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Effects of supplementing cassava peels with cassava leaves and cowpea haulms on the rumen environment and blood profile parameters of West African dwarf goats

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Additional keywords

Rumen fermentation.
Blood metabolites.
Cassava.
Cowpea haulms.
Microbial activity.

SUMMARY

This experiment was conducted to evaluate the effects of supplementing cassava peels with cassava leaves and cowpea haulms on rumen fermentation and blood metabolites of West African dwarf (WAD) goats. Thirty West African dwarf bucks aged 8±1.3 months with an average body weight of 6.06±0.02 kg were used in a completely randomized experiment. The goats were randomly assigned to one of the five dietary treatments which consisted of milled cassava peels, cassava leaves and cowpea haulms in different ratios of 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) and 100:400:475 (T4) g/kg DM respectively. A standard diet formulated to meet the nutrient requirements of the animals with no cassava and cowpea haulms was used as the control diet (T5). Data collected was subjected to analysis of variance using the general linear model procedure of SAS. The results obtained indicated that the highest dietary crude protein was obtained in treatment 5 (206 g/kg) followed by treatment 4 (200 g/kg). Treatment 1 had higher neutral detergent fibre (660 g/kg) and hydrocyanide (30.00 mg/kg) contents. At 0 hr post-feeding, NH_3-N values significantly ranged (L, Q, C: p<0.05) from 8.50 % in treatment 1 to 15.67 % in treatment 4. The acetic and propionic acid content was highest (C: p<0.05) in treatment 1 with values of 68.17 mol/100ml and 21.55 mol/100 ml, respectively. Total fungi counts were similar in treatments 3 and 5, but significantly different (Q, C: p<0.05) from other treatments. The acetic acid values significantly (Q: p<0.01; C: p<0.05) decreased from 63.70 mol/100 ml in treatment 1 to 62.49 mol/100ml in treatment 3; decline further to 61.78 mol/100ml in treatment 4. Values for total fungi counts ranged from 0.20 (cfu/ml x106) in treatment 2 to 0.60 (cfu/ml x106) in treatment 5. Packed cell volume (PCV) values ranged from 21.50 % in treatment 3 to 31.50 % in treatment 1. Haemoglobin concentration was highest in treatment 2 with values of 10.25 g/dl resulting in a significant linear and cubic trend. At the end of the experiment, there was a sharp decline in the PCV values of the goats in treatments 1, 2 and 5. Hb concentration values followed a similar trend though not significantly different (L, Q, C: p>0.05). RBC values significantly (L: p<0.01) increased as the levels of inclusion of cassava peels reduced. Total protein and globulin ranged from 53.30 to 67.30 (g/dl) and 22.00 to 34.60 (g/dl) respectively and were significantly (C: p<0.01; L, Q, C: p<0.01, 0.05) different. The study revealed that supplementing cassava peels with cassava leaves and cowpea haulms as protein sources has no negative effects on rumen fermentation and blood biochemical parameters of West African dwarf goats.

Efectos de la suplementación con peladuras y hojas de yuca y tallos de caupí sobre el ambiente ruminal y parámetros sanguíneos de cabras Enanas del África Occidental

Additional keywords

Fermentación ruminal.
Metabolitos sanguíneos.
Yuca.
Tallos caupí.
Actividad microbiana.

RESUMEN

Este experimento se realizó para evaluar los efectos de suplementar peladuras de yuca con hojas de yuca y tallos de caupí sobre la fermentación del rumen y metabolitos sanguíneos de cabras Enanas de África Occidental (WAD). Treinta machos de 8±1,3 meses con un peso corporal medio de 6,06±0,02 kg fueron usados en un experimento completamente al azar. Las cabras fueron asignadas aleatoriamente de a 1 de 5 tratamientos dietarios que consistian de peladuras de yuca molidas, hojas de yuca y tallos de caupí en diferentes proporciones 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) y 100:400:475 (T4) g/kg de materia seca respectivamente. Una dieta estandar formulada para atender las necesidades nutritivas de los animales sin yuca ni tallos de caupí fue empleada como dieta control (T5). Los datos obtenidos fueron sometidos a análisis de varianza usando el procedimiento del SAS modelo lineal general. Los resultados obtenidos indicaron que la mayor cantidad de proteína bruta dietética fue obtenida en el tratamiento 5 (206 g/kg) seguido por el tratamiento 4 (200 g/kg). El tratamiento 1 presentó mayor contenido de fibra neutrodetergente (660 g/kg) y cianuros (30 mg/kg). En el momento de la administración los valores de NH_3-N significativamente se ordenaron (L, Q, C: p<0,05) de 8,5% en el tratamiento 1 a 15,67% en el tratamiento 4. El contenido de ácidos acético y propiónico fue más alto (C: p<0,05) en el tratamiento 1 con valores de 68,17 mol/100ml y 21,55 mol/100 ml respectivamente. Los recuentos de hongos totales fueron similares en los tratamientos 3 y 5 pero significativamente

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diferentes (Q, C: p<0,05) de los otros tratamientos. Los valores de ácido acético disminuyeron significativamente (Q: p<0,01; C: p<0,05) desde 63,70 mol/100 ml en el tratamiento 1 a 62,49 mol/100ml en el tratamiento 3 bajando aún más a 61,68 mol/100 ml en el tratamiento 4. Los valores para los recuentos totales de hongos oscilaron entre 0,20 (cfu/ml x106) en el tratamiento 2 a (cfu/ml x106) en el tratamiento 5. Los valores del volumen celular (PCV) oscilaron entre 21,50% en el tratamiento 3 a 31,50% en el tratamiento 1. La concentración de hemoglobina fue más alta en el tratamiento 2 con valores de 10,25 g/dl resultando en una tendencia significativa lineal y cúbica. Al final del experimento existió una aguda disminución de los valores PCV en las cabras de los tratamientos 1, 2 y 5. La concentración de Hb siguió una tendencia similar aunque no significativamente diferente (L, Q, C: p>0,05). Los valores de RBC aumentaron significativamente (L: p<0,01) a medida que se reducían los niveles de inclusión de peladura de yuca. La proteína y globulina totales oscilaron de 53,30 a 67,30 (g/dl) y de 22,00 a 34,60 (g/dl) respectivamente siendo significativamente diferente (C: p<0,01; L, Q, C: p<0,01, 0,05). El estudio reveló que la suplementación de peladuras de yuca con hojas de yuca y tallos de caupí como fuente de proteína no tiene efectos negativos sobre la fermentación ruminal y parámetros bioquímicos sanguíneos de cabra Enana de África Occidental.

INTRODUCTION

Ruminant feed resources in the urban and peri-urban areas of Nigeria are mainly agro-industrial by-products. Agro-industrial by-products such as cassava peel, cowpea haulms, maize offals, plantain peel, dried brewer's grains and corn cobs) constitute the largest feed resource. Among the agro-industrial by-products, cassava peel is the most abundant and has the greatest potential as a basal feedstuff for small ruminants. The peel is a by-product of processing the roots for starch, cassava flour and *gari* (a fermented cassava meal product). That cassava is produced throughout the year ensures a consistent supply for livestock feeding. According to Castillo *et al*. (2001), the supplementation of readily degradable energy source will enhance the utilization of available N in the rumen and further improve the productivity of goats through an increased efficiency of utilization of ammonia-N for microbial protein synthesis. Haematological and biochemical indices of animals may give some insight into the production performance potentials of West African Dwarf goats (Taiwo and Ogunsanmi, 2003). Nutrition, breed, sex, age, reproductive status, environmental factors, stress and transportation are known to affect haematological and biochemical parameters Balikei *et al.* (2007). Normal blood values are defined as those of clinically healthy animals which are kept under normal housing conditions and fed balanced ration. Meyer and Harvey (1998) noted that the ingestion of numerous dietary components have measurable effect on blood constituent. It has been severally reported that cassava peel is low in proteinand fibre hence, the need to supplement it with feed resources of high protein contents such as cassava leaves and cowpea haulms. The study is therefore, designed to evaluate the effects of supplementing cassava peels with cassava leaves and cowpea haulms on rumen fermentation and blood metabolites of West African dwarf goats.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Demonstration Farm of Sustainable Livelihoods Support and Development Network Centre for Africa (SLIDEN AFRICA), Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The site is located in the derived savannah vegetation zone of South-Western Nigeria. The climate is tropical, with a wet season from March to October and a dry season from November to February. Annual rainfall averages about 1100 mm and the peak rainfall occurs in the period June–September. The temperatures and relative humidity ranges from 32–35°C and 75–83%, respectively.

Experimental animals, feed and management

thirty West African Dwarf bucks aged 8±1.3 months with an average body weight of 6 - 6.06±0.02 kg, managed under an intensive condition, were used in a completely randomized experiment. The animals were housed in well-ventilated individual pens, in an open-sided housing system with corrugated aluminium roofing sheets and a wooden and slatted floor which were disinfected with Izal solution two weeks prior to the commencement of the experiment. The animals were quarantined for 3 weeks, during this period, vaccination was done against *Peste des petit ruminants* (PPR) with tissue culture rinderpest vaccine; prophylactic treatments, which consisted of intramuscular application of oxytetracycline and vitamin B complex at the dosage of 1 ml/10 kg body weight of the animal. They were also dewormed with 1 ml/10 kg body weight of albendazole® and treated against ectoparasites with 0.5 ml/10 kg body weight of Ivomec® respectively. The 30 goats were closely balanced for body weight (BW) and randomly assigned to one of the five dietary treatments. The dietary treatments **(table I)** consisted of milled cassava peels, cassava leaves and cowpea haulms in different proportions of 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) and 100:400:475 (T4) g/kg DM respectively. A standard diet formulated to meet the nutrient requirement of the animals with no cassava peels, cassava leaves and cowpea haulms was used as

Table I. Ingredient composition (g/kg DM) of the experimental concentrate diets (Ingredientes (g/kg MS) de las dietas experimentales concentradas).

Ingredients	Treatments				
	T1	T2	T3	T4	T5
Cassava peels	700	500	300	100	-
Cassava leaves	100	200	300	400	-
Cowpea haulms	175	275	375	475	-
Dried brewer's grains	-	-	-	-	385
Wheat offal	-	-	-	-	200
Palm kernel cake	-	-	-	-	150
Rice husk	-	-	-	-	250
Bone meal	10	10	10	10	10
Salt	5	5	5	5	5
Sulphur	10	10	10	10	10
Total	1000	1000	1000	1000	1000

Treatments consisted of milled cassava peels, cassava leaves and cowpea haulms in different proportions of 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) and 100:400:475 (T4) g/kg DM respectively. Standard diet formulated to meet the nutrient requirements with no cassava peels, cassava leaves and cowpea haulms was used as the control diet (T5).

the control diet (T5). The animals were given 2 weeks adaptation period and actual data collection period was 116 days. The animals were fed about 650 g/d (DM basis) based on 50 g/kg BW/day with concurrent adjustments as BW increased. Animals were fed in the morning at 08:00 h after proper cleaning of the pens and troughs. Fresh and clean water was offered *ad libitum*. Daily feed offered and refusals were recorded to compute feed intake.

Ruminal microbial analyses

rumen liquor samples were collected at the start and end of the digestibility trial with the use of stomach tubes as described by Wanapat *et al.* (2007). 20 ml of the rumen liquor was collected from 3 replicates per treatment into sample bottles and immediately stored in the freezer at –5 °C until analysis. The rumen pH of each sample was measured immediately after collection using the JENWAY pH meter, model 3150. Rumen fluid samples were strained through four layers of cheesecloth. Samples were divided into two portions; one for NH_3-N and VFA analyses and the other portion was fixed with 10% formalin solution in normal saline (0.9% NaCl). The total direct count of bacteria, fungi and protozoan was done by the methods of Galyean (1989) using a haemocytometer under a light microscope. Rumen ammonia N was determined by the method of Lanyasunya *et al.* (2008). The molar percentages of propionic, acetic and butyric acids were determined using the gas-liquid chromatography (Samuel *et al*., 1997).

Blood collection and analyses

Blood collection was at the start and end of the experiment. 10ml of blood samples were collected from the animals via jugular vein puncture using hypodermic syringes before feeding. The packed cell volume was measured for each animal in fresh ethylene diamine tetra acetic acid (EDTA) anticoagulant samples within 24hrs of collection using the microhaematocrit method. Haemoglobin concentration was also measured in fresh EDTA anticoagulant samples using the Sahl's (acid haematin) method (Benjamin, 1978). RBC was measured in fresh EDTA with the aid of Neubaur counting chamber (haemocytometer). Blood smears were used for total thrombocyte, total WBC counts (Tavares-Dias *et al.*, 2008) and WBC differential relative and absolute counts. Differential relative and absolute counts were classified as lymphocytes, neutrophils, eosinophils, basophils and monocytes. Plasma glucose was measured in fluoride oxalate anticoagulant blood samples using the enzymatic glucose oxidase method (Bauer *et al.* 1974). MCH and MCHC values were calculated from PCV, Hb and RBC values (Jain, 1993). Total serum protein was measured in serum for individual animal using the biuret method. alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were analysed spectrophotometrically by using commercially available diagnostic kits (Randox® Test Kits). Serum albumin and globulin were determined using bromocresol purple method of Varley *et al.* (1980). Serum creatinine was determined using the principle of Jaffe reaction as described by Bousnes and Taussky (1945).

Table II. Chemical composition (g/kg) of the experimental concentrate diets (Composición (g/kg) de las dietas experimentales concentradas).

Parameters	Treatments				
	T1	T2	T3	T4	T5
Dry matter	985	985	995	995	975
Crude protein	153	159	163	200	206
Ether extract	105	90	100	75	135
Ash	75	80	80	80	85
NDF	660	640	620	600	570
ADF	340	400	300	340	280
ADL	100	140	80	100	120
Cellulose	240	260	220	240	160
Hemicellulose	320	240	320	260	290
Tannin	14.7	15.2	12.6	16.1	0.00
HCN(mg/kg)	30.00	25.00	20.00	15.00	0.00
ME 1 (MJ/kg DM)	7.70	7.01	8.31	8.16	7.00
ME 2 (MJ/kg DM)	12.58	12.39	12.63	12.49	12.63
Mean ME (MJ/kg DM)	10.14	9.77	10.47	10.33	9.85

ME 1 was estimated using De Boever *et al.* (1997) equation (ME=12.86+0.0265 FAT−0.0056 ADF−0.0153 ASH−0.0253 ADL); ME 2 was estimated according to MAFF (1984) equation (ME=DOM%×0.15); NDF= neutral detergent fibre; ADF= acid detergent fibre; ADL= acid detergent lignin; HCN; hydrocyanide, ME= metabolizable energy.

Chemical analyses

Feed samples, orts and faeces were milled through a 1 mm sieve in a hammer mill. Prior to milling, samples were oven-dried at 60ºC for 96 h while DM was determined by oven-drying at 100ºC for 24 h. Samples were mixed separately and subsampled for analyses. The samples were later analysed for CP, ether extract (EE), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin. Fresh samples were used for faecal N determination. Crude protein (ID 984.13), ash (ID 942.05) and EE (ID 963.15) were analysed according to standard methods of AOAC (2005). Both NDF and ADF were expressed without residual ash. Lignin was determined by solubilisation of cellulose with sulphuric acid in the ADF residue (Van Soest *et al.*, 1991). The NDF and ADF were determined according to Van Soest *et al.* (1991), with NDF determined without use of amylase or sodium sulphite.

Calculation of metabolisable energy

Metabolisable energy was estimated using two separate equations and the mean values taken. The first was by MAFF (1984) equation: ME = DOM (digestible organic matter) percentage x 0.15, where DOM percentage = (0.92 x OMD percentage) – 1.2. The organic matter digestibility (OMD) was estimated using the equation developed by Jarrige (1989) as follows: OMD = 91.9 – (0.355 NDF %) + (0.387 ADF %) – (2.17 ADL %) – (0.39 EE %). Where NDF = neutral detergent fibre, ADF = acid detergent fibre, ADL = acid detergent lignin and EE = ether extract. The second equation was according to De Boever *et al.* (1997) as follows: ME =

12.86 + 0.0265 FAT – 0.0056 ADF – 0.0153 ASH – 0.0253 ADL. Where EE = ether extract, ADF = acid detergent fibre and ADL = acid detergent lignin.

Statistical analysis

Data were subjected to analysis of variance using the GLM procedure of SAS (2002) in a completely randomized design with six replicates. Model sums of square were partitioned to test linear, quadratic and cubic trends (Gomez and Gomez, 1983).

RESULTS

The chemical composition of the experimental diets **(table II**) showed that the highest CP was obtained from treatment 5 (206 g/kg) followed by treatment 4 (200 g/kg). Treatment 1 had higher NDF (660 g/kg) and hydrocyanide (30.00 mg/kg) contents. The least NDF (570 g/kg), ADF (280 g/kg) and cellulose (160 g/kg) values were obtained from treatment 5.

The rumen environment parameters of WAD goats fed the experimental diets are shown in **table III**. At 0 hr post-feeding, NH_3-N values significantly ranged (L, Q, C: $p<0.05$) from 8.50 % in treatment 1 to 15.67 % in treatment 4. The acetic and propionic acids content was highest (C: $p<0.05$) in treatment 1 with values of 68.17 mol/100 mol and 21.55 mol/100 mol respectively. Total fungi counts were significantly similar in treatments 3 and 5 but significantly different (Q, C: $p<0.05$) from other treatments. At 8 hr post-feeding,

Table III. Rumen environment parameters of West African dwarf goats fed on diets containing cassava peels, leaves and cowpea haulms during digestibility trial (Parámetros del ambiente ruminal de cabras Enana de África Occidental alimentadas con peladuras de yuca suplementadas con hojas de yuca y tallos de caupí, durante el ensayo de digestibilidad).

Parameters	Treatments					SEM	Probability[1]		
	T1	T2	T3	T4	T5		L	Q	C
Ruminal pH									
0 h-post feeding	6.13	6.07	6.17	5.97	5.97	0.03	NS	NS	NS
8 h-post feeding	6.03	5.90	6.00	6.00	5.90	0.03	NS	NS	NS
NH_3-N (mg/dl)									
0 h-post feeding	8.50^{e}	10.7^{d}	11.7^{c}	15.7^{a}	12.6^{b}	0.53	**	**	**
8 h-post feeding	10.6^{e}	11.8^{d}	12.3^{c}	17.4^{a}	14.4^{b}	0.57	**	**	**
Molar proportion of Volatile Fatty Acids (mol/100 mol)									
Acetate (A), C_2									
0 h-post feeding	68.17^{a}	67.49^{b}	66.87^{b}	66.33^{b}	66.27^{b}	3.45	NS	NS	*
8 h-post feeding	63.70^{a}	63.01^{a}	62.49^{ab}	61.78^{b}	62.23^{ab}	2.13	NS	*	*
Propionate (P), C_3									
0 h-post feeding	21.55^{a}	21.23^{a}	20.58^{b}	20.05^{b}	20.54^{b}	2.30	NS	NS	*
8 h-post feeding	19.37^{a}	17.29^{b}	16.91^{c}	16.40^{c}	16.90^{d}	1.44	NS	*	*
Butyrate, C_4									
0 h-post feeding	19.14^{a}	18.79^{b}	16.83^{c}	15.37^{c}	12.91^{d}	3.39	NS	NS	**
8 h-post feeding	10.33^{a}	9.67^{b}	9.06^{bc}	9.05^{bc}	8.45^{c}	2.18	NS	**	*
A: P ratio									
0 h-post feeding	3.17^{a}	3.18^{a}	3.25^{aa}	3.31^{aa}	3.23^{b}	0.08	**	**	**
8 h-post feeding	3.28^{ab}	3.64^{a}	3.69^{a}	3.77^{aa}	3.68^{a}	0.04	NS	NS	**
Total direct Count									
Bacteria (cfu/ml x10^6)									
0 h-post feeding	1.20^{ab}	1.07^{bb}	1.33^{ab}	1.33^{ab}	1.23^{ab}	0.04	NS	NS	NS
8 h-post feeding	1.00^{d}	1.00^{d}	1.20^{b}	1.20^{b}	1.10^{c}	0.03	**	**	**
Fungal zoospores (cfu/ml x10^6)									
0 h-post feeding	0.30^{bc}	0.40^{ab}	0.50^{a}	0.27^{c}	0.50^{a}	0.03	NS	**	**
8 h-post feeding	0.27^{d}	0.20^{d}	0.50^{b}	0.40^{c}	0.60^{a}	0.04	*	NS	**
Total protozoa (cfu/ml x10^6)									
0 h-post feeding	3.00	2.33	2.67	2.67	2.00	0.12	NS	NS	NS
8 h-post feeding	4.00^{b}	5.00^{a}	3.00^{c}	4.67^{a}	5.00^{a}	0.18	NS	NS	**

*p<0.01; **p< 0.05; NS: Not significant. Within a file the values followed by different letters are different (p<0.05); [1]Probability for linear (L), quadratic (Q) and cubic (C) trends..Treatments consisted of milled cassava peels, cassava leaves and cowpea haulms in different proportions of 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) and 100:400:475 (T4) g/kg DM respectively. Standard diet formulated to meet the nutrient requirements with no cassava peels, cassava leaves and cowpea haulms was used as the control diet (T5).

the NH_3-N significantly (L, Q, C: p<0.05) increased with increasing levels of cassava leaves and cowpea haulms, and decreasing levels of cassava peels in the diets. The acetic acid values at 8 hr post-feeding significantly (Q: p<0.01; C: p<0.05) decreased from 63.70 mol/100 mol in treatment 1 to 61.78 mol/100 mol in treatment 4; increased further to 62.23 mol/100 mol in treatment 5. Similar trend was obtained in values for propionic acids resulting into significant quadratic and cubic trend. Values for total fungi counts ranged from 0.20 (cfu/ml x10^6) in treatment 2 to 0.60 (cfu/ml x10^6) in treatment 5.

Table IV shows the haematological parameters of WAD goats fed the experimental diets. At the start of the trial, PCV values ranged from 21.50 % in treatment 3 to 31.50 % in treatment 1. Haemoglobin concentration was highest in treatment 2 with values of 10.25g/dl resulting in a significant linear and cubic trend. WBC values ranged from 4.10 to 5.73 (x10^9/l) resulting in a significant linear, quadratic and cubic trend. The highest neutrophils value 37.30 % was obtained in treatment 3 and was significantly (Q: p<0.01) different.

At the end of the experiment, there was a sharp decline in the PCV values of the goats in treatments 1, 2 and 5. Hb concentration values followed a similar trend though not significantly different (L, Q, C: p>0.05). RBC values significantly (L: p<0.01) increased as the level of inclusion of cassava peels reduced, with an increase in cassava leaves and cowpea haulms in the diets. The values were however, significantly similar to the control diet. Lymphocytes values did not follow a definite pattern but was significantly (Q, C: p<0.05) lowest and highest with values of 59.33 and 70.67 % respectively.

Table V shows the serum biochemical parameters of WAD goats fed experimental diets. At the start of the experiment, total protein and globulin ranged from 53.30 to 67.30 (g/dl) and 22.00 to 34.60 (g/dl) respectively and were significantly (C: p<0.01; L, Q, C: p<0.01, 0.05) different. Creatinine had significant (L, Q, C: p<0.01, 0.05) highest value 1.37 mg/dl in treatment 3 and lowest value 0.25 mg/dl in treatment 1 while glucose ranged from 42.67 to 60.00 (mg/dl) and were significantly different. Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) ranged from 43.67 to 65.67 (Iu/L) and 19.00 to 24.50 (Iu/L) respectively while at the end of the ex-

Table IV. Haemotological parameters of West African Dwarf goats fed on diets containing cassava peels, leaves and cowpea haulms (Parámetros hematologicos de cabras Enana de África Occidental alimentadas con dietas a base de peladuras de yuca, hojas de yuca y tallos de caupí).

Parameters	[1]Normal values	Treatments					SEM	[2]Probability		
		T1	T2	T3	T4	T5		L	Q	C
At the start of the experiment										
Packed cell volume (%)	22-38	31.50^{a}	29.50^{ab}	21.50^{c}	26.50^{b}	28.00^{ab}	0.93	*	*	**
Haemoglobin (g/dl)	8-12	10.10^{a}	10.25^{a}	7.45^{c}	8.65^{b}	9.62^{a}	0.29	*	NS	**
Red blood cell (x10^{12}/l)	8-18	11.50^{a}	10.52^{ab}	7.73^{c}	9.93^{b}	10.30^{ab}	0.35	NS	*	**
White blood cell (x10^{9}/l)	4-13	5.73^{a}	5.23^{ab}	4.10^{d}	4.73^{d}	5.07^{bc}	0.15	*	**	**
Neutrophil (%)	30-38	34.00^{ab}	36.00^{ab}	37.30^{a}	30.00^{b}	34.00^{ab}	0.88	NS	*	NS
Lymphocyte (%)	50-70	64.67^{ab}	61.00^{b}	61.33^{b}	68.67^{a}	64.67^{ab}	0.94	NS	*	NS
Eosinophil (%)	0-3	0.67	0.67	0.00	1.00	1.00	0.14	NS	NS	NS
Basophil (%)	0-2	1.00^{a}	0.00	0.00	0.00	0.00	0.10	**	**	**
Monocyte (%)	0-4	0.33	1.33	1.00	0.33	0.33	0.19	NS	NS	NS
MCH (Pg)	5.2-8.0	8.90^{b}	9.60^{a}	9.63^{a}	9.13^{ab}	9.40^{ab}	0.08	NS	*	NS
MCHC (g/l)	30-36	31.80^{c}	34.80^{a}	34.67^{a}	32.60^{bc}	34.13^{b}	0.32	NS	**	*
After the experiment										
Packed cell volume (%)	22-38	22.50	23.50	25.00	25.50	22.67	0.84	NS	NS	NS
Haemoglobin (g/dl)	8-12	7.45	7.80	8.50	8.45	7.66	0.22	NS	NS	NS
Red blood cell (x10^{12}/l)	8-18	7.73^{b}	8.53^{ab}	8.97^{ab}	9.10^{a}	7.50^{b}	0.31	*	NS	NS
White blood cell (x10^{9}/l)	4-13	6.17^{ab}	5.30^{b}	6.60^{ab}	5.48^{b}	7.50^{a}	0.29	*	NS	NS
Neutrophil (%)	30-38	29.00^{c}	39.67^{a}	32.67^{b}	29.67^{bc}	35.33^{ab}	1.13	NS	NS	*
Lymphocyte (%)	50-70	68.67^{ab}	59.33^{c}	65.33^{b}	70.67^{a}	63.67^{bc}	1.11	NS	*	*
Eosinophil (%)	0-3	0.33	0.67	0.33	1.00	0.00	0.12	NS	NS	NS
Basophil (%)	0-2	1.00	0.00	0.67	0.00	0.00	0.11	NS	NS	NS
Monocyte (%)	0-4	0.67	1.33^{a}	0.67	0.67	0.00	0.18	NS	*	NS
MCH (Pg)	5.2-8.0	9.50^{b}	9.13^{c}	9.50^{b}	9.27^{c}	10.40^{a}	0.14	NS	NS	**
MCHC (g/l)	30-36	33.00	33.40	34.40	33.20	34.30	0.30	NS	NS	NS

*p<0.01; **p<0.05; NS: Not significant. Within a file the values followed by different letters are different (p<0.05); [1]Normal values according to Fraser and Mays (1986); [2]Probability for linear (L); quadratic (Q) and cubic (C) trends; SEM = Standard error of mean; MCH= Mean corpuscular haemoglobin; MCHC = Mean corpuscular haemoglobin concentration.

Table V. Serum biochemical parameters of West African Dwarf goats fed on diets containing cassava peels and leaves (Parámetros bioquímicos del suero de cabras Enana de África Occidental alimentadas con dietas a base de peladuras de yuca con hojas de yuca y tallos de caupí).

Parameters	[1]Normal values	Treatments					SEM	[2]Probability		
		T1	T2	T3	T4	T5		L	Q	C
At the start of the experiment										
Total protein (g/dl)	51.0 -74.5	58.00^{ab}	67.30^{a}	53.30^{c}	58.30^{ab}	54.70^{b}	0.13	NS	NS	*
Albumin (g/dl)	23.5 - 35.7	32.00	32.70	27.00	31.00	32.70	0.09	NS	NS	NS
Globulin (g/dl)	27.0 - 44.3	26.00^{b}	34.60^{a}	26.30^{b}	27.30^{ab}	22.00^{c}	1.52	NS	NS	**
Creatinine (mg/dl)	0.7 - 1.5	0.25^{c}	0.93^{b}	1.37^{a}	0.87^{b}	0.40^{c}	0.12	*	**	**
Glucose (mg/dl)	48.2 - 76.0	60.00^{a}	54.67^{b}	42.67^{c}	51.33^{b}	52.67^{b}	0.10	*	**	**
Urea (mg/dl)	12.6 - 25.8	18.43^{a}	17.33^{ab}	13.30^{c}	15.37^{bc}	16.47^{b}	0.51	*	*	**
ALT (Iu/L)	66.0 -230.0	65.67^{a}	46.33^{bc}	43.67^{c}	62.33^{a}	50.00^{b}	2.57	NS	*	NS
AST (Iu/L)	15.3 - 52.3	19.00	23.00^{a}	21.00	19.67	24.50^{a}	1.08	NS	NS	*
At the end of the experiment										
Total protein (g/dl)	51.0 - 74.5	56.00^{b}	56.00^{b}	56.70^{b}	60.70^{a}	29.70^{c}	1.54	NS	*	NS
Albumin (g/dl)	23.5 - 35.7	29.00	30.00	28.00	30.30	29.30	0.11	NS	NS	NS
Globulin (g/dl)	27.0 - 44.3	27.00	26.00	28.70^{b}	30.40^{a}	26.70	0.70	*	NS	NS
Creatinine (mg/dl)	0.7 - 1.5	0.50^{c}	1.50^{a}	0.75^{c}	1.33^{a}	1.07^{b}	0.10	NS	*	NS
Glucose (mg/dl)	48.2 - 76.0	54.00^{a}	45.00^{c}	58.00^{a}	54.00^{a}	50.33^{b}	0.07	NS	NS	*
Urea (mg/dl)	12.6 - 25.8	15.30^{b}	17.10^{a}	12.50^{c}	17.33^{a}	12.67^{c}	0.50	NS	NS	**
ALT (Iu/L)	66.0 - 230.0	55.00^{a}	56.33^{a}	53.67^{b}	50.33^{c}	53.00^{b}	1.49	NS	*	NS
AST (Iu/L)	15.3 - 52.3	23.33^{a}	16.50	19.67	18.33	23.00^{a}	1.01	NS	NS	*

*p<0.01; **p<0.05; NS: Not significant. Within a file the values followed by different letters are different (p<0.05); [1]Normal values according to Fraser and Mays (1986); [2]Probability for linear (L), quadratic (Q) and cubic (C) trends; SEM= Standard error of mean, ALT= Alanine aminotransferase, AST= Aspartate aminotransferase.Treatments consisted of milled cassava peels, cassava leaves and cowpea haulms in different proportions of 700:100:175 (T1); 500:200:275 (T2); 300:300:375 (T3) and 100:400:475 (T4) g/kg DM respectively. Standard diet formulated to meet the nutrient requirements with no cassava peels, cassava leaves and cowpea haulms was used as the control diet (T5).

periment, total protein, albumin, and globulin ranged from 56.00 to 60.70 (g/dl), 28.00 to 30.30 (g/dl) and 26.00 to 30.40 (g/dl) respectively and all were significantly different.

DISCUSSION

Chemical analysis of dietary combinations in this study showed that increase in the quantity of cassava peel inclusion resulted in reduction in crude protein, while NDF values increased. In a study conducted by Asaolu *et al.* (2012), it was observed that residues of cassava peels and corn starch had lower crude protein and ash contents, and more especially, cassava peels contained more crude fibre. Values obtained for rumen fluid PH at 0 and 8 h post feeding were lower than those reported by Chanjula *et al.* (2007); Chanjula and Ngampongsai (2008). The PH values were however, within the normal level of 6.0-7.0 required for microbial digestion of fibre and protein (Hoover, 1986). A review by Ørskov (1986) indicated that ruminant animals with rumen fluid pH above 5.8 are considered normal while those between 5.0 and 5.8 may be suffering from subclinical acidosis. The relatively normal rumen fluid values obtained in this study suggests that the goats were likely not suffering from subclinical acidosis. According to Chanjula *et al.* (2007), the ruminal pH is partly regulated by the ammonia concentration in the rumen fluid and therefore, its variation may be explained by the urea entering the rumen and being hydrolyzed by microbial ureases to CO_2 and ammonia (Van Soest, 1994).

The values of NH_3-N obtained in this study are in line with the optimum concentration of 8.5 to 30.0 mg/dl in ruminal fluid for proper microbial growth (McDonald *et al.,* 1996; Wanapat and Pimpa, 1999). Feeding tannin sometimes results in a decrease in ammonia concentration, exhibiting the efficient use of volatile fatty acid (VFA) for microbial protein synthesis. Multiple phenolic hydroxyl groups of tannins can react with proteins, forming tannin–protein complexes and thus preventing the degradation by proteases and binding proteins at ruminal pH. Tannins commonly result in a shift in N excretion from urine to faeces during fermentation in the host (Bhatta *et al.,* 2001). The concentration of NH_3-N in ruminal fluid have been reported to decrease when (a) the non-structural carbohydrate content of the diet was increased (MacGregor *et al.,* 1983); (b) urea containing diets fed to non-lactating dairy cows were supplemented with molasses and starch (Fadel *et al.,* 1987) and (c) the amount of starch digested in the rumen was increased (McCarthy *et al.,* 1989).

The molar proportions of volatile fatty acids concentration of the experimental diets exhibited reduction in values as the post feeding hour increased which might be due to conversion of VFAs to energy by the animals. The concentration of VFA is regulated by

its level of production, absorption across the rumen wall and utilization by rumen microorganisms (Van Soest, 1994) and it also depends on the availability of fermentable organic matter in the feed (Oosting, 1993). Getachew *et al.* (2004) reported lower VFA production by adding CT in batch culture of mixed rumen microorganisms. The variability in VFA molar proportion might be due to variations in concentration of cyanide and tannins present in the experimental diets. The population density of total viable microbial count observed in the diets might be due to availability of nutrient in the rumen which triggers microbial proliferation. Protozoa population increased across all diets. This finding was contrary to Makkar *et al.* (1995) who reported lower protozoa numbers by feeding of *L. leucocephala* and leucaena hybrid KX2 with tannins levels of 7.3 and 11.6%. According to McSweeney *et al.* (2001), rumen protozoa, fungi and some of the bacteria are more resistant to condensed tannin as compared to other microbial populations.

The reduced PCV obtained at the end of the experiment in treatment 1 and 2 may be attributed to the higher concentration of cassava peels and HCN in the diets. The values obtained for the diets were however, within the normal range of 22–38% reported by Oni *et al.* (2010) and Merck (2011). They are however; lower than values reported by Ikhimioya and Imasuen (2007). The Hb concentration falls within the normal values of 7–15g/dl indicated by Merck (2011) and 8-15g/dl by Oni *et al.* (2010). The Hb values indicated absence of microcytic hypochromic anaemia occasioned by iron deficiency and improper utilization for the formation of haemoglobin (Sirois, 1995). The reduced RBC values obtained in the control diet underscore the nutritional quality of cassava peels, leaves and cowpea haulms in the diets of WAD goats. The WBC counts were contrary to the range of 6.8 to 20.1 ($x10^9$/l) reported by Daramola *et al.* (2005). Values obtained in this study fell within the broad range of 47–82% and 51.6% reported by Daramola *et al*. (2005) and Tambuwal *et al.* (2002) for lymphocytes and 17–52% and 36.4% for neutrophils reported by the same authors, respectively. These values are suggestive of a well-developed immune system in the WAD goats with such number of immune cells to proffer good health (Daramola *et al.*, 2005). The result also implies that an increase in neutrophils is associated with a decrease in lymphocytes and vice versa (Lazzaro, 2001).

Serum protein obtained in this study compared favourably with values reported by Daramola *et al.* (2005) and Tambuwal *et al.* (2002). The diets in this study did not significantly affect the albumin levels in the serum of the goats, thus indicating the safety of the diets for goats. The higher values for total protein, albumin and globulin in this study compared favourably with reports of Esugbohungbe and Oduyemi (2002) that cassava peels and leaves could contain low levels of tannins known to diminish nutrient permeability in gut walls as well as increase excretion of endogenous protein which is subsequently passed out in the faeces and so may not alter protein metabolism. Serum urea levels obtained in this study were within values reported for apparently healthy Marwari goats (Tanwar *et al.*, 2000). In this study, the relatively close but low mean levels observed in the transaminases could be an indication that the diets did not differ in their effects on enzyme secretion mechanism.

CONCLUSION

The study revealed that supplementing cassava peels with cassava leaves and cowpea haulms as protein sources has no negative effects on rumen fermentation and blood biochemical parameters of West African dwarf goats. Of particular importance is the increased population of rumen protozoan and its positive effects on the rumen environment parameters.

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