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INFLUENCE OF PELLETED BROWSE-BASED SUPPLEMENTS FED WITH A BASAL DIET OF *Andropogon gayanus* HAY ON INTAKE, DIGESTIBILITY, GROWTH AND HAEMATO-BIOCHEMICAL INDICES IN WEST AFRICAN DWARF GOAT

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ABSTRACT: This study evaluated the nutritional value of pelleted supplements based on four major feed resources fed to small ruminants by smallholder farmers in the Accra Plains. Leaves of *Samanea saman, Acacia auriculiformis* and *Ficus exasperata,* and cassava peels were dried, milled, mixed with other ingredients and pelleted to form *Samanea saman* (SS-S)*, Acacia auriculiformis* (AA-S)*, Ficus exasperata* (FE-S) and cassava peel (CP-S) based supplements. The supplements were fed to twenty West African Dwarf goats on a basal diet of *Andropogon gayanus* (Gamba grass) hay in a completely randomised design experiment. Voluntary intake of dry matter did not differ (P>0.05) by the type of supplement. However, crude protein intake was higher (P<0.05) in goats fed FE-S than those fed CP-S. Acid detergent fibre intake was higher (P<0.05) for SS-S, AA-S and FE-S than CP-S. Digestibility of dry matter, organic matter, crude protein, acid detergent fibre and neutral detergent fibre were lowest (P<0.05) for goats on CP-S. Average daily weight gain and Feed conversion ratio were not affected (P>0.05) by dietary treatments. Also, dietary treatment did not affect (P>0.05) the concentrations haematological and blood biochemical constituents determined except urea which was higher (P<0.05) in goats fed SS-S than the other treatments. In conclusion, the above results suggest that browse-based and cassava peel-based supplements could be fed to confined goats on roughage diets especially in the dry season without any deleterious effects on intake, growth and physiology of goats.

Keywords: Accra plains, Performance, Shrub Leaves, Smallholder Farmers, Supplementation

Abbreviations: AA-S: *Acacia auriculiformis*-based supplement; ADMD: Apparent digestibility of dry matter; ANOVA: Analysis of variance; AOAC: Association of Official Analytical chemists; CP-s: cassava peel-based supplement; FE-B*: Ficus exasperata*-based supplement; LIPREC: Livestock and Poultry Research Centre; MCV: mean corpuscular volume; MCH: mean corpuscular haemoglobin; MCHC: mean corpuscular haemoglobin concentration; PCV: packed cell volume; RBC: red blood cell; SEM: standard error of mean; SS-S: *Samanea saman*-based supplement; T. Cholesterol: total cholesterol; WBC: white blood cell

INTRODUCTION

Small ruminant production is a major livelihood diversification strategy among smallholder farmers in Ghana. Often, animals are grazed extensively on natural pasture with little or no feed supplementation coupled with minimal health care (Baiden and Obese, 2010). However, restrictions in animal movement, especially during the cropping seasons, are now compelling many small ruminant keepers to fully or partially confine their animals. Feeding of confined small ruminants is often inadequate and such animals perform less than their free-roaming counterparts (Baah et al., 2012). The challenges associated with confinement in the cropping season, coupled with the scarcity of quality feed during the dry season severely constrain small ruminant production in Ghana (Adjorlolo et al., 2016) affecting income generation. Slow growth rate, unstable weight gains, lowered resistance to diseases and reproductive problems of small ruminants have been reported in these instances (Annor et al., 2007, Konlan, 2010). The provision of appropriate supplementary feed which can supply substantial amounts of dietary energy, protein and minerals would be an important step in enhancing the productivity of ruminants in Ghana.

Recently, Adjorlolo et al. (2020) fed pelleted *Samanea saman, Acacia auriculiformis* and *Ficus exasperata leaf meal-based diets* and cassava peel meal- based diet as supplements to West African Dwarf sheep fed on a basal diet of *Andropogon gayanus* (Gamba grass) hay and concluded that they were acceptable to sheep and could help improve performance on low quality forages.

Currently, there is lack of information on the utilization of browse-based pelleted feed supplements on the growth and physiology of the West African Dwarf goat the most popular goat breed in Ghana. This study therefore evaluated the effects of pelleted *Samanea saman (SS-S), Acacia auriculiformis (AA-S), Ficus exasperata* (FE-S) and cassava peel-based

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(CP-S) supplements on feed intake, growth rate and blood profiles of West African goats fed basal diet of *Andropogon gayanus* (Gamba) grass hay.

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 et al., 2014). `

Experimental animals and their management

West African Dwarf goats 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, similar to the study by Adjorlolo et al. (2020). 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

Leaves of three browse plants, namely, *Samanea saman, Acacia auriculiformis* and *Ficus exasperata* were harvested from trees and shrubs within the study area and shade-dried. Cassava peels were bought from *gari* producers and sun-dried. The dried leaves and cassava peels were ground with a hammer mill (1-mm screen) into meals and each mixed with other ingredients (Table 1) and pelleted. *Andropogon gayanus* (Gamba grass) was harvested at the flowering and seeding stage, sun-dried and tied in bundles for storage.

Table 1 - Ingredient composition of supplements used in the study

Ingredients: (g/kg)	Supplements			
	SS-S	AA-S	FE-S	CP-S
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	32
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-S: cassava peels-based; SS-S: *Samanea saman-based*; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperate* 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:

SS-S = Gamba grass hay + *Samanea saman* leaf meal-based supplement
AA-S = Gamba grass hay + *Acacia auriculiformis* leaf meal-based supplement
FE-S = Gamba grass hay + *Ficus exasperata* leaf meal-based supplement
CP-S = Gamba grass hay + Cassava peel meal-based supplement

Voluntary feed intake and growth study

The voluntary feed intake and growth studies were carried out using twenty young West African Dwarf goats with an initial average live weight of 10.7 ± 2.3 kg. They were allocated randomly to four experimental diets with each treatment having five replicates (five goats per treatment) in a completely randomized design. Animals in each treatment group were offered Gamba grass hay as basal diet and either of the three browses or cassava peel- based supplements. Supplements were offered at about 08:00 hours each day. Supplement allowance was about one percent of each animal's body weight (about 25% of voluntary intake). After each goat had consumed all the supplement provided, the basal diet was offered *ad libitum*. Animals were allowed 14 days to adjust to the diet after which daily feed intake and fortnightly body weights were taken for eleven weeks (77 days). Feed intake was determined daily as the difference between weight of feed offered and refusals.

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Digestibility study

For the digestibility studies, faecal collection bags were used to collect faecal samples from goats on the feeding trial. Faecal samples were taken from two goats per treatment for six days during the final week of the feeding trial. The faecal samples were stored in a refrigerator after collection. They were bulked for each goat and oven-dried at 55℃ to a constant weight for dry matter (DM) determination. The dried faeces were ground through a 1.0mm sieve using a laboratory mill and bagged pending further analysis. Apparent digestibility of dry matter (ADMD%), was calculated as:

ADMD (%) = $(\frac{DM\ intake - Faecal\ DM}{DM\ intake}) \times 100)$

Similar calculations were followed to determine apparent digestibility of organic matter, crude protein, neutral detergent fibre, acid detergent fibre.

Chemical analysis of feed and faeces

Feed and faecal samples were analysed for dry matter, organic matter, crude protein and total ash according to the methods of AOAC (2004). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined according to the method of 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 10 ml of blood sample was collected and 4 ml transferred into a glass vacutainer tube containing the anticoagulant tripotassium ethylene 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^oC. The sera obtained were gently harvested into Eppendorf tubes and stored at -20^oC 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.

Total WBC counts was estimated using the formula given by Campbell (1995): 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) = $(\frac{Hb}{RBC})$ x 10

MCHC(g/dL) = $(\frac{Hb}{PCV})$ 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, urea, sodium and potassium were determined in the serum at weeks 1, 3, 5, 7 and 9 using the Mindray BA -88A Semi-Auto Chemistry Analyzer (Nanshan, China). Globulin concentration was computed as the difference between total protein and albumin concentrations.

Statistical analyses

Data from the feed intake, growth 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, Acacia and Ficus) 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 (88.3 to 91.4%) and organic matter (81.1 to 85.3%) contents. Apart from cassava peels

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all the leaf meals of the three browses had higher crude protein than Gamba grass hay. Also, all the leaf meals of the browses and cassava peel-meal had lower neutral detergent fibre and lignin contents than Gamba grass. The chemical composition of the experimental supplements are shown in Table 3. AA-S had the highest crude protein content (22.3%) while CP-S had the least (15.9%).

Influence of supplements on voluntary intakes in West African Dwarf goat

Intakes of crude protein and acid detergent fibre were influenced by the type of supplement offered (Table 4). Sheep fed FE-S had higher (P<0.05) crude protein intake than those fed CP-S. Acid detergent fibre intake was higher (P<0.05) for SS-S, AA-S and FE-S than CP-S. The dry matter, organic matter, neutral detergent fibre and lignin intakes were however similar across dietary treatments.

Digestibility of nutrients by West African Dwarf goat

Digestibility of dry matter, organic matter, crude protein and detergent fibre were all influenced by the type of supplement fed (Table 5). Dry matter digestibility was similar for SS-S, AA-S and FE-S but higher (P<0.05) than CP-B. Crude protein and neutral detergent fibre digestibilities also followed a similar tend to that of dry matter digestibility. Organic matter digestibility was higher (P<0.05) for sheep fed SS-S and FE-S than those fed CP-S. Also, the acid detergent fibre digestibility in goats fed SS-S or AA-S were higher (P<0.05) than those fed CP-B.

Daily weight gain and feed conversion ratio

Average daily weight gain and feed conversion ratios did not differ (P>0.05) with the type of supplement (Table 6). None of the supplements led to weight loss in the goats.

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

Fraction (%)	Grass hay	Samanea	Acacia	Ficus	Cassava Peels
Dry matter	91.4	90.9	90.7	89.8	88.3
Crude protein	6.2	22.6	14.5	14.4	5.2
Organic matter	81.1	84.6	83.2	85.3	82.9
Neutral detergent fibre	72.2	53.8	62.1	54.4	46.9
Acid detergent fibre	43.5	36.6	47.8	42.5	28.7
Lignin	7.1	5.5	7.1	5.8	3.8
Total ash	11.4	6.5	8.5	6.4	5.1

Table 3 - Chemical composition of the experimental supplements

Fraction (%)	Supplement			
	SS-S	AA-S	FE-S	CP-S
Dry matter	89.9	90.4	90.8	89.7
Crude protein	19.1	22.3	21.7	15.9
Organic matter	85.2	84.1	82.4	84.1
Neutral detergent fibre	46.5	49.1	46.3	42.9
Acid detergent fibre	28.5	33.8	19.4	31.8
Lignin	4.1	4.4	5.3	3.9

CP-S: cassava peels-based; SS-S: *Samanea saman-based*; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements

Table 4 - Influence of supplements on voluntary intakes in West African Dwarf goat

Parameter (g/day)	Treatments				*SEM*	*P-value*
	SS-S	AA-S	FE-S	CP-S		
Dry matter intake	321.2	306.3	388.7	361.9	24.5	0.084
Organic matter	297	282	353	334	22.5	0.109
Crude protein intake	47.3[ab]	50.3[ab]	54.2[a]	45.1[b]	2.84	0.011
Neutral detergent fibre intake	54.3	55.6	69.0	58.5	5.63	0.212
Acid detergent fibre intake	36.9[a]	40.0[a]	41.4[a]	25.5[b]	3.59	<0.001
Lignin intake	27.9	31.4	30.2	21.0	3.63	0.119

[a,b,] Means within a row with different superscripts differ significantly at P<0.05; SEM: standard error of mean; CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements

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Table 5 - Digestibility of components of feed as influenced by supplementation

Fraction (%)	Supplements				SEM	P-value
	SS-S	AA-S	FE-S	CP-S		
Dry matter	57.5[a]	56.8[a]	62.7[a]	47.7[b]	2.85	<0.012
Organic matter	52.4[a]	51.2[ab]	58.6[a]	43.1[b]	3.10	<0.018
Crude protein	46.4[a]	47.2[a]	46.5[a]	38.7[b]	1.36	<0.001
Neutral detergent fibre	38.4[a]	40.2[a]	36.2[a]	30.7[b]	1.34	<0.001
Acid detergent fibre	33.4[ab]	34.2[a]	29.5[bc]	26.8[c]	1.37	<0.004

[a,b,c,] Means within a row with different superscripts differ significantly at P<0.05.; SEM: standard error of mean; CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements

Table 6 – Effect of supplementation on growth parameters in West African Dwarf goats

Parameter	Supplements				SEM	P-value
	SS-S	AA-S	FE-S	CP-S		
Initial weight (kg)	10.9	9.75	12.00	10.75	1.33	0.436
Final weight (kg)	11.8	10.63	12.80	11.88	1.23	0.399
Average daily gain (g/d)	10.8	10.54	9.64	13.55	2.96	0.612
Feed intake (g)	321.2	306.3	388.7	361.9	32.7	0.084
Feed conversion ratio	33.6	35.1	50.7	27.9	12.7	0.330

[a] SEM: Standard error of mean; CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements

Haematological and serum biochemical parameters in West African Dwarf sheep

At the end of the study, dietary treatment did not affect all the haematological and serum biochemical indices measured except serum urea concentrations which was higher (P<0.05) in goats fed SS-S than those fed AA-S, FE-S and CP-S (Table 7). Generally, the concentrations of most of the haemato-biochemical indices remained relatively stable and showed similar trends across dietary treatments during the period of study (Figures 1 and 2).

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

Parameters	Treatments				SEM	P-value	Reference Range[1]
	SS-S	AA-S	FE-S	CP-S			
Haematological Indices							
Haemoglobin (g/dL)	10.3	10.1	10.0	10.1	0.122	0.265	8 – 12
PCV (%)	26.7	24.6	23.1	24.9	1.520	0.350	22 – 38
RBC (x10^{12}g/L)	13.6	12.2	11.6	12.5	0.865	0.351	8 – 18
MCV (fL)	20.0	20.4	20.6	20.1	0.701	0.910	16 – 25
MCH (pg)	7.85	8.47	9.23	8.30	0.584	0.344	5 – 8
MCHC (g/dL)	39.2	41.8	44.9	41.3	2.29	0.317	30 – 36
WBC (x10^9/L)	11.7	12.0	11.9	11.5	0.639	0.934	4 – 13
Neutrophils (%)	50.8	48.6	45.4	44.0	2.45	0.189	30 – 48
Lymphocyte (%)	46.9	50.1	51.6	53.0	2.64	0.360	50 - 70
Eosinophils (%)	0.6	0.90	1.84	1.40	0.372	0.091	1 – 8
Monocytes (%)	1.68	0.50	1.08	1.15	0.480	0.372	0 – 4
Basophils (%)	0.00	0.00	0.00	0.00	0.000	0.000	0 – 1
Serum Biochemical Indices							
Glucose (mmol/L)	1.20	1.30	1.50	1.49	0.130	0.261	2.78 - 4.16
Total protein (g/L)	60.3	55.7	55.6	59.4	0.260	0.145	60 – 70
Albumin (g/L)	29.8	29.3	28.7	28.1	0.090	0.519	27 – 39
Globulin (g/L)	30.6	26.4	26.9	31.3	0.220	0.291	27 – 41
Total cholesterol (mmol/L)	3.43	3.37	4.00	4.28	0.461	0.097	2.07 – 3.37
Urea (mmol/L)	9.39	5.74	6.51	6.17	0.810	0.016	3.6 – 7.1
Sodium (mmol/L)	162	154	159	156	4.62	0.568	139 – 149
Potassium(mmol/L)	5.97	6.18	6.17	6.09	0.290	0.937	4.5 – 6.7

[a,b] Means within a row with different superscripts differ significantly at P<0.05.; SEM: Standard error of mean; CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements. [1]Merck Manual (2012).

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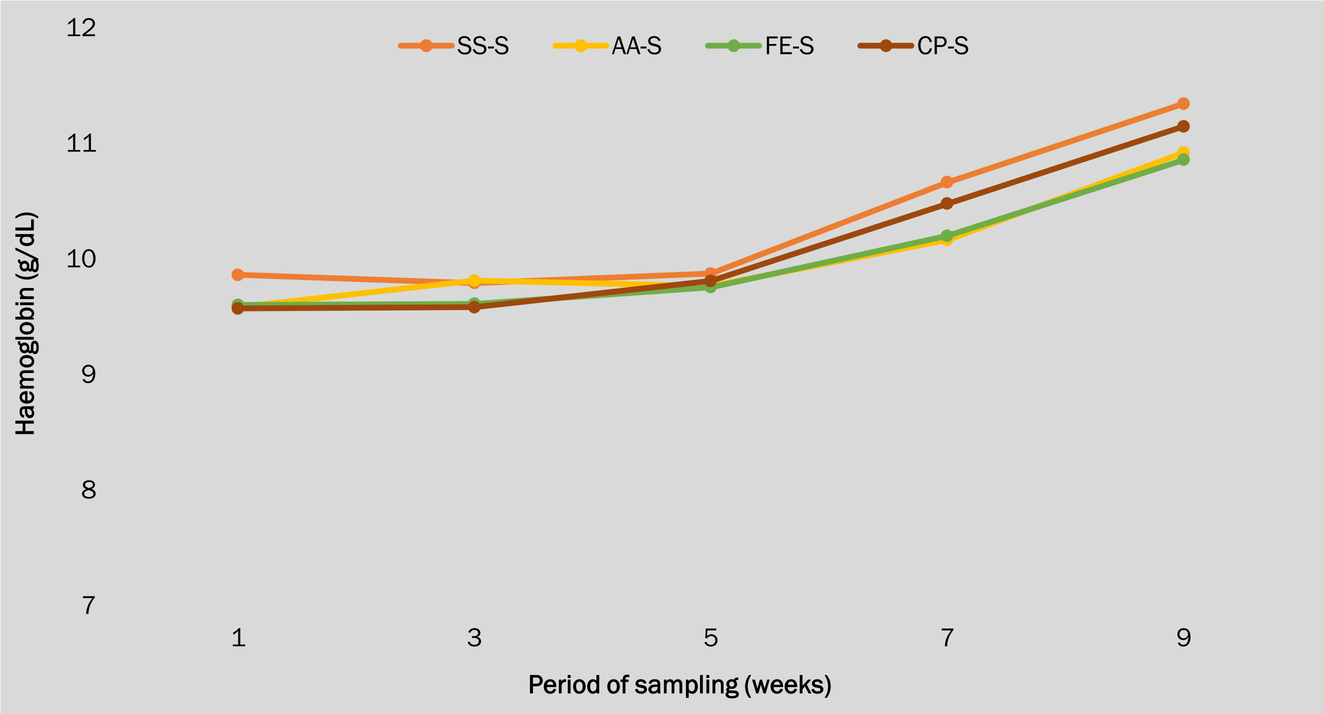

Figure 1 - Changes in haemoglobin concentration in West African Dwarf sheep. CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements.

Figure 2 - Changes in total protein concentration in West African Dwarf sheep. CP-S: cassava peels-based; SS-S: *Samanea saman* based; AA-S: *Acacia auriculiformis*-based and FE-S: *Ficus exasperata*-based supplements.

DISCUSSION

The crude protein content of Samanea, Acacia and Ficus were higher than the mean values reported in the literature (Abdu et al., 2012; Bello et al., 2014; Delgado et al., 2014) probably due to varietal or environmental differences. Sheep fed FE-S had higher (P<0.05) crude protein intake than those fed CP-S. This may be due to the higher crude protein content of FE-S resulting from the higher crude protein content of the Ficus leaf meal used (14.4%) compared with values as low as 6.9% reported by Bello et al. (2012). The crude protein intake range of 45.1 to 54.2 g/day in this study was

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lower than the 59.6 to 67.0 g/day reported in an earlier study when the same supplements were fed to sheep (Adjorlolo et al., 2020).

The lower dry matter digestibility in sheep fed CP-S compared to the other treatments could be attributed to lower crude protein intake of this supplement. This suggests that for goats on grass hay nitrogen is the more limiting nutrient for the rumen microbes, compared with starch which is high in the cassava peels. 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). Crude protein and neutral detergent fibre digestibility also followed a similar tend to that of dry matter digestibility. The higher crude protein intake of goats fed SS-S, AA-S and FE-S based diets over CP-B diets could have enhanced the digestibility of crude protein and neutral detergent fibre in these supplements than the CP-B. The leaves of trees and shrubs are high in readily degradable nitrogen 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 dry matter and crude protein digestibility obtained in the present study were comparable to the 54.7 to 68% and 44.0 to 59.0% respectively reported when Red Sokoto goats were fed elephant grass (*Pennisetum purpereum*) ensiled with varying proportions of cassava peels (Olorunnisomo, 2011).

The high organic matter digestibility for AA-S and FE-S diets than CP-S could be due to the provision of adequate nutrients to the rumen microbes with consequent improvement in organic matter intake whilst higher levels of cyanogenic glycosides in CP-S adversely affected rumen microbial activity resulting in lower organic matter digestibility. Also, the lower crude protein digestibility in goats fed CP-S may account for their lowest organic matter digestibility. The neutral detergent fibre digestibility was higher for SS-S, AA-S and FE-S than CP-B probably due to moderate concentrations of secondary metabolites in the Samanea, Acacia and Ficus leaf meals that might have had positive influence on rumen microbes in accordance with some reports that low or moderate concentrations of secondary metabolites positively impacts rumen fermentation (Salem et al., 2006; Jiménez-Peralta, 2011). The low crude protein level in CP-S could have inhibited rumen activity thus decreasing digestibility of neutral detergent fibre of goats fed that diet.

Similarity in weight gain for goats on CP-S to the other treatments, in spite of the differences in digestibility, may suggest similar metabolisable energy intake due to higher level of digestible starch in cassava peels. Daily weight gain in this study ranged from 9.64 to 13.6 g/day and feed conversion ratio ranged from 27.9 to 50.7 respectively. The average daily weight gains were comparable to the 10.4 to 18.7 g/day obtained when Philippine native goats were fed concentrates with different inclusion levels of *Samanea Saman* (Morais et al., 2018) but lower than in other studies when goats were fed grass- hay basal diets or grass and silage diets supplemented with browse tree leaves or leguminous tree foliage (Okoruwa, 2020; Okoruwa and Ikhimioya, 2020).

Blood indices serve as useful indicators of nutritional, physiologic, metabolic and health status of farm animals (Mirzadeh et al., 2010; Onasanya et al., 2015) and hence essential in evaluating the suitability of introduced feed resources. The non—significant but similar concentrations of haematological parameters measured in the present study suggest similar ability of the dietary treatments in enhancing the production of haemoglobin for efficient transportation of gases, normal synthesis of RBCs and production of enough WBCs to adequately defend the body against infections. The inclusion of the supplements did not adversely affect the health of the goats indicating that the quality of the supplementary diets was good to help sustain growth of goats during periods when animals rely on poor quality fodder. The levels of the haematological parameters measured were within the normal physiological ranges reported for goats (Merck Manual, 2012) and were also comparable to the values reported by Baiden et al. (2007), when West African Dwarf goats were fed varying levels of cassava pulp as a replacement for cassava peels.

The higher serum urea concentrations in goats fed SS-S than those fed AA-S, FE-S and CP-S might be due to the higher crude protein levels in the Samanea leaf meal than the Acacia and Ficus leaf meals and the cassava peel meal. Most concentrations of the serum biochemical indices determined were within the normal physiological range reported for goats (Merck Manual 2012) suggesting feeding the supplements did not have adverse effects on the physiology of the West African Dwarf goats. The concentration of the biochemical parameters measured compared favourably to the values obtained by Hassan et al. (2015) when they fed some forage shrubs made up of Acacia, Leucaena and Moringa to goats during the dry season.

CONCLUSION

Feeding the supplements influenced feed intake and growth performance to a similar extent and did not have any deleterious effect on the physiology and health of the goats. Therefore, all the four dietary supplements could be fed to confined goats on roughage diets especially in the dry season to overcome the adverse effects of seasonal fluctuation in feed quality on growth and health of goats.

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, EA 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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