Performance of Growing Rabbits Fed Diets Containing Fermented and Unfermented Cassava Leaf: Peel Meal Mix as Replacement for Maize

Adeyemi[1*],O.A., Adesanya[2], P.A, Eniolorunda[2], O.O., Sogunle[1], O.M., Egbeyale[1], L.T. and Njoku[1], C.P.

[1]Department of Animal Production and Helath, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. [2]Department of Animal Production, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

*Corresponding author: olajideadeyemi@yahoo.com

Abstract

The effects of feeding diets containing fermented and unfermented combinations of cassava leaf meal and peel meal mix (CLM-PM) on performance and carcass characteristics of growing rabbits were investigated in a derived savannah vegetation zone of South West Nigeria. Fifty 6-week old growing rabbits of mixed breed (New Zealand White x Chinchila) and sexes with an average weight range of 600-610 g were randomly distributed into five groups to assess five treatment diets: Diet A (Control) 50% maize, Diet B 25% and Diet C 50% replacement of dietary maize with unfermented cassava leaf meal and peel meal mix (UCLM-PM) and Diet D 25% and Diet E 50% replacement of dietary maize with fermented cassava leaf meal and peel meal mix (FCLM-PM in a completely randomized design. The rabbits were individually caged. The trial lasted for 56 d after which the rabbits were starved overnight and slaughtered. Performance data indicated that body weight gain and feed to gain ratio were significantly higher ($P<0.05$) for FCLM-PM compared with UCLM-PM. A similar trend was observed for digestibility and carcass attributes. Dietary treatments however did not influence ($P>0.05$) liver and kidney weights. Diet D showed consistent superior performance in dressing out percentage, primal cuts of fore and hind parts compared to the control and other dietary treatments. The superiority of Diet D was further emphasized as the cost of producing a kg of rabbit using the diet was 16.88% lower compared to Diet A. It was therefore concluded that replacement of 25% of dietary maize content of rabbit diet with fermented cassava leaf meal and peel meal mix can result in superior performance over the control diet.

Key words: cassava leaf, cassava peel, carcass attributes, digestibility, fermentation, rabbits

Introduction

There has been increased awareness of the advantage of rabbit meat production in developing countries as a means of alleviating animal protein shortages. Rabbit occupies a unique niche in that it is a mini livestock that is easy to manage, highly prolific and has a short generation interval. Rabbits are renowned for their fecundity and prolificacy (Biobaku and Dosunmu, 2003) and ability to utilize forages (Aduku and Olukosi,1990). In the last two decades rabbits have begun to make useful contribution to meat supply in Nigeria where there is shortage of animal protein (Agunbiade, 2009). The increasing popularity of rabbit in Nigeria arose out of the response to the exorbitant prices of the conventional sources of meat, such as cattle for beef, goats for chevon, sheep for mutton, pigs for pork and poultry for chicken meat. Besides, rabbit meat is low in fat and cholesterol (Biobaku and Oguntona, 1997) thus making the flesh a desirable one for diabetics, hypertensive and middle aged people.

The cost of feeding rabbits is however very high, a condition that also prevails for other Nigerian livestock species (Adeyemi *et al*., 2008). Less developed countries, including Nigeria, are facing serious competition between human and animal nutrition (especially, the monogastric animals) for available conventional foodstuffs (Muriu *et al.*, 2002; Teguia and Beynen, 2005). This problem is exacerbated by the high cost of feeding, and consequently, the resulting animal products (Opara,1996). Increased competition for available conventional feeds and scarcity of food have both led to nutritionists, scientists and agriculturists having the need for research into the use of unconventional feedstuffs that are cheap, readily available and possibly substitute for more expensive protein (groundnut cake and soybean meal) and energy sources (maize) in the future (Onyimonony and Onukwufor, 2003; Obun and Adeyemi, 2012). Among possible sources of cheap protein are leaf meal from some plants such as cassava and processed animal by-products such as blood meal, epithelium scrappings, etc. (Adeyemi *et al*.,2013).

Cassava is traditionally grown for the production of roots. According to FAO (2012), Nigeria is the world's leading producer of cassava which produced 36.822, 42.533, 52.403, 57.564 million tonnes in 2009, 2010, 2011 and 2012, respectively. The roots are used as staple while its by-products of leaves and peels are used for farmstead feeding of ruminant animals. It yields about 10 – 30 tonne ha^{-1} of leaves that is usually wasted or used as manure (Bokanga, 1994). The peels account for l0-13% of the tuber by weight (Tewe and Kasali, 1986). Bakanga (1994) reported that 7-20 tonnes of cassava leaves can be harvested per hectare of cassava farmland. Furthermore, harvesting cassava leaves once every two months does not have negative effect on root yield (Lutaladio and Ezumah, l98l).

In animal nutrion perspective, cassava leaves and peel meals have been extensively utilised as individual ingredients in rabbit feeding (Agunbiade *et al*.,1999, 2001a, 2001b, 2002, 2004; Okonkwo *et al*., 2010). Cassava peel meal (CPM) serves as a cheap fibre source while Cassava leaves are rich in protein but both are low in sulfur amino acids (Phuc *et al.,* 2000 and Ayasan, 2010). The nutritive value of cassava leaf meal (CLM) has been reviewed by Lancester and Brooks (1983). West *et al* (1988) indicated that the proximate composition of CLM is favourably comparable with the composition of other feedstuffs such as soybeans and maize. It is believed that the effective combination of the two (CPM and CLM) will result in a feed ingredient of high nutrient value but one likely to suffer from high crude fibre content if fed to animals that are unable to handle fibre such as the poultry species. According to Cheeke (1981), numerous studies have shown that rabbits digest protein in forages quite efficiently but do not use the fibre fraction efficiently. It was explained that while the low digestibility of the fibre may at first seem to limit forage utilization but may be advantageous as they make efficient use of the 75-80% of forage that is non-fibre, and rapidly excrete the fibre fraction.

Dirar (1992) reported that one of the ways of using feeds that are under normal circumstances denigrated is by the use of fermentation techniques. Martín-Cabrejas *et al.* (2004) observed that fermentation significantly decreased the soluble dietary fiber (SDF) content of Phaseolus beans and cellulose content of all samples was reduced by natural and lactic acid fermentation. Recent studies (Adeyemi, 2005, Adeyemi *et* *al.*, 2007) summarised that fermentation offers such opportunity of a simple approach for reducing fibre content. Recognizing the above therefore, this study was carried out to investigate the use of simple fermentation as a means of bio-degrading of fibre fractions in cassava leaf and peel meals mix and to determine the response of growing rabbits fed diets containing fermented or unfermented cassava leaf and peel meals mix.

Materials and Methods

Treatment Diets

Cassava leaves (variety TMS 30572) harvested without petioles were wilted overnight, followed by sun drying for 3 d. The dry crispy leaves were hammer milled to pass through a 2–mm sieve. Similarly, fresh cassava peels of the same variety collected from garri processing unit was washed to remove soil particles and spread thinly on a concrete platform to dry to moisture content less than 10%, hammer milled through a 2-mm sieve and bagged for subsequent use. The milled cassava leaf (CLM) and peel (CPM) meals were mixed to form cassava leaf: cassava peel mix (CLM-PM) with a protein content of 10% using the Pearson Square method (Wagner and Stanton, 2014). The resulting mix was in the ratio 1.0 part CLM: 2.63 parts CPM, the protein contribution in the mix being 59.10 and 40.90 %, respectively, from CLM and CPM. One part of the mix was bagged immediately (Unfermented) while the other part was finely sprayed with sterile water; hand mixed by stirring and packed in double layer polythene bags (Fermented). The bags were made airtight and placed in screw-capped plastic buckets to allow for fermentation for a period of 7 d. At the end of the period, the fermented material was sundried to practical dryness, sampled for proximate fractions and used in feed formulation (Table 1). The unfermented mix of cassava leaf (CLM) and peel meal (CPM) was tagged UCLM-PM while the fermented version was tagged as FCLM-PM.

Five experimental diets were formulated as follows:

Diet A:
consisting of 40.0% maize (100% maize)-Control diet 100.0% maize,
Diet B:
consisting of 30.0% of maize, 10.0% UCLM-PM mix (75.0% maize: 25.0% UCLM-PM)
Diet C:
consisting of 20.0% of maize, 20.0% UCLM-PM mix (50.0% maize: 50.0% UCLM-PM)
Diet D:
consisting of 30.0% of maize, 10.0% FCLM-PM mix (75.0% maize: 25.0% UCLM-PM)
Diet E:
consisting of 20.0% of maize, 20.0% FCLM-PM mix (50.0% maize: 50.0% UCLM-PM)

Table 1: Composition and proximate analyses of treatment diets with different proportions of unfermented (UCLM-PM) and fermented (FCLM-PM) cassava leaf and peel meal mix

Ingredients (%)	Diet A	Diet B	Diet C	Diet D	Diet E
Maize	40.00	30.00	20.00	30.00	20.00
CLM-PM mix	0.00	10.00	20.00	10.00	20.00
Spent grains	30.00	30.00	30.00	30.00	30.00
GNC	14.00	14.00	14.00	14.00	14.00
Palm kernel cake	12.50	12.50	12.50	12.50	12.50
Oyster shell	2.00	2.00	2.00	2.00	2.00
Bone meal	1.00	1.00	1.00	1.00	1.00
Vit/min premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Determined analysis					
Dry matter	91.12	91.35	91.37	91.02	90.89
Crude protein	19.09	20.00	20.10	20.45	20.58
Ether extract	4.58	4.25	3.81	3.27	3.20
Crude fibre	10.77	11.56	12.21	10.11	11.82
NDF	33.21	40.20	43.86	38.03	40.69
ADF	21.03	24.55	26.18	22.90	24.65
ADL	4.53	8.40	8.64	8.25	8.42
Ash .	5.67	5.95	6.04	5.20	5.88
Metabolisable energy (kJ/kg)	10.80	10.68	10.60	10.62	10.54

*contains Vit. A 4000000IU; Vit. D. 800000IU; Vit. E 40000mg; Vit. K_3 800mg; Vit. B_1 1000mg; Vit. B_2 6000mg; Vit.B_6 5000mg; Vit.B_{12} 25mg; Niacin 6000mg; Pantothenic acid 20000mg; Folic acid 200mg; Biotin 8mg; Manganese 300000mg; Iron 80000mg; Zinc 20000mg;
Cobalt 80mg; Iodine 400mg; Selenium 40mg; Choline 800000mg.

Experimental Animals

Fifty 6-week old weaner rabbits of mixed breed (New Zealand White x Chinchila) and of equal sex with initial weight of 600 to 610 g were selected from a larger pool purchased from a reputable rabbit farm in Ibadan, Oyo State, Nigeria. The rabbits were treated for endo- and ecto-parasites using Ivomec® at 1 ml/50 kg bodyweight. The hutches were washed and disinfected before the arrival of the experimental animals. The hutches raised 90 cm above the floor were housed in an open sided house that allowed for air flow through ventilation. The rabbits were housed individually in cells of dimension 55 x 35 x 45 cm. Each cell was equipped with two flat bottom wide earthen pots of 10 cm diameter with inner lips (2 mm) to prevent wastage; one was the feeder while the other was the drinker. The rabbits were randomly and equally_allocated to the five experimental diets such that each diet was fed to ten individually caged rabbits. Diets and water were provided *ad libitum* throughout the 56-days feeding trial.

Data Collection and Analysis

Feed intake and body weight changes were measured on weekly basis and later converted to daily values.

Feed Intake: The feed intake for each rabbit was determined by collecting left over feed from feeders each morning at 08:00 hrs., before feeding, daily collection of left-over from each animal was stored in a marked nylon bag and kept in airtight plastic containers. The feed orts individual rabbit were bulked together at the end of each week, weighed and subtracted from the addition of daily feed supplied to the rabbit over the week to get the average feed intake.

Average feed intake (g/d) = (Feed supplied – Feed leftover)/No. of d on trial

Body weight and weight gain: Each replicate was weighed at the beginning of the trial and weekly, thereafter. The gain for each week was obtained by difference. From this, the weight gain per day was calculated as:

Average daily weight gain (g/d) = (Final weight – Initial weight)/no. of d on trial

Feed Conversion Ratio (FCR) was determined as:

FCR = Average feed intake (g)/ Average daily weight gain (g)

The formulae for calculating Average daily feed intake and weight gain were as described by Adeyemi *et al*. (2013) while feed conversion was as described by Cullison (1982).

Nutrient Digestibility Study

At the end of the 56-d feeding trial, four rabbits (two of each sex) per treatment were randomly selected and housed in separate metabolic cages to measure apparent nutrient digestibility. The rabbits were acclimatized for 3 d prior to the commencement of the trial. Selected rabbits were fed with diet at quantity which matched their previous mean daily intake. Sample collection was done for 4 d, Excreta (devoid of feed particles and other contaminants) were collected daily from each cage and dried in a Gallenkhamp® drying cabinet at 60 °C for 12 h. Feed samples and ground excreta samples were used for chemical analysis. Daily feed intake during the 4–d collection period was also measured. The total tract apparent nutrient digestibility (%) was estimated using the equation:

$$\frac{[(F_i \times N_f) - ((E \times N_e)])}{(F_i \times N_f)} \times 100$$

where F_i and *E* is the quantity of feed intake and excreta output (g DM) during metabolic trial period. The N_f is the nutrient composition in feed while N_e is the nutrient composition in excreta voided (g DM).

Carcass and Meat Quality Measurements

Six rabbits (three of each sex) per treatment were slaughtered without prior fasting and transportation. Head was separated from the body by cutting though the section between *occiput* and *atlas vertebra.* The paws were removed at the carpal and tarsal joints. Commercial dressing procedures were followed, including removal of genitals, digestive tract and skin.

After 24 h of chilling, weighed carcass was divided according to the recommendations of the World Rabbit Science Association (Ouhayoun and Dalle Zotte, 1996). Proportions of abdominal fat, back and hind-parts were calculated. The meat to bone ratio was determined in the hindleg. The dressed weight and the dressing out percentage (DoP) were calculated using the equation of Ouhayoun and DalleZotte (1996) as:

Dressed weight = Live weight – Offal weight where offal weight included weights of gastro-intestinal tract and internal organs.
DoP % = (Dressed weight/Live weight) x 100

Cost Analysis

Feed cost per kg and cost per kg weight gain were calculated. The calculations were based on the prevailing market prices of feed ingredients at the time of the experiment. The percentage saving in feed cost of rabbits on UCLM-PM and FCLM-PM based diets compared to the maize based control diet were also determined.

Chemical Analysis

Proximate analysis of the experimental diets and faecal samples was carried out according to the method of A.O.A.C. (2005). Crude protein (N x 6.25) was determined by the Kjeldahl procedure while crude fat determination was carried out by petroleum ether (bp 60 – 80 ^{o}C) extraction using the soxhlet procedure. Ash content was determined after combustion of samples at 550 ^{o}C over a 4-h period in a muffie furnace. The detergent components were determined by the procedure developed by Goering and Van Soest (1970). Metabolisable energy (ME) value of the test diet was calculated by the method of Wardeh (1981).

Statistical Analysis

All data collected were subjected to analysis of variance for a completely randomized design (Steel and Torrie, 1980). Significant differences between treatment means were determined using the Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

The performance characteristics and economic evaluation of utilisation of fermented and unfermented cassava peel and leaf meal mixture as replacement for maize in rabbit diets are shown in Table 2. Rabbits fed UCLM-PM mix at 25 and 50% inclusion levels had lowest final weight and average daily weight gain. The average daily weight gain of rabbits of 16.92 and 17.00 g/d for 25 and 50%, respectively, were close to the weight range of 17.65 to 18.80 g/d recorded by Agunbiade *et al.* (1999) for rabbits fed cassava leaf and peel meal in association with palm oil sludge in the same environment as that of this study. It was however lower than 25.5-31.0 g/d reported by Lebas *et al.*(1986) for temperate regions. Lebas (1983) had established that high ambient temperature such as the one in the tropics depresses feed intake and weight gain in rabbits.

Table 2: Performance of rabbits fed treatment diets with different proportions of unfermented (UCLM-PM) and fermented (FCLM-PM) cassava leaf and peel meal mix

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	SEM
Initial weight (g)	605.10	604.50	608.45	606.50	605.25	
Final weight (g)	1638.74^{b}	1551.88^{c}	1560.69	1730.57^{a}	1636.57^{b}	15.01
Weight gain (g)	1033.64^{b}	947.38^{c}	952.24^{c}	1124.07^{a}	1031.32^{b}	10.51
Daily weight gain (g/day)	18.46^{b}	16.92^{c}	17.00^{c}	20.07^{a}	18.42^{b}	2.18
Daily feed intake (g/day)	65.93^{c}	75.49^{b}	81.69^{a}	66.16^{c}	66.47^{c}	6.22
Feed: Gain	3.57^{c}	4.46^{b}	4.81^{a}	3.30^{d}	3.50^{c}	0.4

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

Rabbits on Diet C (50% replacement of maize with UCLM-PM) had the highest feed intake and feed: gain ratio. Rabbits fed Diet D (25% replacement of maize with FCLM-PM) exhibited superior performance over other CLM-PM treatments and compared favourably with those on the control diet. Rabbits on Diet_D consumed the least amount of feed (66.16 g/d) and gained the highest average daily of feed to gain (20.07 g/d). A comparison of the fermented test ingredient with the unfermented showed vividly that fermentation improved performance indices. The fermentation process reduced the amount of feed required to produce a kg of rabbit meat by 28.25 and 20.58% at 25 and 50% replacement level of maize, respectively, by the test ingredient. There was a consistent similarity in values obtained for all indices of performance for the control and diet E (50% replacement of maize with FCLM-PM) except values obtained for average daily feed intake and feed:gain ratio. The fermentation process appeared to have enhanced the feeding quality of the test ingredient hence the superior performance over the unfermented test ingredient. Fermentation is considered to be a major process of cyanide elimination (Westby, 1994). According to Achinewhu *et al.* (1998) fermentation enhances the nutrient content of foods through the biosynthesis of vitamins, essential amino acids and proteins by improving protein quality and fibre digestibility. It also enhances micronutrient bioavailability and aids in degrading anti-nutritional factors. Similar observation was made by Adeyemi *et al.* (2008) for rumen filtrate fermented cassava root meal and Adeyemi *et al.* (2011) for fermented pineapple peel.

Digestibility of dry matter, crude protein and crude fibre were affected (P<0.05) by dietary treatment (Table 3). Digestibility on FCLM-PM was significantly better than the values obtained on the UCLM-PM. The digestibility of nutrients was similar on the control (A) and D diets. Among diets containing CLM-PM, fermentation led to better digestibility of nutrients. Fermentation resulted in an improvement of 29.95 and 8.44% in crude fibre digestibility for dietary combinations of 75.0% of maize: 25.0% CLM-PM and 50.0% of maize: 50.0% CLM-PM, respectively. Similar improvements of 18.78 and 25.31% were observed in crude protein digestibility for the similar dietary combinations, respectively, as a result of fermentation. This positive response may be attributed to the effects of fermentation on the test material, namely, enzymatic predigestion, acquisition of flavour, friability and further reduction of residual anti nutritional factors. Adejinmi *et* *al*. (2007) reported that fermentation of cocoa pod husk before dietary inclusion had a positive effect on nutrient digestibility, average final live weight, average total weight gain, average daily weight gain and feed conversion ratio. A similar result of the beneficial role of fermentation on fibrous feeding material was obtained by Adeyemi *et al.* (2011) when fermented pineapple peel meal was fed to growing rabbits.

Table 3. Nutrient digestibility(%) of rabbits fed diet containing fermented and unfermented cassava peel: leaf meal mix

Digestibility %	Diet A	Diet B	Diet C	Diet D	Diet E	SEM
Dry matter	71.45[a]	62.45[b]	60.13[b]	73.38[a]	68.54[ab]	2.88
Crude protein	75.19[a]	65.74[b]	61.48[b]	78.09[a]	77.04[a]	1.11
Fat	70.10	70.10	69.53	71.21	69.43	0.39
Crude fibre	67.52[ab]	59.06[c]	57.52[c]	76.75[a]	62.38[b]	2.85

[abc]Means within the same row with different superscripts are significantly different ($P<0.05$)

Dressing out percentage (DoP), fore part, hind part, and meat: bone ratio were significantly affected ($P < 0.05$) by dietary treatments (Table 4). Similarly entire gastrointestinal tract (GIT) weight and abdominal fat weight were influenced by dietary treatments ($P<0.05$). No effects of dietary treatments were however observed on liver and kidney weights ($P > 0.05$). DoP was similar for the control diet(A) and diet D (75.0% of maize, 25.0% FCLM-PM mix) and were significantly higher than the other dietary treatments. The same trend was observed for the primal cuts of fore and hind parts. The trend observed for these important indices of carcass composition was considered as an indication of the superior quality of the Diet A and Diet D over the other diets. The reduction observed in abdominal fat content of rabbits on the CLM-PM based diet compared to the Control diet was expected and considered a direct reflection of the effect of dietary fibre. The entire GIT weight was significantly reduced by fermentation of CLM-PM content of the diet. These reductions were thought to be a result of reduction in the bulkiness of diets brought about by the reduction in fibre content as a result of the pretreatment by fermentation. The lack of effect on kidney and liver by the dietary treatments suggested the safety of the test ingredients. Agunbiade *et al*. (2002) and Ojebiyi *et al.* (2010) reported similar non detrimental effects when cassava peel meal (CPM) and cassava peel and leaf meal mix respectively were fed as replacement for maize in diets of growing rabbits.

Table 4: Carcass (% liveweight), visceral (% liveweight) and primal cuts (% dressed weight) evaluation of rabbits fed diet containing fermented and unfermented cassava peel: leaf meal mix

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	SEM
DoP	62.93[a]	56.60[b]	53.70[c]	63.27[a]	57.31[b]	4.91
Pelt %	10.08[a]	9.28[b]	8.17[c]	10.06[a]	9.98[ab]	1.41
Visceral % live weight						
GIT	31.09[ab]	33.29[a]	33.99[a]	30.08[b]	31.15[ab]	1.13
Liver	4.17	4.47	4.26	3.72	4.52	0.39
Kidney	0.45	0.42	0.41	0.44	0.41	0.02
Abdominal fat	1.25[a]	0.79[b]	0.65[b]	0.96[ab]	0.77[b]	0.04
Primal cuts (% dressed weight)						
Fore part	25.72[a]	23.90[b]	19.61[c]	26.91[a]	22.43[b]	1.35
Hind part	30.3[a]	28.11[b]	24.01[c]	30.00[a]	28.52[b]	1.56
Intermediate part	21.47	19.11	19.05	20.05	19.60	1.25
Hind leg	16.7[a]	13.85[c]	13.50[d]	15.5[ab]	14.4[b]	0.50
Meat:Bone ratio	4.15[a]	3.08[b]	3.05[b]	4.10[a]	4.02[a]	0.36

[abc]Means within the same row with different superscripts are significantly different (P<0.05)

Cost per kg of experimental diets was as high as N68.34 for the maize based control and as low as N58.20 for Diet C (consisting of 50.0% of maize: 50.0% UCLM-PM mix) (Table 5). Diets D and E which were based on FCLM-PM were 2.18 and 3.64 % more expensive compared to the unfermented versions. This slight variation in cost per kg of feed is as a result of the extra cost of fermentation and drying. Generally, inclusion of cassava peel/leaf meal mixtures led to a decrease in cost/kg diet compared with the maize based control. However, economic efficiency (Feed cost/kg gain) was lower on Diets B and C using the Control diet (A) as a baseline. The superiority of Diet D was further emphasized as the cost of producing a kg of rabbit using Diet D was 16.88% lower compared to Diet A. The decrease in cost per kg diet resulted from the fact that the cost of a unit of CLM-PM mix was lower than the cost of a unit of maize, which it replaced. This finding corroborates the report of Tewe and Bokanga (2001) that the cost of cassava products was about 40% lower than that of maize.

Table 5: Economic evaluation of rabbits fed treatment diets with different proportions of unfermented (UCLM-PM) and fermented (FCLM-PM) cassava leaf and peel meal mix

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	SEM
Cost/kg feed (₦)	68.34	60.14	58.20	61.45	60.32	
Cost/kg gain (₦)	243.97[c]	268.22[d]	279.94[e]	202.79[a]	211.12[b]	2.68
% Cost saving/kg gain relative to control diet		-9.94	-14.74	+16.88	+13.46	-

[ab]Means within the same row with different superscripts are significantly different (P<0.05)

Conclusion

The analyzed data for this study reveal that replacement of 25% of dietary maize content of rabbit diet with fermented cassava leaf meal and peel meal mix can result in superior performance over the 100% maize based diet without any deleterious effect on performance.

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