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ORIGINAL RESEARCH ARTICLE

Growth performance, haematology and serum biochemistry of rabbits fed varying levels and forms of cassava peel

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ABSTRACT

In a 56 – day feeding trial, performance, haematology and serum biochemistry in grower rabbits fed varying levels of conventional, coarse and fine cassava peel were investigated. Seven diets (I to VII) were formulated with varying levels of cassava peel inclusions. Twenty- eight grower rabbits were randomly distributed to the 7 dietary treatments with four animals per treatment in a completely randomized design. Rabbits fed diet I had significantly ($p < 0.05$) higher daily weight gain and total weight gain than those fed diet V but was comparable to others. Also, rabbits fed diet VII had significantly ($p < 0.05$) higher average daily feed intake than those fed diets II, IV and V but was comparable to others. Feed conversion ratio of the diets were comparable to each other except diets I and IV. The values for all the treatments ranged from 4.83 to 5.86. Significantly ($p < 0.05$) lower dry matter digestibility was observed in rabbits fed diets V and VI (0.73 and 0.75 respectively). Crude protein digestibility was significantly ($p < 0.05$) higher in rabbits fed diets I and VII than diet III, ether extract digestibility values were significantly ($p < 0.05$) lower in rabbits fed diets III, V and VI while crude fibre digestibility improved in rabbits fed diets II, IV and VII (0.67, 0.70 and 0.72 respectively). Rabbits fed diet VI had significantly lower red blood cell count (4.23×10^6/L) compared to those fed with diets III, IV, V and VII. Also, rabbits fed diets V and VII had significantly ($p < 0.05$) higher haemoglobin than those fed diet II. The overall value ranged from 10.10 to 12.05g/dl. Rabbits fed diet I also had significantly ($p < 0.05$) higher albumin compared to those fed diet IV.

Keywords: Cassava peel mash, cassava processing, Rabbit performance, Rabbit blood

INTRODUCTION

The availability of cassava peel makes it an alternative source of energy for livestock feeding. However, the techniques of cassava peel processing in Nigeria still remain at a level which is slow, labour intensive and less efficient. Despite the steady supply of cassava in Nigeria, most cassava peel is wasted annually due to constraints associated with drying, thereby posing a great limitation to its optimal utilisation as feed ingredient for diet formulation. Hence, the consequent deterioration of wet cassava peel due to its perishable nature and its current rate of wastage in Nigeria is an indication for finding faster ways of processing it. Moreover, its potential usage as a feed ingredient for micro – livestock depends to a large extent on the acceptable forms in which it is presented to them. From the studies conducted by Esonu and Udedibie (1993) and Salami (2000), it has been revealed that parboiling prior to sun drying has no advantage over sun drying alone in terms of reduction of cyanide content of cassava peels. Ensiling seems to be as efficient as sun-drying to detoxify cassava peels and the resulting products can be used safely to feed livestock (Heuze *et al*., 2012a). The ensiling process causes disintegration of intact glycoside via marked cell disruption, a drop in pH of the ensiled medium and intense heat generation. Ensiling cassava tuber pulp fractions, peels, and leaves break down glycosides, lowers pH and generates heat if maintained anaerobically; moulding of substrate is less problematic. Good quality silage can be obtained from peels after chopping the peels to lengths of about 2 cm for easy compaction, and wilting for two days to reduce moisture content from 70 or 75 to about 40%. Under these conditions, cassava peel silage after 21 days has light brown colour, firm texture and a pleasant odour (Asaolu 1988; Smith 1988).

In Nigeria, the use of pellets in livestock production is often associated with aquaculture and it is a relatively new concept in ruminant and monogastric production. Cassava pellets are obtained from dried and broken cassava roots, cassava leaves and cassava peels. They are dried, grinded and hardened into a cylindrical shape. The cylinders are about 2-3 cm long and about 0.4 - 0.8 cm in diameter, and are uniform in appearance and texture (IITA, 2005). Improvement in the performance of animals fed pelleted feed have been attributed to decreased feed wastage, reduced selective feeding, decreased ingredient segregation, less time and energy expended for eating, destruction of pathogens, thermal modification of starch and protein and improved palatability (Behnke, 1994). However, the disadvantage of pelletizing feed may be associated with the additional pelleting charges, which may not be offset by improved performance. The longer time frame required in pelletizing feed compared to making mash forms may also contribute to its constraints.

Furthermore, it has been established that feed particle size (granulometry) and diet affect the digestibility and gastrointestinal functions of animals (Jacobs *et al*., 2010; Tufarelli *et al*., 2010). The chemical (degree of lignification) and physical characteristics (particle size) of insoluble fibre also affect the rate of passage of digesta and the susceptibility of fibre to fermentation (Gidenne *et al.,* 2010b). As a result of the unsuitability and poor properties of cassava peel that are improperly processed, there is need to develop and embrace new, quicker and easier ways of making cassava peel into an acceptable form for animals including pseudo – ruminants like rabbits. This will maximize its effective and optimum use. This study was therefore designed to evaluate the performance, haematology and serum indices of grower rabbits fed varying levels of conventional, coarse and fine forms of cassava peel.

MATERIALS AND METHODS

Experimental Site

This study was carried out at the Rabbit Unit of the Teaching and Research Farm, University of Ibadan, Oyo State, Nigeria.

Test ingredients Preparation Procedure

Conventional cassava peel mash

Selected fresh cassava peel of good quality was purchased from a reputable local garri processing industry in Osun State. The peel was sun dried for 7 days after which it was air dried again for 5 days. The cassava peel consisted of the white part of the fleshy tuber with the coat or brownish outer part of the cassava. It was then packed into sacks and was ground at the feed mill of the University of Ibadan. During the process of grinding, the peel was passed into the hammer mill and was ground to a particle size of 3mm.

Coarse cassava peel mash

The coarse cassava peel was made from selected fresh cassava peel of good quality. The selected cassava peel was grated three times because of the tough nature of the peel in order to reduce the particle size. To facilitate dewatering, grated cassava peel was packed into smaller sizes in bags and was pressed with the aid of a hydraulic jack. Then, the cake formed was re-grated and sieved with a sieve of 3mm to separate the fine cassava peel particle from the coarse cassava peel mash. The bigger cassava peel particles (above 3mm) that did not pass through the sieve were taken as the coarse cassava peel and were dried for six hours. The moisture content after drying was between 10 to 12%. This was then packed into bags and stored for usage. This processing was done by the International Livestock Research Institute (ILRI) and the peel was obtained from there after processing.

Fine cassava peel

The process used in the production of fine cassava peel mash was similar to that of the coarse cassava peel mash. The procedure followed the same steps of selection, grating, pressing, sieving and drying. The step was only different at the point of sieving. The cassava peel particle that passed through the 3.0 mm sieve was taken as the fine cassava peel. This was also dried for six hours which reduced the moisture content to about 10 to 12%. It was then packed into bags and stored for usage. The fine cassava peel had a smaller particle size (3mm and below) than the coarse cassava peel. This processing was also done by the International Livestock Research Institute (ILRI) and the peel was obtained from there.

Experimental diets

Experimental diets were formulated for the grower rabbits to meet their nutritional requirements. Seven diets were formulated in which the 3 forms of cassava peel were used to replace maize at various inclusion levels. The diets were diet I – 0% cassava peel diet (Control diet), diet II - 50% conventional cassava peel diet, diet III - 100% conventional cassava peel diet, diet IV - 50% coarse cassava peel diet, diet V - 100% coarse cassava peel diet, diet VI – 50% fine cassava peel diet and diet VII - 100% fine cassava peel diet. The control diet and the conventional cassava peel diets were made to a size of 3mm. While the coarse cassava peel diet had a particle size of 3mm and above, the fine cassava peel diet had a particle size of 3mm and below.

Experimental Animals and Management

Twenty eight cross bred grower rabbits of eight weeks old with average weight of 644g were purchased from a reputable farm. Prior to their arrival and to the commencement of the experiment, the rabbit cages were thoroughly washed and efficiently disinfected with Izal to prevent any contamination and infection. The feeding and watering troughs were washed, disinfected and fixed on the cages. Also, the cage stands were inserted into a concentrated solution of engine oil to prevent the interference of crawling insects, termites, soldier ants and snakes. The rabbits on their arrival were made to undergo one week adaptation period to allow them to adjust to the new environment. Also, they were administered cocidiostat and antibiotics to prevent them from coccidiosis and bacterial infections. The rabbits were then intensively managed in individual compartments in the cage with size (45cm x 40cm x 45cm) and were introduced to their experimental diets according to their treatments after the adaptation period. The rabbits were randomly distributed into seven treatments and four replicates per treatment. The experimental design was a completely randomized design. The rabbits were housed individually in cages and were assessed for growth rate, feed intake, weight gain, feed conversion ratio. The feeding trial lasted for 8 weeks. Feed and water were offered daily to them *ad libitum* during the experimental period and all the rabbits were kept under the same hygienic and environmental condition.

Data Collection

Feed intake, average daily feed intake, weight gain, average daily weight gain and feed conversion ratio were recorded during the experiment.

Digestibility Trials

At the end of the feeding trial, the rabbits were transferred into metabolic cages. Each rabbit was housed separately and three days adaptation period was observed. Then, a seven day collection period of daily faeces from 3 rabbits per treatment was done for the determination of nutrient digestibility. Total amount of faeces voided by each rabbit was measured appropriately on a daily basis. The rabbits were fed weighed quantities of feed each and their faecal output was collected daily for the seven days period. The total faecal sample collected from each animal was oven dried to determine the dry matter. The faecal sample was dried at 65^{o}C for 48 hours. The dried faeces was allowed to cool in a glass desiccators to prevent trapping of moisture from the surrounding atmosphere. It was then grinded through a 1 mm diameter screen. Representative samples of dried and ground faeces were taken and were analysed for proximate composition using AOAC (1990) method. The result obtained from the analysis was used to calculate the digestibility of the feed nutrient by the rabbits. The digestibility values for dry matter (DM), crude protein (CP), ether extract (EE), and crude fibre (CF) were calculated as nutrient intake minus nutrient excreted divided by nutrient intake multiplied by 100.

Haematogical analysis of blood samples

At the end of the feeding trial period, the animals were starved of feed overnight before blood samples were collected from two rabbits per treatment for haematological analysis. The blood samples were collected from the external ear vein of each rabbit using a sterilized disposable syringe and needle between 7.00 and 7.45 am. A total of 1.5 ml of blood was collected from the rabbits into properly labelled sterile universal bottles containing Ethylene- Diamine-Tetra-Acetic acid (EDTA) as anticoagulant. The packed cell volume (PCV) was determined by the micro haematocrit method according to Dacie and Lewis (1991). Haemoglobin concentration (Hb) was determined by the cyanomethaemoglobin method of Kelly (1979). Red Blood Cells (RBC) and White Blood Cell (WBC) counts were determined using improved Neubauer haemocytometer as described by Jain (1986). The determination of the distribution of the various leukocyte cells was done by Shilling method of differential leukocyte counts (Mitruka and Rawnsley, 1977).

Serum Biochemical Analysis

3.0 ml of blood was collected into a labelled sterile sample bottles without anticoagulant and used to determine the serum biochemical components. The blood samples were centrifuged at 500 rpm (revolution per minute) for 3 minutes in a micro centrifuge to obtain serum that was free from cell debris for the biochemical analysis using a spectrophotometer at a wavelength of 500 nm. The serum obtained was analysed colorimetrically for total protein by the Biuret method. Colorimetric determination of total protein was based on the principle of Biuret reaction (copper salts in alkaline medium) in which cupric ions form a blue complex, in alkaline solution, with NH_2 of two or more peptide bonds. The intensity of the blue colour formed is proportional to the protein concentration in the plasma or serum. Albumin concentration was determined by the Bromocresol Green (BCG) method (Peters *et al*., 1982); albumins bind with BCG to form a green compound. The concentration of Albumin is directly proportional to the intensity of the green colour formed. Globulin concentration was computed as the difference between total protein and albumin concentrations. Cholesterol was determined as described by Coles (1986).

Statistical Analysis

Data obtained on weight gain, feed intake and digestibility, serum and haematological indices were subjected to analysis of variance and means were separated using Duncan Multiple Range Test.

Table 1: Gross composition (g/100g) of experimental diets

Ingredients	Diet 1	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII
Maize	35.00	17.50	0.00	17.50	0.00	17.50	0.00
Cassava peel (A,B,C)	0.00	17.50	35.00	17.50	35.00	17.50	35.00
Soya bean meal	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Palm kernel cake	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Wheat offal	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Rice Bran	10.40	11.00	11.00	11.00	11.00	11.00	11.00
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	2.00	1.50	1.50	1.50	1.50	1.50	1.50
Grower Premix	0.30	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100

A – Conventional cassava peel, B – coarse cassava peel mash, C – Fine cassava peel mash, Diet I - Control diet (100% maize diet), Diet II - 50% conventional cassava peel diet, Diet III – 100% conventional cassava peel diet, Diet IV – 50% coarse cassava peel diet, Diet V – 100% coarse cassava peel diet, Diet VI – 50% fine cassava peel diet, Diet VII – 100% fine cassava peel diet

Table 2: Proximate Composition of the Test Ingredient

Nutrients (%)	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII
Dry matter	91.84	91.50	91.10	91.25	91.69	91.39	90.84
Crude protein	17.00	16.20	15.82	16.02	15.88	16.80	16.33
Crude fibre	8.02	14.23	15.20	14.77	15.80	13.99	14.27
Ether extract	5.03	4.23	3.59	5.61	4.79	4.86	4.87
Ash	10.10	7.50	8.11	8.90	10.01	10.10	11.10

Diet I - Control diet (100% maize diet), Diet II - 50% conventional cassava peel diet, Diet III – 100% conventional cassava peel diet, Diet IV – 50% coarse cassava peel diet, Diet V – 100% coarse cassava peel diet, Diet VI – 50% fine cassava peel diet, Diet VII – 100% fine cassava peel diet

Table 3: Fibre component of the experimental diets

Diet	NDF (%)	ADF (%)	ADL (%)	HEM (%)	CELL (%)
DIET 1	41.76	29.24	5.83	12.52	23.41
DIET II	46.77	34.66	8.54	12.11	26.12
DIET III	47.56	36.79	9.88	10.77	26.91
DIET IV	49.69	38.96	11.94	10.73	27.02
DIET V	52.78	45.28	14.86	7.50	30.42
DIET VI	44.58	31.58	6.29	13.00	25.29
DIET VII	45.68	33.95	7.15	11.73	26.80

NDF - Neutral Detergent fibre, ADF - Acid Detergent Fibre, ADL – Acid detergent lignin, Hem – Hemicellulose, Cell – Cellulose, Diet I - Control diet, Diet II - 50% conventional cassava peel based diet, Diet III – 100% conventional cassava peel based diet, Diet IV – 50% coarse cassava peel based diet , Diet V – 100% coarse cassava peel based diet, Diet VI – 50% fine cassava peel based diet, Diet VII – 100% fine cassava peel based diet, % Hem = % NDF - % ADF, % Cellulose = % ADF - % ADL

Table 4: Proximate Composition of the Test Ingredient

Test ingredient	%CP	%CF	%EE	%ASH	%DM
Fine cassava peel mash	4.55	3.50	10.13	2.79	90.00
Coarse cassava peel mash	2.45	7.90	5.03	1.30	92.40

CP = Crude protein, CF= Crude fibre, EE = Ether Extract, DM = Dry matter

Table 5: Effect of the varying inclusion levels of different forms of cassava peel on the performance of growing rabbits

Parameters	Diet 1	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII	SEM
Initial Weight (g/rabbit)	644.00	633.75	638.00	641.00	661.75	636.50	643.00	85.70
Final weight (g/rabbit)	1553.00	1387.75	1389.50	1361.75	1367.50	1444.75	1470.50	133.60
Total Weight gain (g/rabbit)	909.00^{a}	754.00^{ab}	751.00^{ab}	720.75^{ab}	705.75^{b}	808.25^{ab}	827.50^{ab}	65.75
Daily weight gain (g/rabbit/day)	16.23^{a}	13.46^{ab}	13.41^{ab}	12.87^{ab}	12.60^{b}	14.43^{ab}	14.78^{ab}	1.17
Total feed intake (g/rabbit)	4356.12^{ab}	4014.75^{b}	4150.00^{ab}	3562.75^{b}	3717.75^{b}	4083.00^{ab}	4842.75^{a}	350.28
Average daily feed intake (g/day)	77.79^{ab}	71.69^{b}	74.12^{ab}	69.07^{b}	71.06^{b}	72.91^{ab}	86.48^{a}	4.36
Feed conversion ratio	4.83^{b}	5.36^{ab}	5.58^{ab}	4.85^{b}	5.37^{ab}	5.05^{ab}	5.86^{a}	0.30

a,b Means in the same row with different superscripts are significantly different (p< 0.05)
SEM = standard error of mean

RESULTS

Tables 1, 2 and 3 show the gross composition, analysed composition and the fibre fraction component of the experimental diets. The dry matter, crude protein and crude fibre content of the diets ranged from 90.84 - 91.84%, 15.82 – 17.00% and 8.02 – 15.80% respectively. Ether extract and ash content of the diets ranged from 3.59 – 5.61% and 7.50 – 11.10% respectively. The neutral detergent fibre, acid detergent fibre, acid detergent lignin values in all the diets ranged from 41.76 – 52.78%, 29.24 - 45.28% and 5.86 - 14.86% respectively. Also, the cellulose and hemicellulose values ranges were 23.41 – 30.42% and 7.50 – 13.00% respectively. There were significant differences ($p < 0.05$) in the daily weight gain, total weight gain average daily feed intake and feed conversion ratio of the rabbits with the value ranges of 12.60 – 16.23g, 705.75- 909.00g, 69.07 – 86.48g and 4.83 – 5.86 respectively. Rabbits fed diet I had significantly ($p < 0.05$) higher daily weight

gain and total weight gain than those fed diet V but this value was comparable to those obtained from rabbits fed the other 5 diets. Also, rabbits fed diet VII had significantly ($p < 0.05$) higher average daily feed intake than those fed diets II, IV and V although the value was comparable to those fed diets I, III and VI. The values obtained for the feed conversion ratio of the rabbits were comparable to each other except that rabbits fed diets I and IV had significantly ($p < 0.05$) lower feed conversion ratio than those fed diet VII.

Table 6: Effect of the varying levels of different forms of cassava peel on the nutrient digestibility of growing rabbits

Parameters	DIET I	DIET II	DIET III	DIET IV	DIET V	DIET VI	DIET VII	SEM
Dry matter	0.84^{a}	0.84^{a}	0.80^{a}	0.82^{a}	0.73^{b}	0.75^{b}	0.86^{a}	0.07
Crude protein	0.86^{a}	0.75^{bc}	0.81^{ab}	0.74^{c}	0.53^{d}	0.75^{bc}	0.86^{a}	0.02
Ether extract	0.88^{a}	0.86^{a}	0.78^{c}	0.85^{ab}	0.82^{b}	0.77^{c}	0.88^{a}	0.01
Crude fibre	0.56^{b}	0.67^{a}	0.30^{c}	0.70^{a}	0.33^{c}	0.46^{b}	0.72^{a}	0.04
Ash	0.82^{a}	0.61^{b}	0.59^{b}	0.62^{b}	0.61^{b}	0.56^{b}	0.75^{a}	0.03

a,b,c,d Means in the same row with different superscripts are significantly different (p< 0.05) .
SEM = standard error of mean

Varying levels of conventional, coarse and fine cassava peel forms influenced ($p< 0.05$) all the nutrient digestibility values obtained. The dry matter, crude protein, crude fibre, ether extract and ash digestibility of the diets ranged from 0.73 –

0.86, 0.53 – 0.86, 0.30 – 0.72, 0.77 – 0.88, and 0.56 – 0.82 respectively. Significantly ($p < 0.05$) lower dry matter digestibility was observed in rabbits fed diets V and VI than those fed the remaining diets. Crude protein digestibility was also affected with significantly ($p < 0.05$) higher values in rabbits fed diets I and VII than those fed the other diets except diet III whose value was comparable to them. Ether extract digestibility values were observed to be significantly ($p < 0.05$) lower in rabbits fed diets III, V and VI than those fed other diets. Crude fibre digestibility improved in rabbits fed diets II, IV and VII than those fed the other diets. Also, ash digestibility was observed to be significantly ($p < 0.05$) higher in rabbits fed diets I and VII than those fed the other diets.

Only red blood cell, white blood cell, haemoglobin and eosinophil counts significantly varied among the treatments with value ranges of 4.23 – 5.78 x $I0^6$/L, 4.65 – 7.80 x 10^3/L, 10.10 – 12.05g/dl and 0.50 – 2.50% respectively. Other haematological parameters were not significantly different. Rabbits fed diet VI had significantly lower red blood cell counts compared to those fed with diets III, IV, V and VII but the value obtained was comparable to those fed diets I and II. The white blood cell count also varied and rabbits fed diet VII had significantly ($p < 0.05$) higher value than those fed diets II, III and IV although the value obtained was comparable to those of the remaining diets. Also, rabbits fed diets V and VII had significantly ($p < 0.05$) higher haemoglobin than those fed diet II alone while the values were comparable to those of other diets. Eosinophil value was observed to be significantly lower in rabbits fed with diet VI than those fed other diets except those of diets I and V whose values were comparable to it. Albumin, creatinine and aspartate amino transferase values were significantly different ($p< 0.05$) amidst treatments with value ranges of 2.21 – 3.63g/dl, 0.23 – 1.32mg/dl and 2.45 – 16.65U/L. Rabbits fed diet I had significantly ($p < 0.05$) higher albumin compared to those fed diet IV although its value was not significantly different from those fed all the other diets. Also, Rabbits fed diet VI had significantly ($p < 0.05$) higher creatinine value than those of diet II but their values were comparable to those of the other diets. Aspartate amino transferase varied across the treatments with rabbits fed diets V and VII having significantly ($p < 0.05$) higher value than those fed diet VI but the value was not significantly different to those fed the other diets.

Table 7: Effect of the different inclusion levels of different forms of cassava peel on the haematology of growing rabbits

Parameter	Treatments							
	DIET I	DIET II	DIET III	DIET IV	DIET V	DIET VI	DIET VII	SEM
Packed cell volume (%)	34.50	31.00	34.00	32.50	35.50	33.50	35.50	1.44
Red blood cell (x10^6/L)	5.24^{ab}	4.81^{ab}	5.70^{a}	5.26^{a}	5.70^{a}	4.23^{b}	5.78^{a}	0.44
WBC (x10^3/L)	6.58^{ab}	5.28^{bc}	4.65^{c}	5.88^{bc}	6.60^{ab}	6.70^{ab}	7.80^{a}	0.54
Haemoglobin (g/dl)	11.40^{ab}	10.10^{b}	11.30^{ab}	10.50^{ab}	12.05^{a}	11.45^{ab}	12.05^{a}	0.57
Lymphocyte (%)	61.00	62.00	67.50	65.50	62.50	69.00	66.50	3.71
Neutrophil (%)	34.50	33.50	28.00	29.00	34.00	28.50	30.00	3.64
Monocyte (%)	3.00	2.00	2.00	3.00	1.50	2.00	1.00	0.69
Eosinophil (%)	1.50^{ab}	2.50^{a}	2.50^{a}	2.50^{a}	2.00^{ab}	0.50^{b}	2.50^{a}	0.58

a,b,c Means in the same row with different superscripts are significantly different (p< 0.05)
SEM = standard error of mean, WBC = White blood cell

DISCUSSION

The crude protein content was within the range of 16 – 17 % reported for growing rabbits between 42 – 80 days by Gidenne (2000) and Fortun-Lamothe and Gidenne (2003). The crude protein content of the diet**s** was also in conformity with the findings of Lebas (2003) who reported the crude protein requirement of growing rabbits to be 16 -17 %**.** The dry matter and ether extract composition of the diets were similar to those used by Osakwe *et al.* (2008) in feeding growing rabbits with cassava peel as replacement for maize up to 100%. However, the crude fibre content of the diets apart from the 0% cassava peel inclusion diet were in proximity to 13 - 14% requirement reported by Lebas *et al.* (1986) and were also within the range indicated by Adegbola *et al*. (1985) who reported that the rabbit requirement for crude fibre is very high and is about 14-25%. The neutral detergent fibre and the acid detergent fibre values for all the treatments were within the ranges of the recommended requirement by De-Blas and Mateos (2010). Current recommendations agree that diets for rabbit should contain at least 30% NDF and 16% ADF (De Blas and Mateos, 2010).

It was observed that rabbits fed the control diet (0% cassava peel inclusion) had significantly higher total weight gain and daily weight gain than those of 100% coarse cassava peel inclusion diet. This might be due to the lower protein content in the 100% coarse cassava peel diet (according to the proximate analysis) than the control diet. Differences in their particle size might have also influenced this result. Sakaguchi and Hume (1990) and Gidenne (1993) in their studies have shown that bigger particle size promotes a higher rate of passage of feed which can lead to a smaller nutrient absorption. Control diet maize content was prepared to a size of 3.0 mm while the cassava peel in 100% coarse cassava peel diet was above 3mm in size and it was used to replace maize completely in this diet. Auvergne *et al. (*1988*)* in his study similarly revealed that rabbits fed the finest particle size diet experienced an increased diet retention time and higher ileum retention time which could lead to higher nutrient absorption favouring a higher weight gain.

Higher total feed intake and average daily feed intake observed in rabbits fed 100% fine cassava peel diet than 50% conventional cassava peel diet, 50% coarse cassava peel diet and 100% coarse cassava peel diet could be due to increased feed wastage in rabbits fed 100% fine cassava peel diet than those fed the other diets due to the fact that it was in the finest particle size (3mm and below) while others were 3mm and above in size. The feed wasted might have added to the total feed intake recorded. The study of Birendra *et al* (2018) on feed particle size preference and feed wastage in Agouti revealed higher feed wastage in smaller particle sized feed than in larger ones.

Higher feed conversion ratio in rabbits fed 100% fine cassava peel diet than those fed the control diet and 50% coarse cassava peel diet could be attributed to the higher average daily feed intake observed without a commensurate increase in the daily weight gain, thus leading to a higher FCR. Animals that have a low FCR are considered efficient users of feed.

The dry matter digestibility in rabbits fed 100% coarse cassava peel diet observed to be lower than those fed the control diet, 50% and 100% conventional cassava peel diet, 50 % coarse cassava peel diet and 100% fine cassava peel diet may be attributed to its bigger particle sized cassava peel (above 3mm). This is also in support with the findings of Nicodemus *et al. (*2006) who reported that dry matter digestibility increased with particle size reduction. The crude protein digestibility in rabbits fed 50% and 100% coarse cassava peel diet which were significantly lower than those of the control diet and 100% fine cassava peel diet could also be attributed to the larger particle structure of the cassava peel in these diets (above 3mm) in comparison to the control diet (3mm) and 100% fine cassava peel diet (below 3mm). Particle size can influence the digestive process. A longer retention time of finer particles, allowing a higher bacterial digestion in the digestive tract may positively correlate with better digestion (Peter *et al.,* 2016). Significantly higher crude fibre digestibility observed in rabbits fed 100% fine cassava peel diet above those fed the control diet, 100% conventional cassava peel diet, 100% coarse cassava peel diet and 50% fine cassava peel diet could be due to the lower particle size effect of 100% fine cassava peel diet than them. The study of Gidenne (1993) revealed that physical structure especially particle size is an important characteristics of fibre that influence its digestive behaviour in rabbit. The importance of fibre is related to its influence on the rate of passage of digesta and the function as a substrate for microbiotas which in turn affect and regulate the growth performance and digestive health of rabbits (Gidenne *et al*., 2010a and 2010b). Poor digestibility of crude fibre has been attributed to the masking effect of bacteria in animal gut (Okonkwo *et al.,* 2010). Increased ether extract digestibility in rabbits fed the control diet, 50% conventional cassava peel diet and 100% fine cassava peel diet than those of 100% coarse cassava peel diet and increased ash digestibility in the control diet and 100% fine cassava peel diet than 50% and 100% coarse cassava peel diets might also be due to particle size effect. The physiologically normal haematological parameter of all the rabbit in the treatments is an indication of their good health condition, although there were significant differences among the

Table 8: Effect of the varying inclusion levels of different forms of cassava peel on the serum indices of growing rabbits

Parameter	DIET I	DIET II	DIET III	DIET IV	DIET V	DIET VI	DIET VII	SEM
Total protein (g/dl)	8.48	9.42	7.82	8.48	7.57	7.69	7.73	1.06
Albumin (g/dl)	3.63^{a}	2.59^{ab}	2.71^{ab}	2.21^{b}	3.11^{ab}	2.57^{ab}	3.20^{ab}	0.40
Creatinine (mg/dl)	0.73^{ab}	0.23^{b}	1.09^{ab}	1.10^{ab}	0.81^{ab}	1.32^{a}	0.75^{ab}	0.28
Urea (mg/dl)	24.19	16.93	24.67	25.16	20.16	21.61	39.35	8.05
Cholesterol (mg/dl)	78.01	57.90	95.99	71.60	39.31	53.02	102.39	2.00
Glucose (mg/dl)	109.20	74.64	82.19	112.53	112.24	100.76	97.43	1.22
AST (U/L)	11.85^{ab}	7.94^{ab}	6.39^{ab}	10.68^{ab}	16.65^{a}	2.45^{b}	16.31^{a}	3.28
ALT (U/L)	41.00	41.18	48.78	46.64	53.71	38.13	37.97	6.04

^{a,b} Means with different superscripts in the same row are significantly different ($P<0.05$)
SEM- standard error of mean, AST – Aspartate amino transferase, ALT- Alanine amino transferase

treatments. The red blood cell counts in all the diets which were also within the normal physiological range shows that the animals had adequate dietary protein although there was a significantly lower red blood cell count in rabbits fed 50% fine cassava peel diet than those fed the other diets apart from the control diet and 50% conventional cassava peel diet.

The white blood cell count in rabbits fed 100% fine cassava peel diet was significantly higher than those fed 50% and 100% conventional cassava peel diet and 50% coarse cassava peel diet but all were within the physiologically normal range reported by Mitruka and Rawnley (1977). This shows that the rabbits had favourable antibody level in their blood stream as high and normal levels of white blood cells in blood indicates increased antibody level with increased lymphocytes count (Frandson, 1986).
Haemoglobin counts of rabbits fed 100% coarse and fine cassava peel diets that were significantly higher than those of 50% conventional cassava peel diet does not connote any heath problem as they all had physiologically normal Haemoglobin value indicating a good nourishment of the diets fed to the animals.

The eosinophil values in the diets were also within the normal range reported by RAR (2009) and Mitruka and Rawnley (1977) although significantly lower value of eosinophil was observed in rabbits fed diet 50% fine cassava peel diet than those fed 50% and 100% conventional cassava peel diet and 100% fine cassava peel diet. This does not connote any clinical sign of a disease as they all had good immunity to respiratory problem. High level of eosinophil than normal could cause pulmonary dysfunction (Chattopadhyay *et al.*, 2007). Significantly lower albumin below the normal physiological range in rabbits fed 50% coarse cassava peel diet than those fed the control diet might be due to the differences in their crude protein profile of the diets. Abnormal serum albumin usually indicates an alteration of normal systematic protein utilization (Apata,1990) and low dietary protein intake (Onifade and Tewe, 1993). Deviation from normal range for specie results in conditions such as low albumin (hypoalbuminemia). This may be caused by liver disease, mal-absorption, malnutrition or chronic blood loss. High albumin (hyperalbuminemia) is caused by dehydration (Rastogi, 2007).

Creatinine level of rabbits fed 50% conventional cassava peel diet that was observed to be lower than those fed 50% fine cassava peel diet, might be attributed to a poor kidney function in rabbits fed 50% conventional cassava peel diet. Elevated serum creatinine level is a more sensitive indicator of renal failure (Rastogi, 2002). Besides, varying levels of cassava peel forms influenced the AST level in the diets. Significantly lower aspartate amino transferase in rabbits fed 50% fine cassava peel diet below the normal physiological range than those fed 100% coarse cassava peel diet and 100% fine cassava peel diet was observed. Harper *et al* (1997) and Ewuola and Egbunike (2008) observed in their separate studies that increase in the aspartate amino transferase and alanine amino transferase may be a clinical indication of diagonising state of damage done to the visceral organs by toxic substance or infection. Increase in aspartate amino transferase level beyond normal in some cases may also indicate acute kidney failure, heart attack, haemolytic anaemia, hepatitis, lack of blood flow to the liver (liver ischemia), liver tumour, inflamed pancreas and some other factors (Gelderblom *et al.*, 1994).

CONCLUSION

The results from this study revealed that cassava peel can serve as a suitable waste resource that can be processed into different physical forms that are acceptable to rabbits, leading to optimal utilization and productivity. Moreover, the new and quicker method used in this study to process fresh cassava peel into coarse cassava peel mash and fine cassava peel mash involves drying for just 6 to 8 hours after processing to reach 10–12% moisture content level. This makes its processing easier and usage worthwhile and more efficient compared to the old processing methods of cassava peel in which the peel has to be dried for several days. This is laborious, and often lead to wastage. Hence, replacement of maize with cassava peel even up to 100% is tolerable especially with the processed fine cassava peel based diet due to its higher digestibility.

CONFLICT OF INTEREST

Authors declare no conflict of interest as regards data reported in this article.

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