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UTILIZATION OF CASSAVA PEEL AND RUMEN EPITHELIAL WASTE DIETS BY WEST AFRICAN DWARF SHEEP

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ABSTRACT

Twenty West African dwarf, WAD, sheep were randomly divided into five groups of four sheep. Each group was randomly assigned to one of the 5 dietary treatments which consisted of cassava peels supplemented with 5 graded levels of rumen epithelial waste, REW at ratio 100:0(T1), 95:5(T2), 90:10 (T3), 85:15(T4) and 80:20(T5) respectively, fed with a basal diet of *Pennisetum purpureum* grass in a complete randomized design. The study reported the effects of these dietary supplementation on dry matter intake DMI, body weight gain, N utilization, haematological and biochemical parameters. The general trend of the 100d - study was such that the performance characteristics (g/day) which included dry matter intake DMI, body weight gain, crude protein intake, and N retention (%) increased significantly (P < 0.05) across the treatments as the levels of REW supplementation increased. Animals on diets T2 (95:5) to T5 (80:20) had significantly higher (P< 0.05) DMI and N retained (g/day/kgW$^{0.75}$) values than those on T1 (unsupplemented 100% cassava peels). Similarly, body weight (P< 0.05) gain (g/day) was highest (80.15) in sheep fed diet T5 (80:20) and lowest (14.28) in those fed control diet T1 (100.0). Sheep on (T5) also had significantly higher values (P< 0.05) for PCV (41%), RBC (9.25× 10^{6}/ul), Hb concentration (12.5 g/dl) and total protein (7.45 g/dl) than those on other treatments. However, the result of study indicated that supplementation of cassava peel with REW at 20% level (diet T5) highly improved animal performance as evidenced by the outstanding responses (body weight gain 80.15g/day; DMI 71.06 g/day/kgW$^{0.75}$; and nitrogen retention 78.10 g/day/kgW$^{0.75}$) of the fed sheep. This is due to efficient nutrient utilization occasioned by high dietary protein content and palatability of T5 (80:20, cassava peel/REW mixture) diet.

Key words: Cassava peels, Rumen waste, Sheep, Performance.

INTRODUCTION

Inadequate nutrition during the dry season forms a major impediment to the development of ruminant production in the tropics (Proverbs, 1990). This is due to long period of drought with attendant prevalence of inadequate or poor quality roughages for animal consumption (Bawala *et al*., 2006). The menace further results in lessened animal ability to withstand exposure to pathogenic organisms (Youssef, 1990), with concomitant reduction in performance. Tarawali *et al*. (1983) reported that many animals died of starvation during the dry season due to limited availability of all year round feed resources and high cost of conventional feeds.

The unique ability of ruminant livestock to utilize cellulosic materials such as forages and crop residues would make them ideal for increasing local livestock production as they do not compete with man and their requirement for imported ingredients is very much less than that required for monogastrics (Youssef, 1990). Though grass and foliage form greater proportions of ruminant feed resources (Bamikole *et al.*, 2003), their use is limited due to the seasonal availability and content of antinutritional factors (Bawala *et al.*, 2006).

Feed scarcity, therefore, has made it necessary to search for substitutes for the conventional feed resources by harnessing available agro industrial wastes (crop and animal residues) testing them both in the laboratory for chemical constituents and in the feed for efficiency of their utilization by the ruminants. Many agricultural residues have been used directly as energy, protein and mineral supplements in ruminant diets without involving very costly process and have resulted in increased digestibility, voluntary intake and performance of these animals (Alhassan, 1985).

Among such residues with promising position in animal nutrition are the cassava peels and rumen epithelial waste. Cassava peel could be fed to ruminants either as a sole source of energy or as an energy supplement to foliage or poor quality feed. Its' low crude protein (3.45%) requires that it should be supplemented with a dietary protein source (Oyenuga, 1968; Tewe, 1987; Ifut, 1988), preferably of animal origin to make a complete feed suitable for livestock production. Rumen epithelial waste REW is the squamous epithelia lining the ruminants' fore stomach particularly rumen. It's an animal by-product obtained from an abattoir during evisceration of cattle. It contains 62.50% crude protein and forms a good source of dietary minerals (Bawala and Akinsoyinu, 2006).

They are both priceless and readily available throughout the year, hence could be utilized in ruminants' feeds to ease off the problem of feed scarcity and its attendant inadequate nutrition commonly observed in the tropics during the dry season when pasture supply is scanty. Consequently, the study was designed primarily to evaluate the effects of supplementing cassava peel (a crop residue) with REW (an animal residue) on the performance of young WAD sheep during dry season as an approach towards the search for inexpensive and readily available alternative feed resources to utilize in ruminant feeding for sustainable production.

MATERIALS AND METHODS

Experimental site

The study was done at the experimental unit, Small Ruminant Section of the University of Agriculture, Teaching and Research farm, Abeokuta, Nigeria, which falls within the derived savanna zone. The altitude of the region is of 70 masl with latitude 7^0 5´-7^0 8´ and longitudes 3^0 11.2´ – 3^0 2.5´ E. The climatic condition is humid with a mean annual rainfall of 1037mm, and the average daily temperature and relative humidity of 34.7^0 C and 82%, respectively.

Source of animals and management

Twenty (20) West African dwarf (WAD) sheep aged 8 months with average weight of 9.34 kg were purchased from the villages about 10km from the University.

They were quarantined for a period of two weeks in order to assess their health status before the commencement of experiment. They were treated prophylactically against endoparasites with intramuscular injection of levamisole at 1ml / 10kg body weight per animal. The animals were bathed in a solution of diasuntol® to wipe off ecto-parasitic infestation. Vaccination against *Pestes de Petit ruminants*, PPR, was done with PPR vaccine. Individual pens together with wooden slatted floor were washed and disinfected thoroughly with izal disinfectant before the animals were moved in. They were adapted for a period of 14 days within which the experimental diets were gradually introduced to them. Water was given ad libitum.

Experimental diets

Cassava peels were collected from *garri* and *fufu* processing areas located in Abeokuta. They were derived from the bitter variety of *Manihot esculenta*. Processing followed harvesting 13-16 months post planting. The peeling was done with knives and marked the beginning of processing stages after harvesting. The peels were about 5cm long, with averaged 1cm thickness of pulp. They were spread on clean concretized floor for sun-drying between 7-12 days depending on the weather to reduce cyanide. After which they were packed in jute bags till the time required for feeding. Cattle from which the rumen epithelial waste, REW, was obtained were subjected to various clinical and laboratory procedures by the veterinarians, against infectious diseases including tuberculosis, brucellosis, contagious bovine pleuropneumonia and Encephalitis spongiformes bovine (not yet discovered in Nigeria) in order to ascertain their health status prior to slaughtering, at two abattoirs located in Abeokuta City, Nigeria.

The cattle were slaughtered following certification of sound health by the veterinarians who further subjected the entire carcasses to post mortem examination and subsequently confirming their suitability for human consumption. REW was scrapped with knives from the rumen of slaughtered cattle during evisceration. The collection period lasted 2 months in order to obtain sufficient quantities. REW was also spread on the floor and sun dried for about 7 days, after which it was baled into jute bags and kept in a well-ventilated room. In order to prevent bloating of the rumen, harvested *Pennisetum purpureum* (basal diet) was allowed to wilt in air for about 24 hours before serving the animals. The grass was cut at 8 wks of age with the cutting height of 15cm above soil level. However, the experimental diets consisted of cassava peel and REW which were composed to make 5 dietary treatments in the following order:

Treatment 1:100% cassava peel +0% REW
Treatment 2: 95% cassava peel+5% REW
Treatment 3: 90% cassava peel+10% REW
Treatment 4: 85% cassava peel+15% REW
Treatment 5: 80% cassava peel+20% REW
**garri* and *fufu* are local foods made from cassava roots.

Experimental design

The animals were divided into five groups of four sheep, balanced for body weight and randomly alloted to the experimental dietary treatments in a completely randomized design. Sheep were housed individually in separate pens with provision for feeding and water troughs. The grass was offered as a basal diet at 8.00h and supplementary experimental concentrate diets at 16.00h. Each animal was fed 5% of its weight. They had unlimited access to water and mineral salt lick in an experiment that lasted 100 days. The composition of the salt lick included: major minerals (g/kg) phosphorus 44, potassium 10, calcium 73, magnesium 5, sulphur 7; and minor minerals (mg/kg), iron 75.28, manganese 78.12, copper 195.64 and zinc 148.56. Daily voluntary intake was estimated by differences in the feed offered and collected remnants. The weights of the animals were taken at the commencement of the experiment and weekly for body weight changes.

Digestibility trial

This was done two weeks to the end of the feeding trial with the first 7 days used for adjustment of the animals to the metabolic cages fitted with facilities for separate collection of urine and faeces. The quantity of the feed offered, feed residue, faeces and urine were determined for the remaining 7 days. To prevent nitrogen loss from urine via volatilization 10ml of 10% H_2S0_4 was added to each collected sample of urine (Chen and Gomez, 1992). Daily collection of faeces and urine were separately bulked and aliquot (10%) of each sample was taken. Urine samples were collected in plastic containers with lid and stored in a deep freezer at -20^{0}C until required for analysis. Faecal samples were oven dried at 75^{0}C to a constant weight for 48h.

Collection of blood samples

In the last 7 days of the feeding trial blood sample was collected from each of the experimental animals via jugular vein punctured with hypodermic needle fitted on 10ml calibrated syringe, in the morning before feeding. A total of 5ml blood sample was collected from each animal with 3ml deposited in bottles containing EDTA for haematological studies while the remaining 2ml blood samples were put into plain bottles without anticoagulant for serum biochemistry.

Chemical analysis

Milled samples of faeces and the experimental diets were analyzed for their proximate composition (AOAC., 1990). Acid detergent fibre and neutral detergent fibre in both feeds and faecal samples were determined by methods of Van Soest and Robertson (1985). Gross energy of feeds, faeces and urine were determined by Gallenkamp bomb calorimeter. Mineral analysis of calcium was read with atomic absorption spectrophotometer after ashing in a muffle furnace at 550^{0}C. Sodium and potassium were analyzed using the flame photometer, and phosphorus by spectrophotometer (Spectronic 20). Glucose and urea nitrogen N concentration in frozen sera were determines by the auto analyses method (Sarko *et al.,* 1979). Hydrocyanide content of cassava peel was determined according to Grace (1977) method. Haemoglobin (Hb) concentration, packed cell volume PCV, white blood cell WBC and red blood cell RBC counts were determined according to the procedure by Jain (1986).

Statistical analysis

Data obtained data form the following parameters (body weight gain, DMI, crude protein intake, N utilization, apparent digestibility coefficients of DM, CP, NDF

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and ADF; haematological and blood biochemical studies) were subjected to Analysis of Variance (SAS, 1988). Where statistically differences occurred, the means were separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The result of the chemical composition of the diets fed to WAD sheep is shown in Table 1. REW had the highest crude protein (CP) level of 62% followed by grass, *Pennisetum purpureum,* with 7.60%, while the least value of 3.45% was obtained for cassava peel. Highest CP value obtained for REW is similar to 65% reported for fish meal (Nelson, 1979). This is not surprising as both products are animal by-products. Though cassava peel had least value of CP its gross energy content (4.5 Mcal/kg DM) was higher than the corresponding values of 3.53 and 2.78 obtained for REW and grass, respectively. This explains the need for the supplementation of cassava peel with an excellent protein source in formulating better quality diet for improved animal performance. However, various combinations of the two feeding materials as represented in diets T1, T2, T3, T4 and T5 gave CP contents (%) of 3.45, 6.40, 9.30, 12.10 and 15.10, respectively; while the corresponding metabolizable ME energy values (Mcal/kg DM) were 3.24, 3.08, 2.80, 2.52 and 2.38. Except T1 and T2, the energy values of the diets were similar to the range recommended (Gatenby, 1991) for sheep.

Crude protein contents of diets T3 (9.30), T4 (12.10) and T5 (15.10) were comparable to the minimum protein level required for maintenance (8%) and productive (13.40%) activities for rapidly growing lamb (Gatenby, 1991). Also, animals generally had additional supply of nutrients from the *ad libitum* feeding of *Pennisetum purpureum.* REW had higher value of ether extract (6.20%) than grass and cassava peel. Conversely, its contents of crude fibre and ash were relatively lower. The variation could be due to the nature of the feed materials. Grass contained highest crude fibre 35.26, NDF 75.02 and ADF 31.20% values. The (%) NDF (34.90) and ADF (24.60) values of cassava peel is comparable to the reported values of 34.30 and 23.90 respectively (Ifut, 1988).

Fibre fractions were not determined for REW since they are contents of cellwall of plants. Crude fibre content of REW (1.93%) was very low and it was assumed that its fibre fractions could be of negligible values. The hydrocyanide HCN content (363 mg/kg DM) of the fresh cassava peels in this study is similar to the value of 378 mg/kg DM reported by Asaolu and Odeyinka (2006) and falls within the reported range by Tewe *et al.* (1976). The contents of NDF, ADF and HCN of a diet determine the palatability and acceptability of such diet. Except for K, mineral (Ca, P and Na) contents of cassava peels were relatively lower than that of REW and grass.

The summary of performance characteristics of sheep is presented in Table 2. All the animals had average daily intake of 450g and 380g of grass (basal diet) and supplementary experimental diets respectively. Mean dry matter intakes DMI (g/day) of animals on dietary treatments are shown in Table 2. The animals had adequate DMI for their nutrition as the intake constituted an average of 3.71% of the animals' body weights and fell within the recommended (NRC, 1981; Devendra and Mcleroy, 1982) range of 1.9-5% for ruminants. The trend of DMI (g/day) was such that it increased with increasing dietary levels of REW. Sheep on diet containing highest REW inclusion (T5, 20% REW), however, recorded significantly ($p < 0.05$) highest mean DMI of 450.36g/day.

Animals on T1 had significantly ($p < 0.05$) lower value of 58.15g/day/kg$W^{0.75}$. Variations observed in DMI values could be attributed to differences in the dietary levels of protein. Increased CP content of the diet could be responsible for increased intake of feed in the animals. Therefore, highest DMI value obtained by sheep on T5 could be due to the stimulating effect associated with the highest level of supplementation of REW (20%) which might have induced higher level of intake observed in these animals. This is in consonance with the findings of Van Soest (1982) that increase protein supplementation tends to improve intake by increasing nitrogen supply to the rumen microbes. This has a positive effect by increasing microbial population and also improves the rate of breakdown of digesta. High DMI therefore was an evidence of high palatability and acceptability of diet T5, in which 80% of cassava peel was supplemented with 20% of REW. Conversely, low DMI of sheep on T1 was probably due to non supplementation of cassava peel with a rich protein source and/or perhaps oil in order to improve their palatability and digestibility (Oke, 1978; Tewe, 1987). Significant differences existed ($p < 0.05$) among mean crude protein intakes with sheep on T5 having the highest value of 119.13 g/day. This could be a result of increasing dietary CP contents occasioned by elevating levels of REW inclusion and DM intakes. Such variation did not exist ($P > 0.05$) among corresponding treatment means of NDF and ADF intakes.

The trend of body weight changes (g/day) of WAD sheep was similar to that of DMI. It ranges from 14.28 to 80.05 with animals on diet T1 having the least value. Significantly ($p < 0.05$) higher value, of 80.05 g/day was, recorded for T5 sheep was due to efficient feed utilization occasioned by higher nutrient composition of the diet (80% cassava peels combined with 20% of REW) which induced significantly ($p > 0.05$) higher dry matter and crude protein consumption in these animals. This is in line with the reports by Adegbola (1985) that animals cannot meet its maintenance need on grass or cassava peels alone but requires supplementary diet for higher physiological performance.

Table 3 shows the apparent digestibility of the nutrients by sheep. Except for DM and CP digestibility, significant differences did not exist ($p > 0.05$) among the treatments means in the NDF and ADF. Sheep on T5 however had the highest apparent digestibilities of DM, CP and ADF. Generally, the values were high in all treatments especially for those on diets T3, T4 and T5. This is in agreement with the report by Devendra and Mcleroy (1982) that feeding high concentrate diet improve DM digestibility in ruminants. The highest value of DM digestibility observed for T5 sheep was due to palatability of the diet with its attendant supplementary or associative effects with the basal diet. Small ruminants are choosy in their eating habit and abhor bitter tasting or unpalatable diets but tend to consume more of sweet and palatable type (Krueger *et al*., 1974). The digestibility of detergent fibres in this study were similar, but higher than the range of 56 - 69.9% reported by Oduguwa *et al.* (2006) when sheep were fed foliage and agro industrial by- products. The result, therefore, demonstrated the ability of ruminants to process structural carbohydrates into forms utilizable by man.

The result of nitrogen (N) utilization is presented in Table 4. Significant ($p < 0.05$) differences were observed among the treatment means. N intake values (g/day) obtained for sheep on all diets ranged from 7.55 to 17.99, with sheep on T1 and T5 having the least and highest values respectively. The values were higher than the range of 225 – 671mg/day recorded by Tuah *et al*. (1992) for sheep fed cassava peel supplemented with palm kernel cake in which animal performances were reported to be generally poor. The N absorbed and retained by sheep on T4 and T5 were outstanding ($p < 0.05$) in the REW supplemented diets at 15 and 20% levels of inclusion respectively than others. This is in consonance with assertion that the retention of N increased (Mupangwa *et al*., 2000) with protein supplementation. Mean N retention (g/day/kgW$^{0.75}$) values of the experimental sheep (Table 4) were higher than the range of 0.62 to 0.89 reported by Ikhatua and Adu (1983) for sheep fed *Panicum maximum* supplemented with concentrate diets.

Higher values obtained in this study showcase the nutritional importance of REW, an abattoir waste with higher crude protein content as a potent supplementary diet to low quality plant or crop residue in enhancing improved animal performance. It has been reported by Giger-Reverdin and Sauvant (1991) that palatability of a diet is a function of its' crude protein content, among other factors. Therefore, higher N retention observed for sheep on T4 (85:15) and T5 (80:20) diets was also a consequence of higher dietary protein intakes and palatability, which resulted into higher utilization of N for rumen microbial protein synthesis. Bawala *et al.* (2006) also reported that N retention is positively correlated with and thus a function of dietary N intake.

The trend of blood parameters (Table 5) of the experimental sheep is also similar to DM and N intakes. Means values obtained for haematological parameters ($p < 0.05$) except haemoglobin Hb and white blood cell counts (WBCc) of sheep on T1 fell within the normal ranges reported in literature, hence, indicating sufficiency of dietary protein intake by the animals. While sheep on T5 had highest values ($p < 0.05$) of packed cell volume PCV (41%), red blood cell counts RBCc (9.25×10^6/ul), and Hb concentration (12.5g/dl), those on T1 had significantly ($p < 0.05$) lower values than those from other treatments (Table 5). These low values were due to inadequate protein intake observed in those animals as a result of low dietary protein content of the diet. This is in consonance with earlier report by Blood *et al.* (1979) that attributed low PCV values to insufficient protein intake. The normal WBCc reported in this study hence indicates high immunity status of the animals to fight against infection (William, 1998) and further confirms that the animals were in sound health.

However, the normal physiological ranges of studied haematological parameters as reported in literature are: PCV 25-50%; RBCc 8 - 16×10^6/ul (Fraser and May, 1986); Hb 8 – 14g/dl (Puls, 1988) and WBCc 4 -13×10^3/dl (Oscar, 1971) for sheep .

Serum glucose and urea nitrogen levels in ruminants are indices for assessing nutritive value of feed (Torrell *et al*., 1976) as they are indicators of available energy and ability of the animal to synthesize microbial protein, respectively. There were significant ($p < 0.05$) differences observed as a result of the given treatments. There were no signs of physiological stress on the animals since the obtained values of serum glucose and urea N were comparable with the standard ranges of 50 – 80mg/dl (Fraser and May, 1986) and 8 – 25mg/dl (Puls, 1988) recommended for sheep, respectively. However, levels of REW supplementation had a significant ($p < 0.05$) effect on serum total protein with sheep on T1 (100:0) and T2 (95:5) had significantly ($p < 0.05$) lower total protein values (Table 5) which were less than the standard range (6.0 – 7.9g/dl) reported by Meyer and Harvey (1988) for sheep.

It must be noted that before the start of the experiment, the values of the blood parameters were recorded to serve as reference point in assessing the fitness of the animals and to form a basis of comparism with a view to monitoring the effects of treatments. Recorded values (X) of the blood parameters were not subjected to statistical analysis because the animals were yet to be placed on dietary treatments. Obviously, the general haematological and serum biochemical responses of the animals (Y) in the present study were higher, except WBCc of (T1) sheep, than the corresponding values obtained during pre-experimental period. This signifies the nutritional influence of the experimental diets on animal performance.

Table 1: Proximate composition (g/100gm DM) of *Pennisetum purpureum*, Cassava peel and Rumen epithelial waste fed to WAD sheep

Composition	Pennisetum purpureum	Cassava peel	REW
Dry matter	25.51	82.30	85.40
Crude protein	7.60	3.45	62.00
Ether extract	1.45	1.65	6.20
Crude fibre	35.26	15.89	1.93
Ash	14.80	5.68	9.52
Nitrogen free extract	40.11	73.33	20.35
Neutral detergent fibre	75.02	34.90	ND
Acid detergent fibre	31.20	24.60	ND
Energy ME (Mcal/kgDM)	2.32	3.60	2.82
Hydrocyanide (mg/kgDM)	ND	363.00	ND
Minerals			
Calcium	0.60	0.20	1.75
Phosphorus	0.47	0.31	2.06
Potassium	1.75	1.53	0.51
Sodium	0.69	0.05	0.39

ND: Not determined

Table 2: Performance characteristics of WAD sheep fed cassava peel Supplemented with varying proportions of REW

Parameters	T1	T2	T3	T4	T5	SEM
	Levels of REW inclusion (%)					
	0	5	10	15	20	
Initial body weight (kg)	9.52	9.42	9.33	9.33	9.23	
Final body weight (kg)	10.42	11.17	12.42	13.17	17.25	
Body weight changes (g/day)	14.28[a]	27.78[a]	49.05[b]	60.85[b]	80.15[c]	9.25
Nutrient intake (g/day)						
Dry matter intake	321.11[a]	393. 81[ab]	415.46[b]	431.10[bc]	450.36[c]	28.48
Crude protein intake	47.18[a]	67.63[b]	84.81[c]	97.13[c]	112.13[d]	4.75
NDF	164.40	169.20	169.35	178.40	170.23	
ADF	91.01	100.01	107.49	140.27	135.51	
Dry matter intake (g/day/kg$W^{0.75}$)	58.15[a]	69.71[b]	72.09[b]	71.06[b]	64.89[b]	3.84

[a, b, c]: Means along the same row with similar superscripts are not significantly different (p > 0.05

Table 3: **Apparent digestibility (%) of WAD sheep fed cassava peel supplemented with varying proportions of REW**

Parameter	T1	T2	T3	T4	T5	SEM
Dry matter	65.93[a]	68.16[a]	80.87[bc]	85.18[cd]	88.75[d]	2.91
Crude protein	56.02[a]	65.62[b]	81.79[cd]	86.16[d]	87.25[d]	2.78
NDF	68.50	67.80	70.12	71.15	70.05	4.49
ADF	65.42	66.31	68.24	67.20	69.32	6.02

[a,b,c]: Means along the same row with similar superscript are not significantly different (p > 0.05)

Table 4: **Nitrogen N utilization of WAD sheep fed cassava peel supplemented with varying proportions of REW**

Parameter	T1	T2	T3	T4	T5	SEM
N intake (g/day)	7.55[a]	10.82[b]	13.57[c]	15.54[c]	17.99[d]	0.71
N excretion (g/day)						
Faecal	3.32	3.72	2.47	2.15	2.83	
Urinary	0.38	0.28	0.25	0.32	1.11	
Total	3.70	4.00	2.72	2.47	3.94	
N absorbed (g/day)	4.23[a]	7.10[a]	11.10[b]	13.39[bc]	15.16	0.69
N retained (g/day)	3.85[a]	6.82	10.85	13.07	14.05	0.82
N absorbed (g/day/kgW$^{0.75}$)	0.75[a]	1.24[a]	1.85[ab]	2.18[b]	2.18[b]	1.20
N retained (g/day/kgW$^{0.75}$)	0.69[a]	1.19[a]	1.81[b]	2.13[b]	2.02[b]	0.32
N retention (%)	50.90[a]	63.02[a]	79.95[b]	84.10[b]	78.10[b]	2.78

[a,b,c]: Means along the same row with same superscript are not significantly different (P > 0 0.05)

Table 5: Summary of blood parameters of WAD sheep fed cassava peels supplemented with varying proportions of REW

Parameter		T1	T2	T3	T4	T5	SEM
Haematology							
PCV (%)	X	31.00	29.00	35.00	39.00	30.00	
	Y	33.00[a]	39.00[b]	40.00[b]	39.00[b]	41.00[b]	1.54[b]
Hb (x10^6/ul)	X	9.93	8.23	8.57	9.23	8.96	
	Y	7.24[a]	8.50[a]	10.30[b]	10.12[b]	12.50[c]	0.69
RBC (x10^6/ul)	X	7.16	7.21	8.05	7.43	8.01	
	Y	6.83[a]	7.53[a]	8.84[b]	8.47[b]	9.25[c]	0.26
WBC (X10^{3}ul)	X	14.51	11.75	14.61	10.70	10.85	
	Y	13.30[a]	12.80[a]	7.83[b]	9.70[c]	9.75[c]	0.27
Serum Biochemistry							
Glucose (mg/dl)	X	60.50	60.70	62.50	65.80	63.20	
	Y	56.70[a]	65.30[a]	66.70[a]	80.00[b]	75.23[b]	2.57
Urea N (mg/dl)	X	18.50	18.00	19.70	20.29	17.21	
	Y	17.50[a]	19.50[b]	20.50[c]	22.01[d]	22.00[c]	0.29
Total protein (g/dl)	Y	5.22[a]	5.48[a]	6.05[b]	6.03[b]	7.45[c]	
Albumin		3.16	3.26	3.41	3.57	4.41	
Globulin		2.06	2.22	2.64	2.46	3.04	

[a,b,c]: Means along the same row with similar superscripts are not significantly different (p > 0.05)
X, Y: before and after experiment, respectively.

CONCLUSION AND RECOMMENDATION

The responses of the animals suggest that supplementation of cassava peels with 15 – 20% REW (T4 and T5) enhanced improved animal performance, and further indicates that the accompanying dietary crude protein levels of 12 – 15%, respectively, could be adequate for growing WAD sheep. However, since the two agricultural by-products (cassava peels and REW) are readily available all year round and priceless in ruminant nutrition, the 80:20 (T5) combination which yielded the best results on account of highest growth rate, dry matter consumption and N retained, is recommended to small ruminant farmers as an efficient supplementary diet to low quality pasture that are prevalent during the dry season in the tropics. This would not only allow uninterrupted ruminant production at reduced cost across seasons but broadens farmers' profitability.

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