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EFFECT OF PELLETED BROWSE-BASED FEED WITH A BASAL DIET OF *Andropogon gayanus* FOR SHEEP ON INTAKE, NUTRIENT DIGESTIBILITY AND SOME HAEMATOLOGICAL AND BLOOD BIOCHEMICAL PARAMETERS

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ABSTRACT: The study was designed to evaluate the nutritional quality of pelleted diets based on four of the major feed resources fed to small ruminants by farmers in the Accra Plains. Leaves of *Samanea saman, Acacia auriculiformis* and *Ficus exasperata* and cassava peels were dried, mixed with other ingredients and pelleted. A preference trial showed sheep accepted all the four supplements with a marked preference for cassava peels-based (CP-B) and *Samanea saman*-based (SL-B) supplements compared with *Acacia auriculiformis*-based (AL-B) and *Ficus exasperata*-based (FL-B) supplements (P<0.05). The supplements were subsequently fed to Eight West African Dwarf sheep on a basal diet of *Andropogon gayanus* (Gamba grass) hay in Latin square design. Dry matter intakes (DMI) did not differ by the type of supplement (P>0.05). However, crude protein intake (CPI) was higher (P<0.05) in sheep fed AL-B and FL-B than those fed SL-B and CP-B. Dry matter and neutral detergent fibre (NDF) digestibility were lowest (P<0.05) for sheep fed CP-B. Dietary treatments did not affect haematological parameters, except for neutrophil percentage which was higher (P<0.05) in sheep fed CP-B than those fed SL-B. Animals fed CP-B had the lowest monocyte concentrations (P<0.05). Furthermore, all the serum biochemical parameters were not affected by dietary treatment except total protein concentration which was highest (P<0.05) in sheep fed on AL-B. It is concluded that the feed resources available to the small ruminant keepers can be used to prepare pelleted supplements that are acceptable to sheep and help sustain appreciable performance on low quality forages during the dry season without any deleterious effects on intake, digestibility, physiology and health.

Keywords: Acceptability, Browse plants, Dry season, Accra Plains, Blood parameters, Feed intake

Abbreviations: AL-B: *Acacia auriculiformis*-based supplement; ADF: Acid detergent fibre; ADFD: Acid detergent fibre digestibility; ADFI: Acid detergent fibre intake; ANOVA: Analysis of variance; AOAC: Association of Official Analytical chemists; CP: crude protein; CPD: crude protein digestibility: CPI: crude protein intake; CP-B: cassava peel-based supplement; DM: dry matter; DMD: dry matter digestibility; DMI: dry matter intake; FCE: feed conversion efficiency; FL-B: *Ficus exasperata*-based supplement; LIPREC: Livestock and Poultry Research Centre; MCV: mean corpuscular volume; MCH: mean corpuscular hydrogen; MCHC: mean corpuscular hydrogen concentration; NDF: Neutral detergent fibre; NDFD: neutral detergent fibre digestibility; NDFI: neutral detergent fibre intake OM: organic matter: OMD: organic matter digestibility; OMI: organic matter intake; PCV: packed cell volume; RBC: red blood cell; SEM: standard error of mean; SL-B: *Samanea saman*-based supplement; T. Cholesterol: total cholesterol; WAD: West African Dwarf; WBC: white blood cell

INTRODUCTION

In the savannah areas of West Africa, where most livestock in the sub region are kept, the dry seasons are much longer than in the humid areas and are characterised by declines in forage availability and quality. For both cultivated pastures (Olanite et al., 2004) and natural pastures (Adjorlolo, 2014) forage biomass have been shown to decline drastically in the dry season. Other studies have indicated significant decreases in forage quality during the dry season. Even for forage legumes, decreases in crude protein content to as low as 5-7% (Peters et al., 1997) and increases in neutral detergent fibre (Fujihara et al., 2004) during the dry season have been reported. Supplementation, either to increase the dry matter intake or to increase crude protein intake is often necessary for maintenance and possibly production. The use of fodder tree and shrub leaves as supplement is widely practiced by farmers in Ghana. However, during the late dry season, many trees shed their leaves and availability of tree leaves decline. Many small ruminant keepers resort to buying agro-industrial by-products such as wheat bran, rice bran and cassava peels from processing facilities for supplementary feeding.

An earlier study (Nsoh, 2019) identified feed resources commonly used by small ruminant keepers in the Accra Plains. This study sought to use four of the most important feed resources identified to develop pelleted multi-nutrient feed supplements with long shelf life, which can be stored and fed anytime during the year. It therefore assessed the effects of supplementary feed packages based on three browses and cassava peels on intake, metabolism and physiology of the West African Dwarf sheep.

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MATERIALS AND METHODS

Study area

The study was conducted at the Livestock and Poultry Research Centre (LIPREC) of the University of Ghana (05^{0}68' N, 00^{0}10' W) in the Coastal Savannah belt of Ghana, West Africa. Annual rainfall averages 881 mm per annum but with a high degree of variability. The rainy season was from April to June, the minor season was from September to October, and the dry season from November to March (Adjorlolo, 2014).

Experimental animals and their management

All animals used in the study were growing West African Dwarf sheep. The animals were housed in individual pens with concrete floors. The housing unit had roofs made of corrugated iron sheets. The pens were 3m × 1.5m in dimension. Each pen had one wooden feeding trough for the basal diet and two plastic troughs, one for the supplement and the other for water. All the animals were treated against external parasites with pour-on acaricide and dewormed with Albendazole (10%), a broad-spectrum anthelminthic. All the procedures in this study were approved by the Noguchi Memorial Institute for Medical Research Institutional Animal Care and Use Committee (NIACUC), University of Ghana (NIACUC Protocol No: 2017-03-2R).

Preparation of experimental diets

Three browse plants, *Ficus exasperata, Samanea saman* and *Acacia auriculiformis*, and cassava peels were identified in an earlier study (Nsoh, 2019) as the most important feed resources used in small ruminant feeding in the Accra Plains. These were selected for evaluation. Leaves of the browses were harvested from trees around LIPREC. The leaves as well as cassava peels, which was bought from cassava processors were shade dried for four to six days and ground in a hammer mill (1 mm screen) into meals. The meals were each mixed with conventional feed ingredients and micro-nutrients and pelleted (Table 1).

Table 1 - Ingredient composition of supplements used in the acceptability study

Ingredients: (g/kg) \ Supplements	SL-B	AL-B	FL-B	CP-B
Maize	159	124	165	0
Wheat bran	120	135	108	650
Mineral salt	5	5	5	5
Dicalcium phosphate	5	5	5	5
Sulphate of ammonia	5	5	5	5
Urea	6	26	12	15
Cassava peels	0	0	0	320
Samanea saman	700	0	0	0
Acacia auriculiformis	0	700	0	0
Ficus exasperata	0	0	700	0
Total (Kg)	1000	1000	1000	1000
Crude protein (calculated)	160.6	160.1	160.7	160.7

CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B: *Acacia auriculiformis*-based; FL-B: *Ficus exasperata*-based supplements

The pelleted supplements were formulated to be isonitrogenous using literature values of nitrogen concentrations in the browses and cassava peels. The dietary treatments were as follows:

Treatment 1 (SL-B) = Gamba grass hay + *Samanea saman* leaf meal-based supplement
Treatment 2 (AL-B) = Gamba grass hay + *Acacia auriculiformis* leaf meal-based supplement
Treatment 3 (FL-B) = Gamba grass hay + *Ficus exasperata* leaf meal-based supplement
Treatment 4 (CP-B) = Gamba grass hay + Cassava peel meal-based supplement

Preference study

Four female sheep with an average live weight of 13.7±1.5 kg were used for this trial. Each animal was penned individually and given free access to fresh water. Each sheep was offered the four supplements in a cafeteria style at 08:00 hours each day and were allowed one hour to select. After the one hour, the refusal was deducted from the feed offered to determine the amount of each supplement consumed. The *Andropogon gayanus* hay which acted as the basal diet, was then offered *ad libitum*. An adjustment period of 14 days was followed by a data collection period of seven days.

Voluntary feed intake and digestibility study

Eight female sheep with an average initial body weight of 14.9±1.5 kg were randomly allotted to four experimental diets in a replicated Latin square design. Animals on each treatment were offered *Andropogon gayanus* hay as the basal feed and supplemented with either SL-B, AL-B, FL-B or CP-B. A daily supplement allowance of approximately 25% of voluntary intake was offered as single meals at 08:00 hours followed by the grass hay offered *ad libitum*. An adjustment

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period of 14 days was followed by 74 days of data collection. Feed intake was determined daily as the difference between weight of feed offered and refusals. Rectal faecal samples were taken from each animal and bulked for each sheep for six days during the feed intake trial. The faecal samples were stored in a refrigerator. The faecal samples were then oven dried at 55℃ to a constant weight for dry matter (DM) determination. The dried faeces were ground using a laboratory mill through 1mm sieve and bagged for subsequent analysis.

Apparent digestibility (AD) of dry matter and other fractions of the feed were calculated as:

AD (%) = 100 – $\left(100 * \left(\frac{Lignin\ in\ feed}{Faecal\ lignin}\right) \times \left(\frac{Faecal\ lignin}{Total\ dry\ matter\ intake}\right)\right)$ (de Oliveira et al., 2012)

Lignin was used as internal marker.

Chemical analysis of feed and faeces

Dry matter, organic matter, crude protein, and ash for the feed and faeces were determined using the method of AOAC (2004). Neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, cellulose, hemicellulose and silica were determined according to Van Soest et al. (1991).

Blood sampling

Blood samples were collected every two weeks (week 1, 3, 5, 7 and 9) from the jugular vein of each sheep using a vacutainer needle. Sampling was done in the morning, between 07:30 and 08:00 hours. A total of 10ml of blood sample was collected and 4ml transferred into a glass vacutainer tube containing the anticoagulant tripotassiumethelyne diamine tetra acetic acid (K3.EDTA). The tubes were placed on ice and transported immediately to the Laboratory for haematological analysis. The remaining 6 ml was transferred into glass vacutainer tubes containing clot (Gel) activator. This was placed on ice pack and also transported to the Laboratory where it was centrifuged at 3000 rpm for 10 minutes at 4 ^{0}C. The sera obtained were gently harvested into Eppendorf tubes and stored at -20^{0}C until the analyzed for biochemical parameters.

Haematological analysis

The haemoglobin concentration was determined by the cyanmethaemoglobin method (Gillet et al., 2009), while PCV was estimated by the microhaematocrit method (Samour, 2006). The RBC and WBC counts were determined using the haemocytometer.

Total RBC count was determined using the formula given by Samour (2006): RBC (10^{12}/L)= $\frac{N}{100}$, Where: L= Litre; N= Number of cells counted in 160 small squares.

The total WBC counts was estimated using the formula given by Campbell (1994): WBC (10^9/L) $= \frac{N \times 10 \times 200}{9}$, Where: L= litre; N= number of cells counted in nine small squares

The RBC indices were computed using the formulas provided by Reece and Swenson (2004) below:

MCV (fL)= $\left(\frac{PVC}{RBC}\right)$ x 10; MCH (pg)= $\left(\frac{Hb}{RBC}\right)$ x 10; MCHC (%)= $\left(\frac{Hb}{PCV}\right)$ x 100

In determining the differential WBC counts, thin smears of blood were made from blood samples obtained from venipuncture, on well ethanol-cleaned, grease-free microscope slides. They were air-dried, fixed in absolute methanol and stained with Giemsa stain. Stained slides were studied under oil immersion objective at 1000X magnification. Percentages of neutrophils, lymphocytes, monocytes, eosinophils and basophils were all determined based on observation of 200 WBC per film.

Blood biochemical analysis

The concentrations of glucose, total proteins, albumin, total cholesterol and urea were determined in the serum at weeks 1,3,5,7, and 9 using the Mindray BA -88A Semi-Auto Chemistry Analyzer. Globulin concentration was computed as the difference between total protein and albumin concentrations.

Statistical analyses

Data from the acceptability, feed intake and digestibility studies were subjected to Analysis of variance procedure (ANOVA) of GenStat Release 12th Edition (VSN International, 2009), whilst that of the blood parameters was analyzed using repeated measures analysis of variance procedure of GenStat (VSN International, 2009). The Least significant difference procedure of GenStat was used to separate the means at 5% level of significance.

RESULTS

Chemical composition of feed ingredients and supplements

The chemical composition of the basal diet (Gamba grass hay), the three browses *(Samanea saman, Acacia auriculiformis* and *Ficus exasperata*) and cassava peels are presented in Table 2. The basal diet, the leaf meals of the three browses and cassava peels had comparable dry matter contents (range 89.9 to 94.6%) and organic matter (range 80.8 to 87.2%) contents. The chemical composition of the supplements are shown in Table 3. The dry matter, organic

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matter, NDF and lignin contents were similar. FL-B had the highest crude protein content (21.5%) while CP-B had the least (16.3%) crude protein but highest ADF.

Preference of sheep for the pelleted supplements

The sheep accepted all the supplements but preferred (P<0.05) SL-B and CP-B to the rest. The supplement least preferred (P<0.05) was FL-B. The preference of sheep for the three browses and cassava peel meal supplements is shown in Table 4.

Influence of supplements on voluntary intakes in West African Dwarf sheep

The influence of the supplements on voluntary intake in sheep is shown in Table 5. The total dry matter intake was similar (P>0.05) across the treatments. Crude protein intake ranged from 59.63 to 67.01%. Sheep fed AL-B and FL-B had similar crude protein intakes but significantly higher (P<0.05) crude protein intake than those fed SL-B and CP-B. Organic matter intake was least (P<0.05) in FL-B Sheep. However, intake of NDF was significantly higher (P<0.05) in sheep fed FL-B than those fed the other treatments. The ADF intake on the other hand was in the range of 25.44 to 54.65g/day and was found to be significantly higher (P<0.05) in sheep fed SL-B and CP-B than those fed AL-B and FL-B. Sheep CP-B had lower (P<0.05) lignin intake than those fed SL-B, AL-B and FL-B.

Digestibility of nutrients by West African Dwarf sheep

Dry matter digestibility was lowest (P<0.05) in sheep fed CP-B (Table 6). SL-B had the highest dry matter digestibility value of 62.35% and this was significantly (P<0.05) higher than the digestibility of 60.33% for AL-B. The crude protein digestibility followed a similar pattern as dry matter digestibility. The organic matter digestibility in this study ranged from 46.31 to 52.25%. Sheep fed SL-B had the highest (P<0.01) organic matter digestibility. Also, sheep fed FL-B had higher (P<0.05) organic matter digestibility than those fed AL-B and CP-B. The NDF digestibility in this study ranged from 34.9 for CP-B to 41.57% for FL-B. NDF digestibility was similar (P>0.05) for sheep fed SL-B and FL-B, but both were higher (P<0.05). The ADF digestibility in this study ranged from 22.30 to 33.47%. The ADF digestibility was similar (P>0.05) in sheep fed SL-B and CP-B, but both were higher (P<0.05) than for AL-B and FL-B.

Table 2 - Chemical composition of leaf meals of browses, cassava peel meal and *Andropogon gayanus* hay

Fraction (%)	Andropogon hay	Samanea	Acacia	Ficus	Cassava Peels
Dry matter	89.9	92.7	93.4	91.9	94.6
Crude protein	6.7	21.9	16.4	15.9	2.1
Organic matter	80.8	83.8	87.2	87.2	80.9
Neutral detergent fibre	73.8	59.8	60.7	42.9	36.3
Acid detergent fibre	44.9	39.7	49.5	36.4	27.4
Lignin	6.1	6.8	6.2	3.7	9.7
Total ash	12.6	8.9	6.2	3.7	7.3

Table 3 - Chemical composition of the experimental supplements

Fraction (%)	Supplement (%)			
	SL-B	AL-B	FL-B	CP-B
Dry matter	92.5	91.7	90.2	91.2
Crude protein	18.3	20.5	21.5	16.3
Organic matter	85.9	84.7	83.7	84.8
Neutral detergent fibre	41.6	44.5	43.4	41.3
Acid detergent fibre	30.2	29.6	14.6	30.6
Lignin	3.8	4.7	4.5	3.4

CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B: *Acacia auriculiformis*-based; FL-B: *Ficus exasperata*-based supplements

Table 4 - Preference of West African Dwarf sheep for the supplements

Supplements	Means of intake (g)
CP-B	223.3[a]
SL-B	195.8[a]
AL-B	111.3[b]
FL-B	57.6[c]
SEM	*24.16*
P-Value	*<0.001*

[a,b,c] Means within a column with different superscripts differ significantly at P<0.05.

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Table 5 - Influence of supplements on voluntary intakes in West African Dwarf sheep						
Parameter (g/day) \ Supplements	SL-B	AL-B	FL-B	CP-B	*SEM*	*P-value*
Dry matter intake	649.5	636.8	629.6	653.3	11.52	0.143
Crude protein intake	63.69[b]	67.01[a]	66.32[a]	59.63[c]	1.277	< 0.001
Organic matter intake	533.6[a]	520.9[a]	497.3[b]	534.4[a]	9.40	< 0.001
Neutral detergent fibre intake	74.36[b]	76.75[b]	85.98[a]	72.98[b]	2.042	< 0.001
Acid detergent fibre intake	54.65[a]	50.81[b]	25.44[c]	53.79[a]	1.158	< 0.001
Lignin intake	35.49[a]	36.56[a]	36.17[a]	34.14[b]	0.629	< 0.001

[a,b,c]Means within a row with different superscripts differ significantly at P<0.05.; CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B*: Acacia auriculiformis*-based*;* FL-B*: Ficus exasperata*-based supplements.

Table 6 - Digestibility of components of feed as influenced by supplementation (%)						
Fraction (%) \ Supplements	SL-B	AL-B	FL-B	CP-B	*SEM*	*P-value*
Dry matter	62.35[a]	60.33[b]	61.22[ab]	57.10[c]	0.655	<0.001
Crude protein	57.25[a]	56.30[b]	56.25[ab]	51.10[c]	0.553	<0.001
Organic matter	52.25[a]	47.22[c]	49.43[b]	46.31[c]	0.892	<0.001
Neutral detergent fibre	40.62[a]	36.29[b]	41.57[a]	34.90[b]	0.993	<0.001
Acid detergent fibre	32.87[a]	22.30[c]	25.64[b]	33.47[a]	1.034	<0.001

[a,b,c.] Means within a row with different superscripts differ significantly at P<0.05.; SEM = Standard error of mean. CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B*: Acacia auriculiformis*-based*;* FL-B*: Ficus exasperata*-based supplements

Haematological and serum biochemical parameters in West African Dwarf sheep

Details of the effects of the supplements on haematological and serum biochemical parameters of sheep are shown in Table 7. There was no significant treatment effect (P>0.05) on most of the haematological parameters measured except neutrophils and monocyte levels. Sheep that were fed the CP-B had significantly (P<0.05) higher neutrophil value than those fed on SL-B. Values for sheep on AL-B and FL-B, however, were not significantly different (P>0.05) from those on SL-B and CP-B. Sheep on SL-B and AL-B had significantly (P=0.05) higher monocyte concentrations than those on CP-B. Dietary treatment did not significantly (P>0.05) affect all the serum biochemical parameters determined except total protein concentration which was significantly (P<0.05) higher in sheep fed on AL-B than those fed on SL-B, FL-B and CP-B. Generally, the concentrations of most of the haematological and serum biochemical parameters remained relatively stable and showed similar trends across dietary treatments during the period of study (Figures 1 and 2).

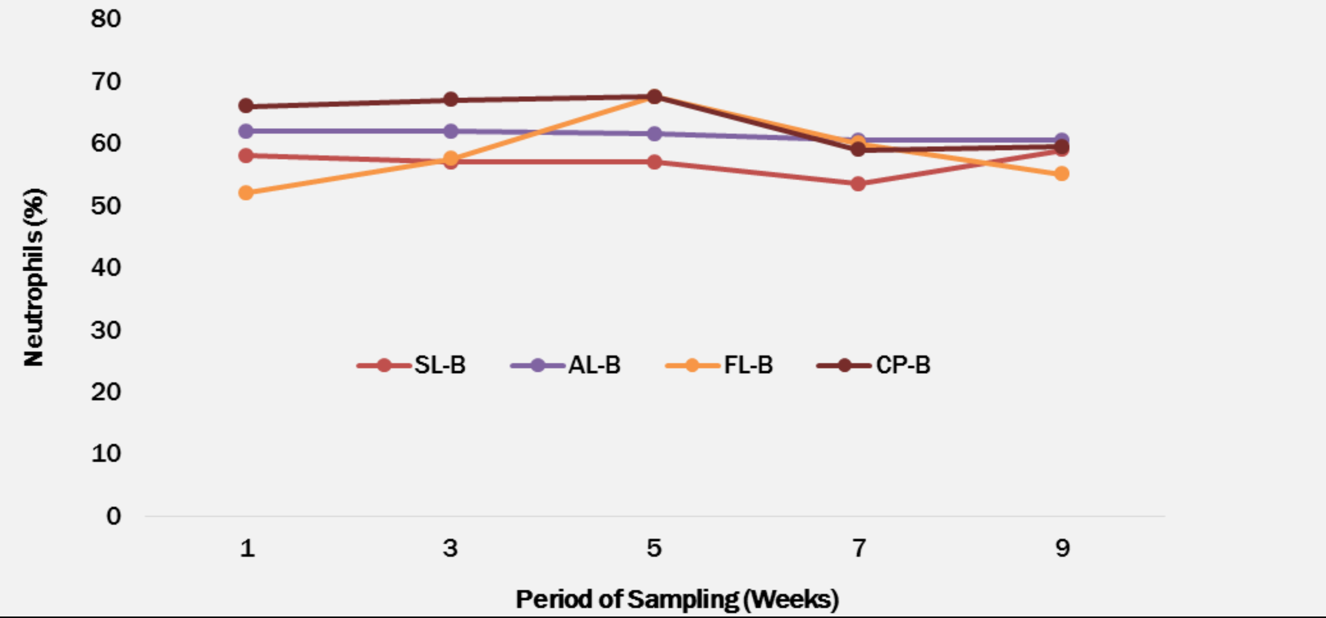

Figure 1 - Changes in neutrophil concentration in West African Dwarf Sheep. CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B*: Acacia auriculiformis*-based*;* FL-B*: Ficus exasperata*-based supplements

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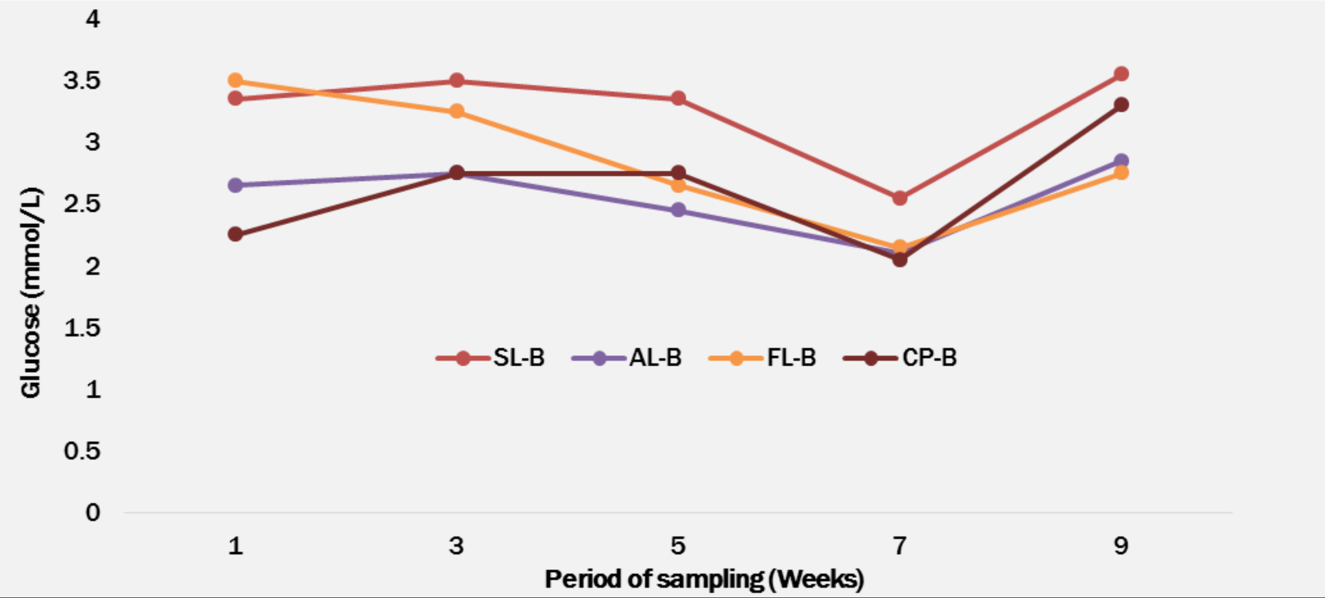

Figure 2 - changes in Glucose concentration in West African Dwarf Sheep. CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B: *Acacia auriculiformis*-based; FL-B: *Ficus exasperata*-based supplements

Table 7 - Haematological and serum biochemical parameters of West African Dwarf sheep fed basal diet of *Andropogon gayanus* hay and supplements

Parameters	Treatments				SEM	P-value
	SL-B	AL-B	FL-B	CP-B		
Haematological Indices						
Haemoglobin (g/dL)	13.27	15.27	15.33	15.46	1.01	0.162
PCV (%)	29.20	33.60	32.80	35.60	2.05	0.291
RBC (x10^{12}g/L)	10.63	11.94	11.80	11.24	0.66	0.160
MCV (fL)	27.80	27.87	28.73	29.45	0.14	0.577
MCH (pg)	12.40	12.87	13.26	13.92	0.07	0.157
MCHC (g/dL)	45.44	45.24	46.74	43.43	0.15	0.053
WBC(x10^{9}/L)	4.37	4.96	4.34	4.87	0.39	0.641
Neutrophils (%)	56.90^{b}	61.30^{ab}	58.40^{ab}	63.80^{a}	4.37	0.037
Lymphocyte (%)	39.20	34.60	39.30	34.70	4.10	0.487
Eosinophils (%)	1.60	1.50	0.80	0.80	0.80	0.625
Monocytes (%)	2.20^{a}	2.30^{a}	0.90^{ab}	0.50^{b}	0.73	0.50
Basophils (%)	0.09	0.11	0.22	0.18	0.10	0.596
Serum Biochemical Indices						
Glucose (mmol/L)	1.96	1.54	1.72	1.57	0.20	0.108
Total protein (g/L)	60.46^{b}	64.38^{a}	61.48^{b}	61.57^{b}	0.65	0.030
Albumen (g/L)	36.96	38.43	37.07	37.37	0.78	0.374
Globulin (g/L)	23.50	25.95	24.41	24.14	1.23	0.388
T. cholesterol (mmol/L)	1.40	1.50	1.48	1.79	2.87	0.497
Urea (mmol/L)	9.51	9.67	8.71	9.21	0.36	0.492

^{a,b} Means within a row with different superscripts differ significantly at P<0.05.; T.cholesterol = total cholesterol. CP-B: cassava peels-based; and SL-B: *Samanea saman*-based; AL-B: *Acacia auriculiformis*-based; FL-B: *Ficus exasperata*-based supplements

DISCUSSION

All the supplements were acceptable but SL-B and CP-B had the highest preference by sheep. A number of factors may influence acceptability of feed by small ruminants. Provenza and Cincotta (1994) reported that plant physical structure and chemical composition are the most vital factors that influence preference for feed. Oldham and Alderman (1982) reported that *ad libitum* intake by animals is increased by an increase in crude protein content of diets. However, in this study, no association between crude protein concentration and preference could be established.

The similarity in dry matter intakes may suggest that the supplements stimulated intake of the basal diets to similar extents despite the differences in the crude protein concentrations. The higher crude protein intake in sheep fed AL-B and FL-B compared to the SL-B and CP-B could be attributed to higher crude protein concentration of the supplements of AL-B and FL-B. High crude protein intake makes available nitrogen needed to improve the rumen eco-system and increase the animal's ability to digest fibrous portions of feed. Odedire and Oloidi (2014) reported a decrease in crude protein intake

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due to reduced palatability of the diet when West African Dwarf goats were fed supplements containing increasing levels of wild sunflower. In the current study however, dry matter intakes were similar. The lower organic matter intake in sheep fed FL-B could be attributed to the high levels of anti-nutritional factors, such as alkaloids, saponins, cyanogenic glycosides and tannins contained in that supplement that could potentially have adverse effects on nutrient utilization as reported by Ljeh and Ukwemi (2007). The higher NDF intake of sheep fed FL-B could be attributed to the higher crude protein level in FL-B (21.5%) which could have improved rumen environment aiding rumen microbial fermentation thereby increasing dry matter intake and consequently, NDF intake. The high intake of ADF in sheep fed SL-B and CP-B may be due to moderate quantities of antinutritional factors in SL-B (Obasi et al., 2010) and tolerable levels of cyanogenic glycosides in CP-B which might not have adversely influenced the rumen environment but rather aided in ADF digestion thereby increasing its intake. The lower lignin intake in sheep fed CP-B compared to those fed SL-B, AL-B and FL-B could be attributed to an imbalance or inadequacy of nutrients especially crude protein intake in sheep fed CP-B which might have resulted in reduced rumen ammonia production and microbial growth and activity. This could indirectly slow down the rates of digestion and passage and subsequently reduce intake as reported by Preston and Leng (1987).

The lower dry matter digestibility in sheep fed CP-B compared to the other treatments could be attributed to lower crude protein intake of this supplement. Also, anti-nutritional factors such as cyanogenic glycosides in the cassava peels might have slowed down microbial action and thereby decreased dry matter digestibility. Anti-nutritional factors are known to interfere with normal digestion, metabolism and absorption of nutrients (Gilani et al., 2005). The leaves of forages are high in readily degradable nitrogen as reported by NRC (2000) and some by-pass protein. Inclusion of such browses in ruminant diets cause faster fermentation rate and substrate degradation hence increasing dry matter intake. The higher crude protein intake of sheep fed SL-B, AL-B and FL-B over CP-B could have enhanced the digestibility of crude protein in these supplements than the CP-B. The presence of cyanogenic glycosides in the cassava peel meal supplement could have inhibited the effective digestion of protein by the rumen microbes. The leaves of forages are high in readily degradable nitrogen as reported by NRC (2000) and some by-pass protein. Inclusion of such browses in ruminant diets will cause faster fermentation rate and substrate degradation hence increasing dry matter intake.

The high digestibility of organic matter of sheep fed SL-B and FL-B could be due to the provision of adequate nutrients to the rumen microbes with consequent improvement in organic matter intake whilst higher levels of flavonoids and triterpenoids in AL-B and cyanogenic glycosides in CP-B adversely affected rumen microbial activity resulting in lower organic matter digestibility. Also, the lower crude protein digestibility in sheep fed CP-B may account for their lowest organic matter digestibility.

The high NDF digestibility in sheep fed SL-B and FL-B is likely due to moderate concentrations of secondary metabolites in the Samanea and Ficus leaf meals that might have had positive influence on rumen microbes as several researchers have reported secondary metabolites having positive impacts on rumen fermentation due to their low or moderate concentrations (Jiménez-Peralta et al., 2011; Salem et al., 2014). The low crude protein level in CP-B could have inhibited rumen activity thus decreasing digestibility of NDF of sheep fed that diet. However, ADF digestibility in sheep fed CP-B was higher probably as a result of low lignin contents in CP-B compared with the others.

Haematological and blood biochemical indices provide useful information on the physiological status of animals and hence serve as a tool in determining normal healthy state of animals (Onasanya et al., 2015). The similar concentrations of the haematological parameters in most of the test diets suggest that the inclusion of the supplements did not have adverse or detrimental effects on the health of the sheep. This suggests the quality of the supplementary diets were good to help sustain growth of sheep during periods when animals have to rely of poor quality fodder. The haemoglobin and PCV levels of 13.27 to 15.46 g/dL and 29.20 to 35.60% respectively obtained in the present study were within the normal physiological range of 9 to 15 g/dL and 27 to 45% respectively reported for sheep (The Merck Veterinary Manual, 2010). This suggests similar ability of the dietary treatments in augmenting the production of haemoglobin and RBCs for efficient transportation of gases during respiration. Konlan et al. (2012) and Dougba (2017) in earlier studies reported haemoglobin and PVC ranges of 12.41 to 13.60 g/dL and 27.45 to 29.43% respectively for the same breed of sheep fed diets containing various agro-industrial by-products. Total RBC counts range of values (10.63 to 11.94 x 10^{12} g/L) was within the normal physiological range of 9 to 15 x 10^{12} g/L reported for sheep (The Merck Veterinary Manual, 2010) indicating the efficient synthesis of RBCs across the dietary treatments. The MCV, MCH and MCHC values obtained in the present study were also comparable to the normal physiological range for sheep. The total WBC counts (4.34 x 10^9 to 4.96 x 10^9 g/L obtained in the present study were within the normal range of 4 x 10^9 to 12 x 109/L reported for sheep (The Merck Veterinary Manual, 2010). This suggests the test diets supplied enough nutrients for the production of WBCs to adequately defend the body against infections. Konlan et al. (2012) reported a range of 8.37 x 10^9 to 9.30 x 10^9 for the West African Dwarf sheep fed a basal diet of rice straw and groundnut haulms with graded levels of shea-nut cake supplement. Also, the WBC differential counts across dietary treatments were within the normal ranges reported for sheep (The Merck Veterinary Manual, 2010). This suggests similar ability of the sheep to fight infection when fed the supplements. The distribution of WBC observed in the present study were comparable with the range of values reported for the same breed of sheep by Baiden and Obese (2010) and Konlan et al. (2012).

The nonsignificant difference in the concentrations of most of the blood biochemical parameters across the dietary treatments suggest that the inclusion of leaf meal supplements based on Samanea, Acacia, Ficus, and Cassava peel meal-based supplements did not have adverse effects on the physiology of the West African Dwarf sheep. The similar concentration of serum glucose across dietary treatments suggest the inclusion of the browse species leaf meal and

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cassava peel-based supplements did not adversely deprived the sheep of energy for metabolic activities. The range of values (1.54 to 1.96 mmol/L) obtained in the present study was however, lower than the 2.85 to 3.10 mmol/L reported for West Africa Dwarf sheep fed basal diet of rice straw and supplemented with varying levels of neem leaf meal concentrate diets (Dougba, 2017). Serum concentrations of total protein, albumin and globulin serve as indicators of protein status (Ndlovu et al., 2007). Also, circulating concentrations of globulin usually give indication of an animal's immune state and its response to fighting diseases and infections (Kapele et al., 2008). The higher crude protein intake for sheep fed AL-B than those fed the other three supplements may account for its high total protein value. The values obtained for total protein concentrations, 60.46 to 64.38 g/L were within the normal physiological range of 59 to 78 g/L reported for sheep (The Merck Veterinary Manual, 2010). The total protein concentrations were comparable to the 56.00 to 61.34 g/L reported for the same breed of sheep fed basal diet of rice straw and groundnut haulms with graded levels of shea nut cake concentrate supplement (Konlan et al., 2012), but lower than the 72.3 to 83.3 g/L reported for the same breed of sheep (Dougba, 2017). The age, type of diet fed and physiological state of the sheep used may account for the differences. The concentrations of serum albumin (36.96 to 38.43 g/L) were similar to the reported normal physiological values of 27 to 37 g/L reported for sheep (The Merck Veterinary Manual, 2010). However, globulin concentrations (23.50 to 25.95 g/L) in the present study were lower than the reported normal physiological values of 39 to 60 g/L in sheep (The Merck Veterinary Manual, 2010). The low globulin concentrations in the sheep may indicate low ability of the sheep to resist infections or diseases. All the sheep used in the study were however healthy and did not show any signs of disease throughout the study. The normal and similar total protein and albumin concentrations in sheep fed the various supplements indicates that the inclusion of leaf meal and cassava peel - based supplements did not adversely influence the availability of protein to the sheep, their immune status and ability to fight diseases. The range of values for total cholesterol (1.40 to 1.50 mmol/L) was within the reported normal physiological range of 1.1 to 2.3 mmol/L in sheep (the Merck Veterinary Manual, 2010). However, the concentrations of serum urea (range 8.71 to 9.67mmol/L) in the present study was close to the normal physiological upper range value of 9.3 mmol/L reported for sheep (The Merck Veterinary Manual, 2010), but lower than the values 13.26 to 16.32 mmol/L reported for West African Dwarf sheep fed basal diet of rice straw and supplemented with varying levels of neem leaf meal concentrate diets (Dougba, 2017). The difference may be attributed to the type of diet fed to sheep in these studies.

CONCLUSION

From the above studies, feed resources available to the small ruminant keepers can be used to prepare pelleted supplements that are acceptable to sheep and help improve performance on low quality forages. Feeding these supplements did not adversely affect the health and physiology of sheep as indicated by the blood parameters. These supplements, which have high bulk density and long shelf life, can help prevent the major losses in ruminant production during the dry season.

DECLARATIONS

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Authors' Contribution

LA conceived the study, participated in the design of the study, contributed to data analysis and the write up of the manuscript, MS participated in the data collection and contributed in data analysis and the write up of the manuscript, AM was in involved the design and data analysis of the study and contributed to the write up of the manuscript. FO participated in the design and coordination of the study, contributed to data analysis and the write up of the manuscript.

Conflict of interests

The authors have not declared any conflict of interests.

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