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Hematology and Serum Biochemical Parameters of Kano Brown Bucks Fed Ensiled Cereal and Legume Fodders Supplemented with Concentrate Diets in Semi-Arid Region of Nigeria

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ABSTRACT

The experiment was conducted to determine the hematology and serum biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets. Eighteen (18) Kano Brown bucks with an average live weight of 10.59±0.07kg were allotted to six (6) dietary treatments with three (3) replications in a completely randomized design (CRD). Cereal and legume fodders were chopped and ensiled at different combinations as; maize stover + cowpea haulms + (60:40), maize stover + groundnut haulms (60:40), maize stover + cowpea haulms + groundnut haulms (60:20:20), sorghum stover + cowpea haulms + (60:40), sorghum stover + groundnut haulms (60:40), sorghum stover + cowpea haulms + groundnut haulms (60:20:20) designated as T_1, T_2, T_3, T_4, T_5 and T_6 respectively. The silages were offered at 4% body weight daily in the morning, after which the animals were supplemented with concentrate diets at 1.5% of body weight daily in the evening for 84 days. The parameters determined include the chemical composition of the ensiled forages and concentrate diets and blood metabolites. The results for chemical composition of the silages showed that forage combinations in treatments 6 and 3 had the highest crude protein content. Hematological and serum biochemical values obtained were significantly ($P<0.05$) higher in T_6 and T_3 and within the normal physiological ranges. In conclusion, Forage combination containing sorghum stover + cowpea haulms + groundnut haulms, 60:20:20 (T_6) had the best crude protein content. All the values for hematology and serum biochemical parameters were within the normal physiological ranges for healthy goats; therefore, all the forage combination has no deleterious effects on animal health and therefore, recommended.

Keywords: Kano Brown bucks, Hematology, Serum, Silage, Haulms, Stover.

1. INTRODUCTION

Background Information

Agriculture in West Africa is intensifying in response to the increasing population of humans and livestock. In Nigeria, livestock contributes 32.60% of agricultural gross domestic product (GDP) and constituted an important sector in northern part of the country (Statista, 2023). Livestock is an important component in the agricultural production system and plays a crucial role in the Nigerian economy (Hassan *et al*., 2010). One of the major factors limiting the productivity of goats in developing countries is over dependence on low digestible feeds which is uncertain throughout the year and also cannot meet even the maintenance requirements of these animals. Inadequate nutrition, particularly during the dry season, is a major constraint for livestock producers (Lengarite *et al*., 2014). Forages during the dry season are highly fibrous, low in digestible protein, energy, minerals and vitamins which do not meet goat nutrient requirements, and the role of livestock in providing protein is essential in human nutrition and it is increasingly being recognized. This necessitates immediate concern in development programs for improvement of livestock productivity, through improved nutrition. However, feed constraint is the most important limiting factor in livestock production (Aregawi *et al*., 2013). Animal productivity could be increased by the introduction of low-cost technologies such as feeding systems that are simple, consistently practical and within the limits of the farmer's resources (Douthwaite, 2002).

The major constraints of livestock production in Nigeria and other tropical countries are inadequate and poor quality of the available energy and protein feedstuffs during the dry season, when natural pastures are scarce and are of low nutritional value (Hassan *et al*., 2014). The dry season period results in a rapid decline in the quantity and quality of forages, leading to low forage intake and digestibility with resultant poor animal performance (Ukanwoko *et al*., 2009). Productivity and performance of small ruminants, particularly goats in Nigeria, are significantly affected by the quality and availability of feed resources. Cereal forages such as fodder maize and fodder sorghum are typically low in crude protein and may not provide sufficient nutrients when fed alone. Productivity and performance of small ruminants, particularly goats in Nigeria, are significantly affected by the quality and availability of feed resources. Ruminants that feed mainly on forages and crop residues are affected by seasonality (Befikadu *et al*., 2019). This has resulted in a gap between demand and supply of goat meat and other products (Tegegne *et al*., 2011). Researchers have reported that meeting the nutritional needs of ruminant animals throughout the year has been a major challenge facing livestock farmers in the tropics due to the seasonality of forages (Babayemi and Bamikole 2009). This study therefore aimed to evaluate the hematology and serum biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets in semi arid region of Nigeria.

Objectives

The broad objective of this study was to determine the hematology and serum biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets in semi arid region of Nigeria. The specific objectives were to:

- Evaluate the chemical composition of mixed diets of ensiled cereal and legume fodders.
- Investigate the hematological and serum biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets.

2. MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Teaching and Research Farm, Aliko Dangote University of Science and Technology Wudil, Kano State, Nigeria. The area is located on Latitude 12˚58' N, Longitude 8˚25' E at an altitude of 403m above sea level. The mean annual rainfall is 800mm with a relative humidity of 75% during the rainy season, with a mean annual minimum and maximum temperatures of 20˚C and 46˚C, respectively (Adamu *et al*., 2019).

Experiment I (Silage Making)

Ensiling procedure

Cereal and legume dry fodders were obtained in Jajaye farms Nigeria Limited in Shagogo, Gaya Local Government area of Kano State Nigeria. The fodders were chopped into 2-3cm and water was sprinkled at 15L to 25kg forage then ensiled using the following ratio and combinations; maize stover + cowpea haulm (60: 40%), maize stover + groundnut haulm (60: 40%), maize stover + cowpea haulm + groundnut haulm (60: 20:20%), sorghum stover + cowpea haulm (60: 40%), sorghum stover + groundnut haulm (60: 40%), sorghum

stover + cowpea haulm + groundnut haulm (60: 20:20%), respectively. The mixtures were thoroughly mixed and transferred into polythene silage bags (silos) and compressed by applying manual pressure to expelled trapped air to achieve maximum compaction for a period of 21 days (3 weeks). All silages were shade dried for three (3) days and samples taken to the laboratory for chemical analysis.

Experiment II (Feeding Trial)

Experimental Animals and Their Management

A total of eighteen (18) growing Kano Brown bucks with an average live weight of 10.59±0.07kg were used for the experiment. The animals were purchased from Wudil livestock market located in Wudil Local Government Area of Kano State, Nigeria. The animals were quarantined for two (2) weeks and ear tagged for easy identification. The animals were dewormed with Albendazole against endo-parasites at the dose rate of 3ml/10kg body weight and Ivermectin at 1ml/50kg body weight, subcutaneously against ecto-parasites. Oxytetrecycline long acting (LA) and multi-vitamin were also administered by intramuscular route at 1ml/10kg body weight as broad spectrum antibiotic against bacterial infection and to enhance appetite. The experimental Animals were housed individually in a disinfected cross ventilated pens equipped with feeding and watering troughs and managed under intensive system.

Experimental Design and Treatments

The experimental animals were balanced by weight and allotted to six (6) dietary treatments with three (3) replications in a Completely Randomized Design (CRD). The treatments were maize stover + cowpea haulm (60:40%), maize stover + groundnut haulms (60:40%), maize stover + cowpea haulm + groundnut haulm (60:20:20%), sorghum stover + cowpea haulm (60:40%), sorghum stover + groundnut haulms (60:40%), sorghum stover + cowpea haulm + groundnut haulm (60:20:20%) designated as T_1, T_2, T_3, T_4, T_5, and T_6, respectively (Table 1).

Experimental Procedure

The experimental animals were offered the basal diet (silages) *ad libitum* at 4% of body weight to monitor the intake in the morning, after which supplementation was done with a concentrate diet at 1.5% of body weight in the evening. All the experimental animals were provided with fresh, clean water *ad libitum.* The experiment lasted for twelve (12) weeks.

Table 1. Composition of Concentrate Diet

Ingredients	Inclusion (%)
Rice milling residue	25
Wheat offal	25
Sorghum chaff	18
Cowpea husk	20
Cottonseed cake	10
Salt	1
Potash	1
Total	**100**
Calculated Analysis	
Crude Protein (%)	16.72
ME (Kcal/kg)	2100.50

Blood Samples Collection

Blood samples were collected at the end of the feeding trial and before the digestibility trial for hematological and serum biochemical parameters using three (3) animals randomly selected from each treatment. The blood sample was drawn via the jugular vein using

sterile 10ml syringe and 18g (gauge) needle. Bleeding was done early in the morning before feeding. About 10mls of blood was collected from each animal, 5mls of each blood sample collected was placed into a bottle containing ethylene diamine tetra acetic acid (EDTA) as an anticoagulant for hematological studies. The remaining 5mls was placed in a universal bottle and allowed to stand for 2hrs at room temperature, this allows for coagulation to take place. The blood sample in a universal bottle was thereafter centrifuged at 3000 rpm for 20 minutes to separate and decant the serum. The serum was stored at -200 ^{0}C for biochemical analysis according to the procedure of Dacie and Lewis (1991).

Laboratory Analyses

Hematological Indices Determination

The blood samples in ethylene diamine tetra acetic acid (EDTA) bottles were analyzed for hemoglobin (HB) content using cyanmethemoglobin method (Coles, 1986). Packed cell volume (PCV), red blood cells (RBC), white blood cells (WBC) and its differentials (neurophils, basophils, eosinophils, monocytes and lymphocytes) counts were determine according to the method described by Coles (1986). Mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHV) were calculated according to the formula stated in the Merck's Veterinary Manual (2016) as MCV= PCV ÷ RBC X 10; MCH = Hb g/DL ÷ RBC X 10; and MCHV= Hb g/DL ÷ PCV X 100).

Blood Chemistry Analysis

The blood urea nitrogen (BUN) Concentration was estimated by Nessler's reaction (Tanis and Nylor, 1968), serum total protein (TP) was estimated by biuret method as describe by Kohen and Allen (1995). Albumin was determined by the Bromo Cresol Green (BCG) method (Peter *et al.,* 1982) while globulin concentration was determined by the difference between total protein and albumin. Blood glucose (BG) was determined by the oxidase method.

Data Analysis

Data generated from the study were subjected to analysis of variance (ANOVA) using the general linear model procedure of Statistical Analysis System (SAS, 2006). Differences between the means are considered significant at 5% level of probability ($P<0.05$) and separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1995).

3. RESULTS AND DISCUSSION

3.1. Results

Chemical composition (%) of basal diets (silages) and concentrate diet

The results of the chemical composition of basal diets (silages) were presented in Table 2. There were significant ($P<0.05$) differences in the treatment means of all the parameters evaluated. The results showed that T_6 was significantly ($P<0.05$) higher in dry matter (DM) content (87.97%) compared to other treatments. Ash value (6.89%) was significantly ($P<0.05$) higher in T_3 and lower in T_2 (4.55). The value (6.64%) of ether extract (EE) was significantly ($P<0.05$) higher in T_3 and lower in T_1 and T_5, which were statistically ($P>0.05$) similar. Crude protein (CP) was significantly ($P<0.05$) higher in T_6 (12.70%) and lower in T_1 (8.89) whereas crude fiber (CF) value was significantly ($P<0.05$) higher in T_1 (36.38%) and lower in T_3 (30.14%). The value (34.84%) of nitrogen free extract (NFE) was significantly ($P<0.05$) higher in T_6 and lower in T_3 (31.22%) while T_2 and T_4 were statistically ($P>0.05$) similar. The value (46.41%) of neutral detergent fiber (NDF) was significantly ($P<0.05$) higher T_3 and lower in T_5 (45.71%) whereas acid detergent fiber (ADF) was significantly ($P<0.05$) higher in T_6 (34.90%) and lower in T_3 (32.04%). Acid detergent lignin (ADL) and hemicellulose values were significantly ($P<0.05$) higher in T_6 (7.82%, 12.88%) and lower in T_1 (7.09%, 10.59%), respectively. The value (27.28%) of cellulose was significantly ($P<0.05$) higher in T_3 and lower in T_5 (25.04%). The concentrate diet contains 90.57% dry matter, 13.18% crude fiber, 17.71% crude protein, 4.14% ether extract, 6.89% ash, 48.65% nitrogen free extract, 43.22% neutral detergent fiber, 28.63% acid detergent fibre, 8.77% acid detergent lignin, 14.49% hemicelluloses, 19.86% cellulose.

Hematological parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

The results for hematological parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets were presented in Table 3. There were significant ($P<0.05$) difference in all the parameters evaluated. However, all the values obtained in this study were within the normal physiological ranges for healthy bucks. The values of Hb were significantly ($P<0.05$)

higher in T_6 (12.85) and T_3 and lower in T_5. Values for PVC were significantly ($P<0.05$) higher in T_6 (37.74) and T_5 followed by T_3, T_4, T_1 and lower in T_2 (27.75). RBC value was significantly ($P<0.05$) higher in T_6 (10.48) and T_3 and lower in T_4 and T_5 which were statistically ($P>0.05$) similar. The values obtained in WBC and its differentials were significantly ($P<0.05$) higher in T_6 except in eosinophils which is significantly higher in T_3. The value of MCV was significantly ($P<0.05$) higher in T_3 (32.42) and T_6 and lower T_4, T_5. The value of MCH was significantly ($P<0.05$) higher in T_6 (11.85) and T_4 and lower in T_2 and T_1. The value of MCHC was significantly higher in T_4 (3.19) and T_2 and lower in T_4 and T_1.

Table 2. Chemical composition (%) of basal diets (silages) and concentrate diets

Parameters	Treatments							
	T_1	T_2	T_3	T_4	T_5	T_6	SEM	Conc. Diet
DM	86.60^{f}	86.96^{e}	87.63^{b}	87.25^{d}	86.63^{b}	87.97^{a}	0.016	90.57
CF	35.47^{a}	35.98^{b}	30.14^{f}	31.18^{e}	34.68^{d}	36.38^{c}	0.015	6.89
CP	8.89^{f}	9.46^{e}	12.06^{b}	9.85^{d}	10.60^{c}	12.70^{a}	0.012	4.14
EE	2.88^{e}	2.78^{c}	6.64^{a}	2.41^{d}	2.26^{e}	5.38^{b}	0.040	17.71
Ash	4.98^{e}	4.55^{f}	6.89^{a}	5.53^{d}	5.67^{c}	5.80^{b}	0.016	13.18
NFE	34.32^{b}	33.40^{c}	31.22^{e}	32.79^{d}	34.42^{b}	34.84^{a}	0.108	48.65
NDF	43.20^{e}	44.10^{d}	46.41^{a}	44.93^{c}	41.52^{f}	45.71^{b}	0.019	43.22
ADF	32.60^{d}	33.33^{c}	34.45^{b}	31.45^{f}	32.04^{e}	34.90^{a}	0.018	28.63
ADL	7.09^{e}	7.20^{d}	7.62^{b}	7.53^{c}	6.43^{f}	7.82^{a}	0.012	8.77
HEMI	10.59^{e}	10.77^{d}	11.51^{b}	10.06^{f}	11.26^{c}	12.88^{a}	0.009	14.49
CELLU	25.51^{d}	26.12^{c}	27.41^{a}	24.22^{f}	25.04^{e}	26.92^{b}	0.060	19.86

^{abcdef} Means within the same row with different superscripts differ significantly ($P<0.05$), SEM = Standard error mean. DM (dry matter), CP (crude protein), CF (crude fibre), EE (ether extract), NFE (nitrogen free extract), NDF (neutral detergent fibre), ADF (acid detergent fibre), ADL (acid detergent lignin), HEMI.(hemicelluloses), CELLU. (Cellulose).T_1 - Maize + Cowpea (60:40%), T_2 - Maize + Groundnut (60:40%), T_3 - were Maize + Cowpea + Groundnut (60:20:20%), T_4 - Sorghum + Cowpea (60:40%), T_5 - Sorghum + Groundnut (60:40%), T_6 - Sorghum + Cowpea + Groundnut (60:20:20%).

Table 3. Hematological parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

Parameter	Treatments							
	T_1	T_2	T_3	T_4	T_5	T_6	SEM	*Normal range
Hb (g/dl)	9.80^{ed}	10.54^{c}	11.37^{b}	10.13^{d}	9.61^{e}	12.85^{a}	0.125	9-15 (g/dl)
PCV (%)	28.88^{e}	27.75^{f}	30.5^{c}	29.23^{d}	32.89^{b}	37.74^{a}	0.019	21-35%
RBC (x10^6/µl)	9.24^{d}	9.55^{c}	10.22^{b}	9.01^{e}	9.06^{e}	10.48^{a}	0.030	9-15 (x10^6/µl)
WBC (x10^9/L)	5.52^{c}	4.64^{e}	5.85^{b}	5.11^{d}	4.36^{f}	5.94^{a}	0.019	4-12 (x10^9/L)
Neutrophils (%)	37.52^{e}	36.24^{f}	41.31^{b}	38.02^{d}	39.84^{c}	42.43^{a}	0.018	10-50 %
Basophils (%)	1.31^{e}	1.45^{d}	1.74^{b}	1.22^{f}	1.54^{c}	1.92^{a}	0.017	0-3%
Monocytes (%)	4.34^{d}	4.11^{e}	4.66^{c}	4.02^{f}	4.76^{b}	5.01^{a}	0.022	0-6%
Eosinophils (%)	6.85^{c}	5.81^{f}	7.22^{a}	6.31^{d}	7.02^{b}	6.08^{e}	0.019	0-10%
MCV (fL)	28.41^{d}	29.02^{c}	32.42^{a}	28.22^{e}	28.06^{f}	31.88^{b}	0.025	28-40fl
MCH (pg)	8.05^{f}	8.64^{e}	10.30^{c}	9.03^{d}	10.98^{b}	11.85^{a}	0.024	8-12pg
MCHC (g/L)	30.06^{f}	32.66^{b}	31.55^{c}	30.62^{e}	33.19^{a}	30.92^{d}	0.025	31-34g/dl

^{abcdef} Means within the same row with different superscripts differ significantly ($P<0.05$), SEM = Standard error mean. PCV (packed cell volume), RBC (red blood cells), WBC (white blood cells), MCV (mean corpuscular volume), MCH (mean corpuscular heamoglobin), MCHC (mean corpuscular heamoglobin concentration). T_1 - Maize + Cowpea (60:40%), T_2 - Maize + Groundnut (60:40%), T_3 - were Maize + Cowpea + Groundnut (60:20:20%), T_4 - Sorghum + Cowpea (60:40%), T_5 - Sorghum + Groundnut (60:40%), T_6 - Sorghum + Cowpea + Groundnut (60:20:20%).

Serum Biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

The results of serum biochemical parameters were presented in Table 4. All the values obtained were within the normal physiological range for healthy bucks. There were significant (P<0.05) differences in all the parameters evaluated. Blood glucose value was significantly (P<0.05) higher in T_6 and T_3 and significantly (P<0.05) lower in T_4. Total protein value was significantly (P<0.05) higher in T6 and T3 and lower in T_4. Blood urea nitrogen value was significantly (P<0.05) higher in T6 and T_5 Followed by T_3 and T_1 which were statistically (P>0.05) similar while T_2 and T_4 were lower. Creatinine value was significantly (P<0.05) higher in T_6 and T_3 and lower in T_5 and T_1.

Table 4. Serum Biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

Parameters	Treatments							
	T_1	T_2	T_3	T_4	T_5	T_6	SEM	*Normal range
BG (mmol/L)	4.34^{d}	4.11^{e}	4.76^{b}	4.02^{f}	4.66^{c}	5.01^{a}	0.022	3.7-9.3(mmol/L)
TP(g/dIL)	6.08^{e}	6.31^{d}	7.02^{b}	5.81^{f}	6.85^{c}	7.22^{a}	0.019	5.9-7.8(g/dIL)
BUN (mmol/L)	4.09^{c}	3.92^{d}	4.16^{c}	3.84^{e}	4.44^{b}	5.36^{a}	0.024	3.7-9.3(mmol/L)
CRT(mmol/L)	1.08^{f}	1.24^{d}	1.42^{b}	1.31^{c}	1.11^{e}	1.63^{a}	0.036	1.0-1.8(mmol/L)

^{abcdef} Means within the same row with different superscripts differ significantly (P<0.05), SEM = Standard error mean. BG (Blood glucose), TP (Total protein), BUN (Blood urea nitrogen), and CRT (Creatinine). T_1 - Maize + Cowpea (60:40%), T_2 - Maize + Groundnut (60:40%), T_3 - were Maize + Cowpea + Groundnut (60:20:20%), T_4 - Sorghum + Cowpea (60:40%), T_5 - Sorghum + Groundnut (60:40%), T_6 - Sorghum + Cowpea + Groundnut (60:20:20%).

3.2. Discussion

Chemical composition of basal diets (silages)

The dry matter (DM) values obtained in this study (Table 2) were higher than the values (91.90 to 92.40) reported by Sariyyu *et al.* (2018) when sugarcane waste was ensiled with soybean meal residue and fore stomach digesta of sheep. The high dry matter values of the silages in this study (Table 2) indicated that the diets might be good energy sources that could enhance rumination and prevent digestive upsets in the rumen (Ashiru *et al.*, 2018). The crude fiber (CF) values obtained in the present study (Table 2) were higher than the values (18.94 to 20.65) reported by Okunade *et al.* (2021) for ensiled sugarcane scrapping with urea and molasses in the diets of small ruminants. The differences might be due to different test material. The crude protein (CP) values obtained in the present study (Table 2) increased with increasing level of legumes in the diet, and it is within the moderate level 10-12% recommended by Gatenby (2002) but lower than the 14-18% range suggested by NRC (2007) for small ruminants hence, concentrate diets were supplemented. The ash content in the present study (Table 2) was higher than the values of (3-4%) reported by Ibrahim *et al.* (2018), as lower ash content implies those of the diet might be low in minerals. The ether extract (EE) of the present study (Table 2) was within the range of 3.75 to 6.00% reported by Yahaya *et al;* (2019) when Yankasa rams were fed ensiled sugarcane waste with non-protein nitrogen. The neutral detergent fiber (NDF) values obtained in the present study (Table 2) were lower than those of the values (47.55 to 49.68 %) obtained by Olufemi *et al*. (2019) for maize stover ensiled with or without urea or poultry litter for ruminant feeding. This is probably due to differences in experimental materials and procedure. The acid detergent fiber, acid detergent lignin, hemicelluloses and cellulose values obtained in the present study (Table 2) were lower than the ranges of values for ADF (40.60 to 45.69%), ADL (8.45 to 12.67%) HEMI. (29.20 to 29.60%), CELL.(31.55 to 32.21%) Reported by Kebede *et al;* (2018), for ensiling sugarcane waste treated with urea and molasses on nutritive value and animal performance, the differences might be as a result of the test material used, breed of the animal, season, location, etc.

Hematological parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

Examination of blood provides the opportunity to investigate the clinical and the presence of several metabolites and other constituents in the body of animals and plays a vital role in the physiological, nutritional, and pathological status of an organism (Iliyasu *et al*., 2022). The hemoglobin values obtained in the present study (Table 3) were within the normal physiological range as reported by The Merck (2016). The higher values of Hb in T_6 and T_3 indicated the higher tendency for compensatory accelerated production of Hb in the case of better transportation of oxygen to the blood and absorbed nutrients (Ogundumi *et al*., 2010). The PCV values obtained in the present study (Table 3) were slightly higher than the values (35.0 to 35.33%) reported by Ashiru *et al.* (2025) when ensiled sugarcane waste treated with poultry litter fed to Yankasa rams. This variation could be due to differences in experimental diet or environment.

High PCV values leads to production of too many RBC (polycythemia) or impaired pulmonary functions, and low PCV values results in anemia, which is attributed to reduced oxygen carrying capacity of blood, increase pulse rate and consequently heart failure. The RBC Values obtained in the present study (Table 3) were lower than the values (13.73 to 13.90x10^9/L) reported Ashiru *et al.* (2025) when ensiled sugarcane waste treated with poultry litter were fed to Yankasa rams. similarly WBC values obtained in the present study (Table 3) were also lower than (8.67 to 10.67 x10^9/L) when ensiled sugarcane waste treated with poultry litter fed to Yankasa rams but were within the normal physiological range of healthy goats (Merck, 2025). The values for neutophils, basophils, monocytes and eosinophils in the present study (Table 3) were higher than (39.33 to 44%, 0.52 to 0.90%, 1.15 to 1.32% and 1.67 to 2.3%) reported by Toviesi *et al*. (2024) when Kalawad weaner goats fed diets containing *Moringa oliefera* leaf meal. This variation might be due to differences in experimental animals and or climatic conditions. The values were within the normal range (Merck, 2025). The MCV values of the present study (Table 3) were lower than (35.41 to 45.46 fL) reported by Kwaido *et al,* (2024) for Rice straw ensiled with urea and molasses at varying levels. However, low MCV indicates that the RBC are lower than normal, and may indicate anemia, this condition may be caused by iron deficiency, leading to poisoning or thalassemia. This genetic condition that caused less hemoglobin than normal and may indicate normocytic anemia (Iliyasu *et al.,* 2022). Hence, the MCV values of the present study (Table 3) were within the normal range. The MCHC values obtained in the present study (Table 3) agreed with the values (30.46 to 34.14g/L) reported by Merck (2016), and were within the normal ranges.

Serum Biochemical parameters of Kano Brown bucks fed ensiled cereal and legume fodders supplemented with concentrate diets

Serum biochemical parameters are used to determine the level of heart attack, liver damage and to evaluate protein quality and amino acid utilization by animals (Ewuola *et al.,* 2004). Serum glucose is an indication of cito metabolism, in high energy diets (Coles, 2004) when glucose is lower than the normal range is an indication of hypoglycemia, where higher level is indication of hyperglycemia (Olorunnisomo, 2012). Blood glucose values obtained in the present study (Table 4) were lower than (7.15 to 8.30mm/l) reported by Bishir *et al.* (2021) but higher than the values (3.0 to .81mmol/l) reported by Olafadehan (2011) for Red Sokoto bucks. Hence, the values were within the normal range. The values of total protein in the present study (Table 4) were lower than the values (66.01 to 67.35 g/dl) reported by Jiwuba *al.* (2022) for West African dwarf goats fed ensiled rice milling residue. This could be a result of the different test material. Ikyume *et al.,* (2018) reported that serum total protein values are indications of both quality and quantity of protein utilization in the diets. Similarly, Etana *et al*. (2011) reported that lower values of protein in feeds result in depression of total protein values. The Blood urea nitrogen values in the present study (Table 4) were slightly higher than the values (4.50 to 4.57 mmol/L) reported by Ashiru *et al.* (2025) for Yankasa rams fed ensiled sugarcane waste with poultry litter. The values of blood urea nitrogen in the present study (Table 4) showed that the amino acids of the diets were balanced, while an amino acid imbalance will result in an increase in blood urea (Ilyasu *et al,* 2022). The creatinine values obtained in the present study (Table 4) were within the normal physiological ranges (Merck, 2016). The levels of creatinine in conjunction with blood urea concentrations point towards normal kidney function, hence the creatinine levels observed across all treatments indicate a normal renal function in the experimental animals, which could have resulted from efficient protein and amino acid metabolism (Omotoso *et al.,* 2021).

4. CONCLUSION

Based on the results of the present study, it was concluded that; Forage combination containing sorghum stover + cowpea haulms + groundnut haulms (60:20:20) and maize stover + cowpea haulms + groundnut haulms (60:20:20) had the best crude protein content. All the values for hematology and serum biochemical parameters were within the normal physiological ranges for healthy goats; therefore, all the forage combination has no deleterious effects on animal health.

Recommendations

Based on the results of this research, the following recommendations were made:

a) Sorghum Stover + cowpea haulms + groundnut haulms (60:20:20) combination was recommended due to higher CP content.
b) Cereal and legume fodders could be combined together (60:20:20) and fed to Kano Brown bucks without compromising the blood metabolites.
c) Further research could be carried out to evaluate other different ratios in small ruminants especially sheep.

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Author Contributions
Faruq Usman Yakubu: Conceptualization, methodology, writing-original draft.
Rabi Muhammad Ashiru: writing- review and editing.
Umar Ibrahim: Data curation, Formal analysis.
Mubarak Ahmad Hassan: investigation.

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Conflict of interest
The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval
In this article, the animal regulations are followed as per the ethical committee guidelines of Department of Animal Science, Aliko Dangote University of Science and Technology Wudil, Kano state-Nigeria; the authors observed the Hematology and Serum Biochemical Parameters of Kano Brown Bucks Fed Ensiled Cereal and Legume Fodders Supplemented with Concentrate Diets in Semi-Arid Region of Nigeria. The Animal ethical guidelines are followed in the study for observation, identification & experimentation.

Informed consent
Not applicable.

Data availability
All data associated with this study are present in the paper.

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