improvement observed could undoubtedly be due to the enhancing effect of nutrase xylase to release the entrapped nutrients by the non-starch polysaccharide in the litter material for animal utilization. This finding agreed with the works by Khan et al. (2006) on broiler fed sun flower-corn supplemented with enzyme, Olagundoye and Ojebiyi (2010) works on broiler chickens fed rice bran supplemented with Roxazyme G2G, Obasa et al. (2009) works that fed African cat fish on poultry manure, Onu et al. (2011) works on broiler starter chicks fed enzyme supplemented sheep manure-based diets. Viveros et al. (1993) reported that improvement in nutrients digestibility with enzyme supplementation, in addition to improving nutrients availability and absorption, also promote the growth of useful bacteria in the gut of the animals. The poor nutrients digestibility in the diets not supplemented with exogenous enzyme might be due to the lock up nutrients by

Table 5. Nutrients digestibility of rabbits fed poultry litter-based diets with or without nutrase xylase enzyme supplementation.

Nutrients (%)	Diets											
	1	2	3	4	5	6	7	8	9	10	SEM	Sig
	Levels of inclusion (%) and enzyme supplementation											
	0 - E	0 + E	10 – E	10 + E	20 - E	20 + E	30 - E	30 + E	40 - E	40 + E		
Dry matter	70.18^{b}	70.53^{b}	68.41^{b}	70.84^{b}	66.79^{b}	69.36^{b}	60.56^{a}	62.17^{a}	60.04^{a}	62.38^{a}	3.92	*
Crude protein	74.35^{d}	76.67^{c}	72.45^{c}	74.71^{d}	68.13^{bc}	71.53^{c}	65.26^{b}	70.05^{c}	62.74^{a}	66.52^{b}	4.36	*
Crude fibre	43.33^{d}	46.82^{e}	40.64^{c}	44.57^{d}	38.84^{c}	42.75^{cd}	35.38^{b}	40.03^{c}	31.92^{a}	39.66^{c}	4.09	*
Crude fat	67.51^{b}	69.80^{c}	64.32^{a}	68.43^{b}	65.76^{ab}	70.83^{c}	66.13^{ab}	76.24^{d}	62.15^{a}	68.39^{b}	3.71	*
Ash	63.72^{a}	65.31^{b}	63.85^{a}	70.27^{c}	61.15a	66.40^{b}	60.46^{a}	69.49^{c}	61.43^{a}	67.81^{b}	3.28	*
Carbohydrate	68.74^{b}	70.26^{b}	64.53^{a}	67.74^{b}	63.89^{a}	71.35^{b}	62.39^{a}	68.57^{b}	64.67^{a}	69.32^{b}	2.89	*

^{abcde}Means with different superscripts on the same row are significant (P<0.05).

Table 6. Economic effect of rabbits fed poultry litter-based diets with or without nutrase xylase enzyme supplementation.

Costs	Diets									
	1	2	3	4	5	6	7	8	9	10
	Levels of inclusion (%) and enzyme supplementation									
	0 - E	0 + E	10 - E	10 + E	20 - E	20 + E	30 - E	30 + E	40 - E	40 + E
Average feed cons. (kg)	3.24	3.22	3.25	3.19	3.57	3.30	3.71	3.33	3.49	3.46
Average weight gain (kg)	0.09	1.04	0.87	1.00	0.80	1.01	0.79	0.99	0.75	0.83
Cost of feed (₦/kg)	67.34	73.18	64.73	71.62	63.15	68.87	60.93	66.48	58.64	64.17
Cost of feed ₦/kg weight gain	242.42	226.58	241.81	228.47	281.81	225.02	286.14	223.61	272.87	267.50
Cost differential	-	15.84	0.61	13.95	-39.39	17.40	-43.72	18.81	-30.45	-25.08
Relative cost benefit/kg gain (%)	-	6.53	0.25	5.75	-16.25	7.16	-18.03	7.76	-12.56	-10.35

the non starch polysaccharide or high fibre content in the diets.

Economic analysis

Dietary inclusion of poultry litter steadily reduced the feed cost ₦/kg for both enzyme supplemented and non-enzyme supplemented diets across board as shown in Table 5. Enzyme supplementation reduced the cost of feed ₦/kg weight gain across the various test diets up to 30% poultry litter-based diet compared to the reference diet. At 40% inclusion, the cost of feed ₦/kg weight gain was higher (₦267.50) than both the positive and negative control diets (₦242.42 and ₦226.58, respectively). In all cases, the cost of feed ₦/kg weight gain was highest (N286.14) at 30% non-enzyme supplemented-based diet and least (₦241.81) at 10% non-enzyme supplemented-based diet. On the contrary, lowest (₦223.61) cost of feed ₦/kg weight was recorded at 30% enzyme supplemented-based diet. Cost differential and relative cost benefit/kg weight gain analysis recorded better savings (₦18.81 and 7.76%, respectively) at 30% enzyme supplemented diet. The economic results of this study revealed that while it was economical to raise rabbits on poultry litter supplemented with exogenous enzyme (nutrase enzyme) up to 30% inclusion level as evidenced in the improved savings (5.75 to 7.76%) and cost differential 15.84 to 18.81, it was however not cost effective to incorporate non-enzyme supplemented poultry litter-based diet above 10% inclusion, as doing this could lead to a loss as shown in the -10.35 to -18.03% relative cost benefit/kilogram gain and ₦25.08 to ₦43.72 evidenced by the cost differential analysis (Table 6).

The loss observed might be because of the need for the rabbits to eat more to gain 1 kg weight. Thus, the high feed intake, poor feed conversion ratio, poor feed utilization and poor growth rate of rabbits that consumed above 10% non-enzyme supplemented poultry litter diet may have resulted to the high cost of production. Interestingly, enzyme supplementation reduced feed cost ₦/kg weight gain up to 30% poultry litter inclusion and consequently improved savings. The observed reduction in feed cost ₦/kg weight gain with enzyme supplementation might probably be due to the reduced feed intake, improved feed conversion ratio, better nutrients digestibility and utilization that resulted to higher weight gains over the control and non-supplemented diets. Similar result was reported by Onu et al. (2011) on starter chicks fed enzyme supplemented sheep manure.

Conclusion

The results from this study showed that rabbits fed enzyme supplemented diets up to 30% poultry litter inclusion at the expense of maize grains performed better than rabbits placed on diets not supplemented with enzyme as evidenced in the performance response criteria and nutrients digestibility data. Economics of production showed gradual decrease in the cost of feed ₦/kg weight gain and better savings up to 30% poultry litter-based diets with enzyme supplementation. However, for all rabbits fed non-enzyme supplemented diets, except at 10% poultry litter-based diet, higher cost (₦267.50 to 286.14) was incurred to produce a kilogram of rabbit meat over the positive control diet (₦242.42). The findings from this study recommends the use of poultry litter with enzyme supplementation up to 30% inclusion level in place of maize grains, as this will help improve rabbits performance, better animal protein affordability and by extension a means through which poultry litter can be efficiently utilized in animal diet, thus helping to reduce the effect of environmental hazards caused by poultry litter to the host community.

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