Replacement value of rumen liquor fermented cassava peels for maize in growing rabbit diet

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Additional keywords

Cassava peels.
Health status.
Growth indices.
Rumen liquor.

SUMMARY

The nutritive potential of rumen liquor fermented cassava peels (RLFCP) was assessed in rabbit nutrition in an 8 weeks trial. The freshly collected droppings from layers were sundried, ground and mixed at 100 g/kg with ground cassava peels, sprayed with rumen filtrate and fermented for 144 hours. Thereafter, one basal diet was formulated to meet the nutrient requirement of a growing rabbit. The maize content (43 g/100 g) of the basal diet was replaced at 0, 25, 50, 75 and 100% with RLFCP and named as diets 1, 2, 3, 4 and 5 respectively. One hundred and fifty mixed sexes healthy 5-weeks old crossbred weaner rabbits were randomly distributed among the five dietary treatments at a rate of 30 rabbits per treatment. The response criteria were growth indices, cost benefit, carcass and organ weight, blood and serum indices. While the average daily feed intake increased (49.27-58.00 g/rabbit/day) with an increased RLFCP inclusion, the average daily weight gain only increased (12.38-17.75 g/rabbit per day) when the increased RLFCP inclusion reached up to a 50%. The feed conversion ratio of rabbits fed on the control and those fed on 25% and 50% RLFCP was similar (3.03-3.20) ($p>0.05$). Only the slaughtered weight (1116.50-1416.16 g), dressed weight (477.65-695.85 g), dressing% (42.77-50.14), relative weight (% slaughter weight) of the liver (2.18-2.57) and heart (0.20-0.23) were significantly ($p<0.05$) influenced by the dietary treatments. From all the haematological parameters considered; only the packed cell volume (PCV) (35.67-37.15%), mean cell haemoglobin concentration (MCHC) (32.65-34.05 g/dl) and platelets (275.50-452.00 109/l) were significant ($p<0.05$) while serum glutamic oxalo acetic transaminase (SGOT) (67.57-113.10 µl), glutamic pyruvic transaminase (SGPT) (97.43-152.50 µl), amylase (463.50-699.00 µl) and glucose (53.60-100.50 mg/dl) of the serum metabolites measured were significant ($p<0.05$). The replacement of maize in growing rabbit diet with RLFCP appeared not to compromise the health status of the rabbits and its inclusion at a 50% of maize reduced cost of feeding by 20% and promoted better growth performance indicators than the control diet of the RLFCP-based diets.

Valeur de remplacement des écorces de manioc fermenté au liqueur ruminale avec le maïs dans l'alimentation des lapins en croissance

Mot clés additionnels

Écorces de manioc.
État de santé.
Les indices de croissance.
Liqueur ruminale.

RESUMÉ

Le potentiel nutritif de pelures de manioc fermentées avec liqueur du rumen (RLFCP) a été évalué chez le lapin dans un essai de nutrition pendant 8 semaines. Les déjections séchées mixées, (100 g/kg) avec des pelures de manioc, aspergés de filtrage ruminal et fermentées pendant 144 heures. Par la suite, une diète basale a été élaboré pour satisfaire aux besoins nutritionnels du lapin en croissance. Le maïs (43 g/100 g) de la diète basale a été remplacé à 0, 25, 50, 75 et 100% avec RLFCP (régimes 1, 2, 3, 4 et 5 respectivement). Cent cinquante lapins agées 5 semaines, sains, des deux sexes, et de races croisées ont été aléatoirement alloués à cinq traitements diététiques (30 lapins par traitement). Les critères de réponse étaient les indices de croissance, coût-bénéfice, la carcasse et le poids d'organes, et les indices du sang et du sérum. Bien que la prise de l'alimentation quotidienne moyenne a augmenté (49,27-58,00 g/lapin/jour) avec l'augmentation de l'inclusion de RLFCP, la moyenne de gain de poids quotidien seulement augmenté (12,38-17,75 g/lapin par jour) avec l'inclusion RLFCP accrue jusqu'à 50%. L'indice de conversion alimentaire des lapins recevant le contrôle et ceux sur 25% et 50% RLFCP sont semblables (3,03-3,20) ($p>0.05$).). Seul le poids d'abattage (1116,50-1416,16 g), le poids de la carcasse (477,65-695,85 g), rendement de la carcasse (42,77-50,14 %), poids relatif (% poids d'abattage) du foie (2,18-2,57) et du coeur (0,20-0,23) étaient significativement ($p<0,05$) influencées par le traitement alimentaire. De tous les paramètres hématologiques considérés; seul le PCV (35,67-37,15%), MCHC (32,65-34,05 g/dl) et de plaquettes (275,50-452,00 109/l) étaient significatives ($p<0,05$). En relation avec taux sériques de les métabolites mesurés: SGOT (67,57-113,10 µl) 97,43 -152,50, SGPT (µl), l'amylase (463,50-699,00 µl) et la glucose (53.60-100.50 mg/dl) étaient significatives ($p<0,05$). Le remplacement du maïs en régime de lapin avec RLFCP croissante semblaient ne pas compromettre le statut

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sanitaire des lapins et son inclusion à 50 % de maïs, promu une meilleure croissance des indicateurs de rendement que la diet contrôle dans les régimes à base de RLFCP.

INTRODUCTION

The current high cost of energy concentrates such as maize in developing countries is one of the major contributing factors limiting animal protein production. There is increase usage of maize in the industries to produce confectioneries (Ogunsipe *et al.,* 2011) and for producing bio-fuel, ethanol. This has grossly affected the cost of animal protein, thereby limiting the accessibility and affordability of animal proteins to the rich few.

In most Africa and pacific countries, it has been estimated that the average animal protein intake is as low as 10 g, which is very much lower than 35 g recommended by (FAO, 1986). This necessitates the search for alternative feed resources, such as cassava peels that are not consumed by man which when incorporated into animal feeds could lead to reduced cost of finished feeds. For instance, in Nigeria about 40-44 metric tones of cassava tubers are being produced annually. The peel constitutes about 10-20 % of the cassava tuber and this translates to 4-4.4 metric tones of cassava peels that are often left to rot away unharnessed (Aro *et al.,* 2010). Thus improving on the nutritive contents of this waste may be of tremendous benefit to livestock feed industry.

Cassava peel has crude protein, crude fibre, ether-extract and ash ranges of 3.7 to 5.9 g, 10.3 to 31.8 g, 0.0 to 3.3 g and 3.4 to 8.0 g/100 g respectively (INRA *et al.,* 2012). However, the utilization of cassava peel is limited by the presence of hydrocyanic acid (HCN) and high fibre, which may cause chronic toxicity in human and livestock particularly when inappropriately processed (Oluremi and Nwosu, 2002; Aro *et al.,* 2010). Fermentation technique has been reported to be of tremendous importance in enhancing the nutrient potentials of cassava products such as protein (Nwafor and Ejulonemu, 2004), flavor (Akindahunsi *et al.,* 1999) and detoxification of antinutrients (Oboh and Akindahunsi, 2003). Also, improvement in crude protein content of cassava root and pomace when fermented with rumen filtrate has been reported by Adeyemi and Sipe (2010) and Songsak and Sirilak (2009) respectively. However, there appears to be limited information on fermenting cassava peels with rumen micro-organisms especially when fermented with animal wastes such as droppings over a period of time. Oloruntola *et al.* (2015) obtained 49.55 % increase in crude protein and 44.5 % decrease in crude fibre value of cassava peels in a solid state fermentation with rumen liquor using layer waste as source of nitrogen. The same rumen liquor fermented cassava peels were used in this experiment to replace maize in growing rabbit's diet.

The advantages of raising rabbits include high prolificacy, short generation interval, and ability to strive well on forages, and effective conversion of up to 30 % fibre as against 10 % by most monogastrics including poultry (Cheeke *et al.,* 1987) among others. This thus explains the choice of rabbit as animal model for this trial. This, study was consequently carried out to evaluate the replacement value of rumen liquor fermented cassava peels for maize in rabbit diets using growth performance, economy of production and health implications as response criteria.

MATERIAL AND METHODS

EXPERIMENTAL SITE

The feeding trial was conducted at the Rabbit unit of the Teaching and Research Farm of the Agricultural Technology Department, The Federal Polytechnic, Ado Ekiti. Nigeria after the right to conduct the research had been granted by the Research Committee of the Department of Animal Production and Health, The Federal University of Technology, Akure, Nigeria. The study area is located between latitudes 7°37'N and 7°12'N and longitudes 5°11'E and 5°31'E with the mean annual rainfall of 1247 mm, 70 to 85 % relative humidity. The experimental site is 437 mm above sea level with a mean annual temperature of 26.2°C.

EXPERIMENTAL ANIMALS AND ANIMAL MANAGEMENT

The rabbits were managed as described by Fernández-Carmona *et al.* (2005) for applied nutrition experiments in rabbits. One hundred and fifty (150) healthy, five weeks old weaner rabbits of cross-breeds and mixed sexes were randomly allotted to the five dietary treatments after balancing for weight in a completely randomized design. Each treatment group was replicated with 30 weaning rabbits with three (3) weaner rabbit representing a replicate. The rabbits were housed individually in three-tiers, wooden framed and wire meshed cages. The cages were raised 90 cm above the ground and housed in well ventilated pen. Each rabbit was provided with separate galvanized water trough and feeder. Prior to the commencement of the experiment, the rabbits were treated against some disease (coccidiosis, bacterial infection and mange) by administering prophylactic coccidiostat, ivomectin and antibiotics (tetracycline) and thereafter, made to undergo a week adaptation period in their individual cages. The rabbits were fed their respective diet *ad libitum* throughout the period of 8 weeks.

THE TEST INGREDIENTS AND EXPERIMENTAL DIETS

Fresh cassava peels were obtained from a cottage cassava processing factory, washed, drained immediately and spread lightly on clean concrete floor for sun-drying for 8-10 days. Thereafter, the dried cassava peels (DCP) were hammer-milled and stored in polythene bags until used. Fresh layer's wastes were obtained from the laying unit of the Teaching and Research Farm of the Agricultural Technology Department of The Federal Polytechnic, Ado Ekiti, sundried, hammered-milled and stored until used. Rumen liquor from freshly slaughtered cattle was squeezed out of the rumen content in Ado Ekiti central abattoir through a sieve in a clean environment and used almost immediately.

Thus, a dried layer waste was mixed at the rates of 100 g/kg in air tight black polythene bag with DCP, sprayed with rumen liquor, made airtight for fermen-

Table I. Gross composition of the experimental diets (%) and test ingredient (Composition brute des diètes expérimentales (%) et le test de l'ingrédient).

	Level of RMFCP inclusion (%)						
	0	25	50	75	100		
Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	RMFCP	DCP
Maize	43.00	32.25	21.50	10.75	00.00		
RMFCP	00.00	10.75	21.50	32.25	43.00		
Maize husk	22.40	22.40	22.40	22.40	22.40		
Wheat offal	8.00	8.00	8.00	8.00	8.00		
BDG	10.00	10.00	10.00	10.00	10.00		
Soya bean meal	14.85	14.85	14.85	14.85	14.85		
Bone meal	1.00	1.00	1.00	1.00	1.00		
Methionine	0.15	0.15	0.15	0.15	0.15		
Lysine	0.10	0.10	0.10	0.10	0.10		
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		
Calculated analysis							
Crude protein %	15.44	15.88	16.32	16.11	16.33		
Crude fibre %	11.33	12.15	12.13	12.56	12.97		
Lysine %	0.76	0.70	0.81	0.67	0.65		
Methionine %	0.39	0.35	0.43	0.33	0.31		
Calcium %	0.43	0.43	0.46	0.42	0.42		
Avail. Phosphorus %	0.38	0.36	0.30	0.36	0.35		
ME (kcal/kg)	2965.04	2964.61	2964.61	2964.39	2964.18		
Analyzed composition (%)							
Moisture	92.9	92.99	93.03	93.05	93.09	93.87	94.6
Crude protein	16.05	16.15	16.37	16.61	17.68	10.87	5.49
Crude fibre	11.33	11.68	12.09	12.48	12.87	5.83	10.50
Ether extract	3.12	3.13	3.11	3.15	3.17	2.15	1.62
Ash	6.21	6.24	6.17	6.16	6.18	5.61	5.32
Nitrogen free extract	56.19	55.79	55.29	54.65	53.19	69.41	71.67

RLFCP= Rumen liquor fermented cassava peels; DCP= Dried cassava peels; BDG= Brewers' dried grain; ME= Metabolizable energy.

tation durations of 144 hours and thereafter sun-dried for 4-5 days. The composition of the rumen liquor fermented cassava peel (RLFCP) was determined. Thereafter, one basal grower rabbit diet was formulated in which maize was the main energy source. The maize content of the basal diet was replaced with RLFCP at 0, 25, 50, 75 and 100 %, and designated as diets 1, 2, 3, 4 and 5 respectively **(table I)** and the diets were pelletized (4 mm diameter and 8 mm long). The metabolizable energy (ME) of the experimental diets was the cumulative ME contributed by the various feed stuffs used in compounding the diets.

Response criteria

Growth performance

The initial weight of each rabbit was subtracted from the final weight at end of each week to obtain the weight gain. The feed consumption was the difference between the feed left over and feed given daily, and the feed conversion ratio was calculated as the ratio of feed consumed to the total weight gain of each rabbit.

Evaluation of carcass and relative organ weights

Six rabbits were randomly selected from each treatment group of ten rabbits at the end of the 8 weeks feeding trial. These rabbits were starved overnight, slaughtered according to the guidelines of the World Rabbit Science Association (WRSA) and skinned. Pelts, rabbit's heads and legs were removed and weighed. Their major internal organs (lungs, liver, kidney, heart, pancrease and bile) and gastrointestinal tract were removed and weighed. Thereafter, dressing weights were determined and used to calculate the dressing percentage for the rabbits, while the gastrointestinal tract and other internal organs were expressed as a percentage of slaughtered weight.

Haematological and serum analyses

Cotton wool impregnated with 70 % alcohol was used to clean the surface of the pinna before slaughter for carcass and organ weight measurement. Thereafter; blood were collected from the marginal ear vein of each rabbit, using syringe and needle. The blood samples were collected into two separate bottles, a blue top bottle containing K3-EDTA and plain purple top bottle. The haematological indices (white blood cells, lymphocytes, monocytes, granulocytes, red blood cells, haemoglobin concentration, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration) on EDTA samples were determined on the day of collection by Shenzhen Mind ray Auto Haematology Analyzer (Model Bc-3200, Shenzhen Mind ray Biomedical Electronics Co. Hamburg 20537, Germany). The serum was separated from plain purpled top bottled blood sample and frozen at -20ºC prior to analysis. The cholesterol, urea, creatinine, high density lipoprotein (HDL), low density lipoprotein (LDL), bilirubin, serum glutamic oxalo acetic transaminase (SGOT), Serum glutamic pyruvic transaminase (SGPT), Alkaline phosphatase (ALP), amylase, total protein, albumin, globulin and glucose were determined with a Reflectron ® Plus 8C79 (Roche Diagnostic, GonbH Mahnheim, Germany), using kits.

Economic Analysis

The cost of producing the experimental diets was estimated by using the market prices for the feed ingredients during the time of the experiment. The cost of feed consumed was estimated as the product of the cost of 1 kg and total feed consumed while the feed cost/kg body weight was obtained by dividing the cost of feed consumed by the final body weight of rabbits fed the diet.

$$\text{The \% cost reduction} = \frac{\text{Control diet´s cost} - \text{Test diet´s cost}}{\text{Control diet´s cost}} \times 100$$

Chemical and statistical analyses

Proximate composition of the dried cassava peels, rumen liquor fermented cassava peels, other test ingredients and experimental diets were determined (AOAC, 1995). The procedures 920.15 (dry matter, DM), 984.13 (crude protein, CP), 942.05 (crude ash) and 920.39 (ether extract, EE) were employed. Data were subjected to analysis of variance (ANOVA) using SPSS (2011) version 20, while the difference between treatment means were examined by Duncan multiple range test of the same package.

RESULTS

Table I shows the analysed composition of the experimental diets, rumen liquor fermented cassava peels (RLFCP) and dried cassava peel (DCP). The crude protein (CP) and crude fibre (CF) contents of the experimental diets ranged from 15.44 to 16.33 % and 11.33 to 12.97 % respectively. The CP and CF for RLFCP was 10.87 % and 5.83 % while 5.49 and 10.50 % was observed for DCP respectively.

All the performance characteristics of the weaner rabbits measured were significantly (p<0.01, 0.001) affected by the dietary treatments **(table II)**. The final live weight (FLW): 1425.13 g/rabbit: 993.88 g/ rabbit and daily weight gain (DWG): 17.75 g/rabbit per day of rabbits fed 50 % RLFCP-based diet were significantly (p<0.01) higher than those fed on 75 % and 100 % RLFCP-based diets, but similar to those fed the control and 25 % RLFCP-based diets. Rabbits fed the control diet had the least average daily feed intake (49.27 g/rabbit/day) and protein intake (454.19 g/ rabbit/week) and this increased with increase RLFCP to 100 % in the diets to (58.99 g/rabbit/day and 575.12 g/rabbit/week) respectively. The feed conversion ratio (FCR) of the rabbits fed the control diet, 25 and 50 % RLFCP-based diets (3.03, 3.20 and 3.04) were similar but significantly (p<0.001) higher than those fed the rest test diets (3.99 and 4.98).

Table III shows that the slaughter weight (SW), dressing weight (DW) and dressing percentage (DP) were significantly (p<0.001) affected by the dietary treatments. The SW and DW of those rabbit fed 50 % RLFCP-based diet (1416.16g and 695.85 g) were significantly (p<0.001) higher than those fed on the control and those fed on the rest test diets. While the DP of rabbits fed the control, 25 %, 50 % and 75 % RLFCP-based diets (49.21-50.28 %) were similar , they were significantly (p<0.001) higher than those fed 100 % RLFCP-based diet (42.77 %). Also, only the relative organ weights of the liver and heart were significantly (p<0.01; 0.05) influenced by the dietary treatment. The relative organ weight of the liver decreased with increased level of RLFCP inclusion in the experimental diets (2.57-2.18 % slaughtered weight) while the relative organ weight of the heart did not follow a particular trend; however, highest value was observed in rabbits fed 25 % RLFCP-based diet (0.23 % slaughtered weight and lowest (0.18 % slaughtered weight) in rabbits fed 50 % RLFCP-based diet.

Table IV shows that of all the haematological indices measured; only the packed cell volume (PCV),

Table II. Performance characteristics of weaner rabbits fed rumen liquor fermented cassava peel (Caractéristiques de performances de sevré des lapins nourris liqueur du rumen manioc fermenté peel).

	Level of RLFCP inclusion (%)						
	0	25	50	75	100		
Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	p value
Initial live weight (g/rabbit)	429.38	421.62	431.25	411.25	420.50	10.11	0.656
Final live weight (g/rabbit)	1369.88^{ab}	1344.13^{ab}	1425.13^{a}	1213.25^{bc}	1113.50^{c}	30.97	0.01
Average daily weight gain (g/rabbit/day)	16.79^{ab}	16.47^{ab}	17.75^{a}	14.32^{bc}	12.38^{c}	0.55	0.01
Average daily feed intake (g/rabbit/day)	49.27^{d}	50.34^{cd}	53.17^{bc}	55.92^{ab}	58.99^{a}	53.54	0.001
Protein intake (g/rabbit/week)	454.19^{d}	470.24^{d}	502.87^{c}	535.83^{b}	572.12^{a}	8.16	0.001
Feed conversion ratio	3.03^{a}	3.20^{a}	3.04^{a}	3.99^{b}	4.98^{c}	0.16	0.001

Means with different superscripts in the same row are significantly different (p<0.05).

Table III. Carcass characteristics and relative organ weight of weaner rabbits fed fermented cassava peels (Caractéristiques de performances de sevré des lapins nourris liqueur du rumen manioc fermenté peel).

	Level of RLFCP inclusion (%)						
	0	25	50	75	100		
Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	p value
Slaughter weight (g)	1316.61[b]	1306.64[c]	1416.16[a]	1135.50[d]	1116.50[e]	26.37	0.001
Dressing weight (g)	660.18[b]	656.95[b]	695.85[a]	570.62[c]	477.65[d]	18.77	0.001
Dressing percent (%)	50.14[a]	50.28[a]	49.21[a]	50.27[a]	42.77[b]	0.77	0.001
Lung (% SW)	0.72	0.68	0.71	0.75	0.62	0.03	0.814
Liver (% SW)	2.33[bc]	2.57[a]	2.42[ab]	2.25[bc]	2.18[c]	0.04	0.01
Kidney (% SW)	0.68	0.66	0.52	0.62	0.54	0.02	0.084
Heart (% SW)	0.21[ab]	0.23[a]	0.18[b]	0.20[ab]	0.20[b]	0.01	0.052
Pancrease (% SW)	0.05	0.04	0.04	0.05	0.05	0.00	0.764
Bile (% SW)	0.04	0.04	0.05	0.04	0.04	0.00	0.896
Gastrointestinal tract (% SW)	18.27	19.04	17.94	18.72	16.12	0.42	0.203
Carcass length (cm)	30.63	30.00	29.68	30.38	29.93	0.24	0.776

Means with different superscripts in the same row are significantly different ($p<0.05$). SW= slaughter weight.

Table IV. Haematology of weaner rabbits fed rumen liquor fermented cassava peels (Hématologie de sevré des lapins nourris de pelures de manioc fermentée liqueur du rumen).

	Level of RLFCP inclusion (%)						
	0	25	50	75	100		
Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	p value
PCV (%)	34.64[b]	35.68[ab]	37.15[a]	35.08[b]	35.67[ab]	0.29	0.047
Haemoglobin conc. (g/dl)	11.80	12.68	11.94	12.03	11.69	0.19	0.569
Red blood cells ($x10^{12}$/l)	6.53	6.36	6.45	6.74	6.01	0.16	0.713
White blood cells ($x10^{9}$/l)	8.08	7.80	7.91	7.67	7.87	0.21	0.985
Lymphocytes ($x10^{9}$/l)	1.74	2.53	2.98	2.15	3.02	0.21	0.234
Monocytes ($x10^{9}$/l)	1.08	1.23	1.27	1.08	1.13	0.04	0.507
Granulocytes ($x10^{9}$/l)	1.48	2.76	2.80	2.48	2.40	0.19	0.179
MCV (fl)	54.75	56.25	59.25	56.24	61.26	1.05	0.296
MCH (pg)	18.75	22.33	22.43	21.65	21.13	0.48	0.072
MCHC (g/dl)	32.65[b]	33.50[ab]	34.2[a]	33.78[a]	34.05[a]	0.19	0.042
Platelets (10^{9}/l)	452.00[a]	358.75[ab]	358.25[ab]	275.50[b]	383.25[ab]	17.73	0.012

PCV= Packed cell volume; MCV= Mean cell volume; MCH= Mean cell haemoglobin; MCHC= Mean cell haemoglobin concentration. Means with different superscripts in the same row are significantly different ($p<0.05$).

Table V. Serum metabolites of weaner rabbits fed rumen liquor fermented cassava peels (Le sérum des métabolites de lapins ingérant sevré liqueur du rumen de pelures de manioc fermentée).

	Level of RLFCP inclusion (%)						
	0	25	50	75	100		
Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	p value
Total protein (g/l)	67.00	72.00	69.67	67.66	73.65	0.87	0.117
Albumin (g/l)	52.00	55.00	53.67	52.67	56.33	0.77	0.430
Globulin (g/l)	15.00	17.00	16.00	17.00	17.33	0.43	0.468
Cholesterol (mmol/l)	1.70	1.72	1.65	1.92	1.72	1.56	0.273
Urea (mg/dl)	42.80	37.85	30.30	35.60	39.75	1.56	0.093
Creatinine (mg/dl)	0.80	0.72	0.71	0.84	1.05	0.04	0.060
HDL (mg/dl)	24.25	22.30	24.40	27.03	36.35	1.85	0.095
LDL (mg/dl)	68.08[a]	63.37[ab]	61.83[ab]	70.42[a]	55.17[c]	1.85	0.046
Bilirubin (µmol/l)	0.84	0.85	0.78	0.83	0.86	0.02	0.468
SGOT (µ/l)	95.75[a]	93.00[ab]	90.25[bc]	87.57[cd]	85.73[d]	1.02	0.001
SGPT (µ/l)	112.00[b]	126.50[a]	127.00[a]	126.77[a]	127.50[a]	1.64	0.001
ALP (µ/l)	156.00	145.67	195.66	138.33	135.65	9.79	0.308
Amylase (µ/l)	699.00[a]	481.50[b]	463.50[b]	498.33[b]	647.00[a]	217.62	0.001
Glucose (mg/dl)	53.60[c]	89.30[ab]	90.95[ab]	85.77[b]	100.50[a]	4.53	0.001

Means with different superscripts in the same row are significantly different ($p<0.05$). HDL= Higher density lipo-protein; LDL= Lower density lipo-protein; SGPT= Glutamic pyruvic transaminase; ALP= Alkaline phosphate; SGOT= Serum glutamic oxalo acetic transaminase.

mean cell haemoglobin concentration (MCHC) and platelets were affected by the dietary treatments. The highest PCV value (37.15 %) observed in rabbits fed 50 % RLFCP-based diet was similar to 35.68 % and 35.67 % in rabbits fed 25 % and 100 % RLFCP-based diets respectively but higher (p<0.005) than 34.46 % in rabbits fed the control diet. The MCHC value did not follow a particular trend; however, the highest value (34.20 g/dl) observed in rabbits fed 50 % RLFCP-based diet was similar to 33.50 g/dl, 33.78 g/dl and 34.05 g/dl observed for rabbits fed 25 %, 75 % and 100 % RLFCP-based diets respectively, but higher than (p<0.05) 32.65 g/dl for rabbits fed on the control diet. The platelets value did not follow a particular trend. However, the highest value (452.00 × 10^9/l) observed in rabbits fed the control diet was similar to 358.75 × 10^9/l, 358.25 × 10^9/l and 383.25 × 10^9/l observed for rabbits fed 25 %, 50 % and 100 % RLFCP-based diets respectively, but higher than 275.50 × 10^9/l for rabbits on 75 % RLFCP-based diet.

Of the entire serum metabolites measured, only the low density lipo-protein, LDL (p<0.05), serum glutamic oxalo acetic transaminase, SGOT (p<0.01), glutamic pyruvic transaminase, SGPT (p<0.01), amylase (p<0.001) and glucose (p<0.001) were significantly influenced by the dietary treatment. The LDL levels of rabbits fed the 75 % RLFCP-based diet (70.42 mg/dl) and those fed the control diet (68.08 mg/dl) were similar to those fed the 25 % and 50 % RLFCP-based diets but significantly (p<0.05) higher than those fed 100 % RLFCP-based diet (55.17 mg/dl).

SGOT values decreased with increase in the replacement level of maize with RLFCP from the control (95.75 µ/l) up-to 100 % RLFCP-based diet (85.73 µ/l); while the SGPT values appears to increase across the dietary treatments, although the value (112.00 µ/l) recorded for the control was significantly (p<0.001) lower than 126.50 µ/l, 127.00 µ/l, 126.77 µ/l and 127.50 µ/l recorded in 25 %, 50 %, 75 % and 100 % RLFCP-based diets respectively. The amylase value decreased from the control diet (699.00 µ/l) to 100 % RLFCP-based diet (497.00 µ/l). The glucose levels of the rabbits in control diet (53.60 mg/dl) was significantly (p<0.001) lower than those fed the rest test diets; specifically, the glucose level of the rabbits increased with increase in the RLFCP inclusion in place of maize up to 50 % inclusion (53.6-90.95 mg/dl), decreased in rabbits fed 75 % RLFCP diet (85.77 mg/dl) and increased to 90 mg/dl in rabbits fed 100 % RLFCP-based diets.

Table VI shows that the cost of experimental diet ($/kg) was least in 100 % RLFCP-based diet (0.25 $/kg) and highest in control diet (0.44 $/kg). The best percentage cost reduction (42.36 %) was observed in 100 % RLFCP (diet 5) while the least (10.58 %) was observed in control diet.

DISCUSSION

The high demand for maize for human consumption and industrial uses has given rise to the price of maize, with resultant reduction in the quantity remaining for animal feeding. This actually called for increased research studies at sourcing for alternative to maize with a view to reducing the cost of finished feeds with consequential increase in the animal protein production and affordability by the resource poor in developing countries. This forms the major focus of this study.

In this study, the crude protein of the RLFCP was lower than 12.64 % and 21.50 % reported by Aderemi and Nworgu (2007) and Oboh (2006) when dried cassava peel was fermented with *Aspergillus niger* and combination of *Saccharomyces cerevisae* and *Lactobacillus* spp., respectively. However, of major interest in the composition of rumen liquor fermented cassava peels used in the present feeding trial is that fermenting the peels led to 49.5 % increase in the crude protein and 44.5 % decrease in the crude fibre over the dried cassava peels, suggesting the adequacy of using rumen microbes and animal wastes at enhancing the nutritive potential of cassava peels.

The current study showed that the FLW and ADWG of rabbit fed diets in which maize was replaced with RLFCP at 50 % level had numerical improvement of 3.88 % and 5.41 % respectively over those fed the control diet. Also, the feed intake as well as protein intake increased with increased RLFCP inclusion in the diets at the expense of maize, rabbits fed with 50 % RLFCP

Table VI. Comparative cost of feeding weaner rabbits with rumen liquor fermented cassava peels (Coût comparatif de nourrir sevré des lapins avec des pelures de manioc fermentée liqueur du rumen).

	Level of RLFCP inclusion (%)				
	0	25	50	75	100
Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial live weight (g/rabbit)	421.62	390.62	431.25	411.25	420.50
Final live weight (g/rabbit)	1369.88	1344.13	1425.13	1213.25	1113.50
Weight gain (g/rabbit/week)	940.50	922.50	993.88	802.00	693.00
Weight gain (g/rabbit/day)	117.56	115.31	124.23	100.25	86.63
Total feed intake (g)	2759.36	2819.20	2977.32	3131.68	3303.24
Cost of feed consumed ($/kg)	83.18	67.95	55.76	43.95	33.08
Cost of experimental diets ($/kg)	0.44	0.39	0.34	0.30	0.25
Cost of feed/kg gain ($)	0.09	0.07	0.06	0.05	0.05
% Cost reduction		10.58	21.17	31.76	42.36

1 US Dollar= ₦ 220.00 as at May, 2015.

inclusion had the best feed conversion ratio among the RLFCP-based diets suggesting that diet containing 21.5% RLFCP+21.5% maize **(table I)** might contain the required crude protein to crude fibre ratio (1.6:1.0) (Villamide *et al.*, 2009; Xiccato and Trocino, 2010) that could enhance intestinal physiological activities with a concomitant increase in the FLW and ADWG in rabbit and that 50% RLFCP might be the optimum replacement value for maize in growing rabbit diet as can be observed in this study. Thus by implication, irrespective of the% cost reduction **(table VI)**, increased replacement of RLFCP for maize beyond 50% replacement level would lead to reduction in the total weight gain and feed conversion ratio of the rabbits. Generally, the ADWG range of 12.38-17.75 g/rabbit per day observed in this study falls within 11.77-19.82 g/rabbit per day reported for weaner rabbits in a related study (Osakwe and Nwose, 2008), in most cases surpassed 6.55-12.70 g/rabbit per day reported by Ibrahim *et al.* (2014) but lower than 44.1-45.1 g/rabbit per day reported by Mora *et al.* (2014). In addition, the progressive increase in feed intake of rabbits fed on the test diets may be attributed to increase in fibre contents **(table I)** observed to have associated with increased replacement level of maize with RLFCP across the test diets. This observation was consistent with the report of de Blas and Wiseman, (2003) that rabbits' appetite is stimulated by increase in fibre levels. The slaughtering weight and dressing weight of the carcasses were highest in rabbits fed with 50% RLFCP-based diets. Thus, the observed finding could be attributed to the variation in the final live weights of experimental rabbits, which was highest in rabbits fed with RLFCP 50% based diet. While this finding agreed with the report of Olafadehan (2011), it is however not in consonance with the report of Oluremi and Nwosu (2002) who reported non-significant difference in pre-slaughtering weight and dressing percentage of rabbits fed cassava peels. The dressing percentage range (42.77-50.28) in this study is lower than 57.93-62.87% reported by Oluremi and Nwosu (2002), 52.00-59.00% (Ani, 2006) and 50.03-58.51% (Olafadehan, 2011) but falls within 43.24-53.83% and 48.70-49.45% reported by Akinmutimi and Alufo (2006) and Oteku and Igene (2006) respectively. These variations could be attributed to the differences in the nutrition, age, breeds, final live weight and slaughtering weights of the experimental rabbits. Of the entire relative internal organs weights measured, only the relative weights of liver and heart were affected by the dietary treatments. However, they did not follow a definite trend.

The liver, known as the largest gland in the body principally functions in the formation and secretion of bile, metabolism of nutrients and vitamins, inactivation of toxins, steroids and other hormones and synthesis of plasma protein such as acute-phase protein, albumin, clothing factors and steroid binding and other hormone-binding proteins (Williams, 2001). The liver weights range (2.18-2.57% slaughter weight) in this study was lower than 2.94-3.07% body weight reported for rabbit fed millet offal-based diets (Ogunsipe and Agbede, 2012) and 2.30-2.41% body weight for rabbits on soaked cassava peels (Oluremi and Nwosu, 2002).

The heart, the muscular organ pumps blood through the blood vessels of the circulatory system (Taber and Venes, 2009). The heart weight range (0.20-0.23% SW) in this study is very much lower than 3.57-4.17% reported by Ogunsipe and Agbede (Ogunsipe and Agbede, 2010) for rabbits fed unripe plantain peels and 0.19-0.23% on rabbits fed millet offal-based diet by Ogunsipe and Agbede (2012).

The blood profiles have been used widely to establish the health status of animals particularly when they are subjected to dietary treatment that could affect their well being. Thus, Aro and Akinmoegun (2012) and Isaac *et al.*, (2013), identified haemoglobin concentration (HbC), PCV, WBC, RBC, MCH, and MCHC among others as blood parameters that are useful in feed toxicity and feed quality monitoring and their effect on health status of the animals. In this study, the PCV and MCHC of rabbits fed 50% maize+50% RLFCP-based diet are higher than those fed the rest test diets although only significantly higher than those fed the control diet. This further confirms the nutritive potential of 50% maize+50% RLFCP combination which had better haematopoiesis than other test diets. As shown in this study, most of the haematological parameters measured were not significantly affected by the dietary treatments, suggesting that the haematopoietic activity was enhanced identically by the dietary treatments and by extension the health status of the rabbit was not compromised by replacing maize with RLFCP in the diets of growing rabbit. Thus, in most cases the blood parameters reported here falls within the ranges reported by Latimer *et al.* (2003); Ahamefule *et al.* (2008) and Ibrahim *et al.* (2014). Platelets function mainly in the formation of plugs during the normal haemostatic response to vascular injury in order to prevent excess linkage of blood through blood vessels (Hoffbrand *et al.*, 2006). In this study the platelets values falls within 200-1000 $\times 10^9$/L reported as normal range by Flecknell (2000). This tends to suggests that the inclusion of RLFCP in rabbits' diets did not affect their normal haemostatic response to vascular damage.

It is an acceptable fact that increase in enzyme's activity in serum may indicate problem in the cell population from which the enzyme is derived (Agbede *et al.*, 2011). In this study, the adequacy of the dietary treatment was further supported by the stability of the total protein, albumin, globulin, cholesterol, urea, creatinine, high density lipo-protein, bilirubin and alkaline phosphate among the dietary treatments as there were no significant dietary effects observed for the rabbits. Also, nutrition and the endogenous synthesis in liver and intestine have influence on total cholesterol and fractions of low-density lipoprotein (LDL), high-density lipoproteins (HDL) and very low-density lipoprotein (VLDL) cholesterol in the blood serum (Fasina *et al.*, 1999). The LDL values of rabbits fed the test diets were not statistically affected by the dietary treatments; except rabbits fed on 100% RLFCP-based diets which was statistically lower than those fed the other test diets, suggesting that both the control and other test diets enhanced the production of lipoprotein identically and by implication further confirmed the nutritive quality of the test ingredient in the diet at enhancing the health status of growing rabbits.

Serum glutamic oxalo acetic transaminase (SGOT) is being found in tissues such as liver, skeletal and cardiac muscles. Also in this study, there is a decline in SGOT values (95.75 µl) from rabbits fed the control diet to (87.57 µ/l) in rabbit fed 75 % RLFCP-based diet and thereafter a rise to 95.44 µ/l in rabbit fed 100 % RLFCP-based diet, suggesting that the liver disease and muscle damage can be precipitated in growing rabbits only when maize component of the feed is completely replaced with RLFCP. However, the SGOT values in this study fall within the normal range (33-99 µ/l) reported by Flecknell (2000). Contrarily, the SGPT values increased with increase in RLFCP inclusion levels. This tends to suggest possible occurrence of liver, myocardial infarction and damages. Fasina *et al.* (2000) had earlier reported that SGPT, which is considered as liver-specific enzyme in small animals is associated with some clinical conditions among which are liver tumor, infectious hepatitis, fatty degeneration of liver and induced hepatopathy. Although in this study, values of SGPT are within normal range (55-260 µ/l) reported by Flecknell (2000).

Amylase is one of the serum enzymes primarily used in acute pancreatitis and renal disease diagnosis. It is an enzyme produced when pancreatic acinar cells damaged, this enzyme is then reabsorbed into the blood stream causing its rise in concentration. The amylase activity of rabbits fed the 25, 50 and 75 % RLFCP-based diet were lower than those fed the control as well as those fed 100 % RLFCP-based diets, suggesting that inclusion of RLFCP up to 75 % replacement for maize in the diet of a growing rabbit might not precipitate acute pancreatitis and by extension are safe for rabbit consumption. The RLFCP would further support the maintenance of integrity of pancrease and kidney, two of the major vital organs of the body; particularly when the test ingredient is not included beyond 75 %. The ability of the test diet to support the health being of the experimental rabbits is however further confirmed by the fact that glucose value through which energy is derived by the animal is lower than 200-500 mg/dl reported by Latimer *et al.* (2003), as increased glucose values had been associated with diabetes mellitus and endocrine disorders (Flurharty and Loerch, 1996).

From the foregoing, the replacement of the maize content with rumen liquor fermented cassava peels up to 75 % replacement appeared not to have deleterious effect on the health status of growing rabbits. However, 50 % replacement enhanced the best final body weight, total weight gain and feed conversion ratio, PCV and MCHC suggesting that replacement at this level could be the optimum level of RLFCP in the diet of a growing rabbit. In addition, up to 50 % maize replacement for RLFCP in the diets of growing rabbits would help to reduce cost of feeding by 20 %.

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