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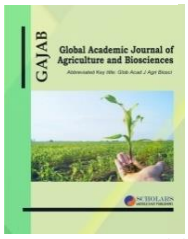

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Original Research Article

Blood Profile of West African Dwarf Goat Fed Composite Raw Cashew Nut Shell Meal

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Abstract: The study was conducted using twenty four West African Dwarf (WAD) goats with average weight of 6.74 ± 0.33kg to investigate the effect of raw composite cashew nut shell (CNS) meal on blood profile. The goats were assigned to four dietary treatments with five replicate per treatment in a completely randomized design. The raw cashew nut shell was sun-dried and crushed to less than 1 mm particle size and included at 0% (diet A), 5% (diet B), 10% (diet C) and 15% (diet D) with other conventional feed ingredients to formulate a complete diet. The animals were stabilized for two weeks while the experimental period lasted 63days. After the feeding trial, blood sample of 5ml was collected from each goat via the jugular vein puncture into a sterilized Ethylene Diaminetetra Acetate Acid (EDTA) bottles to prevent coagulation for haematological assay while another 5ml sample was collected in bottles without EDTA for serum biochemical indices. The results of the chemical composition showed that the dry matter ranged from 74.49 – 82.87% while the crude protein ranged from 7.16 – 7.89%. The raw cashew nut shell significantly ($P < 0.05$) influenced the lymphocytes which ranged from 45.67% (diet D) – 61.67% (diet A) but serum biochemical indices were not significantly influenced except in the high density lipoprotein (HDL) and no significant ($P > 0.05$) difference was also observed in the serum electrolytes. Based on the findings of this study, raw composite cashew nut shell had no detrimental effect on the blood profile of WAD buck, thus, raw CNS could serve as a substantial alternative feed ingredient in ruminant production.

Keywords: Blood, Serum electrolytes, cashew nut shell, West African dwarf (WAD) goats.

INTRODUCTION

The availability of sustainable animal protein has been the major concern of the livestock industry in Nigeria. The animal protein intake in the tropics had been reported to be low due to high cost of livestock product which results from rapid increase in the cost of most conventional feedstuff (Sobayo *et al.,* 2013). During dry season, feeds become scarce as most of the grasses are dried up, low in nutritive value and are not suitable for production (Abubakar *et al.,* 2011). According to Ibe, (2000), animal protein is one of the most important components of human diet and its consumption varies from country to country (Okai *et al.,* 2005) and this protein deficit can be filled by venturing into small ruminant production like sheep and goat. However, nutrition plays a major role in the overall wellbeing of the goat flock (Alokan, 2008). Goats being a multi-functional ruminant have the capacity to efficiently utilize forages and agro industrial by-

products as feeds (Aye and Adegun, 2010) and are probably the most efficient converters of plants into muscles because their digestive system can utilize cellulose and fibrous materials and even non-protein nitrogen. Ruminants convert the materials into a well-balanced source of protein and energy for human consumption called meat (Aye and Adegun, 2010). Hence, future hope of feeding the nations and safe guarding their food security will depend on the better utilization of wastes and agro-industrial by-products which are readily available and at the same time not in direct use by humans (Fajemisin *et al.,* 2014); (Ogunjemite and Ibhaze, 2020). One of such agro-industrial by-product that holds promise but has not been fully utilized in ruminant feeding is cashew nut shell. It is made up of outer hard shell and inner edible kernel. The shell is the left over after cashew kernels have been removed. However, when using agro by-products, it is important to assess the health status of the animals because some are known to affect blood parameters (Olabanji *et al.,* 2007). According to Esonu *et al.* (2001), blood bio- chemical constituents reflect the physiological response of animals to their internal and external environments, which include feeds and feeding. Blood act as a pathological reflector of the health status of an animal to toxicant and other conditions. It also helps to establish the presence or absence of disease and determine the nature and extent of a disease process (static, progressive or regressive) (Olafadehan *et al.,* 2010). Blood metabolite profiling is a technique that is used to evaluate the concentration of blood compounds or 'metabolic signature' that serve as markers to assess specific biochemical response of an individual. Blood metabolic profiling has also been suggested for use as a diagnostic tool for reproductive analysis, metabolic disorders, and nutritional status of individuals (Ugoigwe, 2006). Researchers have applied blood metabolite profiling to improving feeding management, sub-clinical health problems, and prevent disease in animal production (Ewuola *et al.,* 2004). Nampanya *et al*. (2010) evaluated the practicability of using blood metabolite profiling in dairy herds as a way to prevent peri-parturient disease. Herds with high incidence of peri-parturient diseases showed low blood values of hematocrit, albumin, glucose, cholesterol, calcium, and magnesium levels during dry period but when feed was abundant the values went to normal. Therefore, results from the Nampanya *et al.* (2010) study correctly diagnosed malnutrition as the cause of the peri-parturient disease in dairy production. According to Omotoso *et al.* (2017), blood profiling is also useful to identify the nutritional short comings before productivity is compromised. Hence, this study was designed to evaluate the dietary effects of raw cashew nut shell meal on the blood profiles of West African Dwarf goats.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Small Ruminant Section of the Teaching and Research Farm of the Federal University of Technology, Akure (FUTA), Ondo State, Nigeria. The laboratory analysis was carried out in Microbiology Laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State, Nigeria. Akure is located on longitude 4.944055ºE, and latitude 7.491780ºN with annual rainfall ranging between 1300 and 1650 mm and annual daily temperature ranging between 27º C and 38º C (Daniel, 2015).

Collection and Preparation of Experimental Diets

Cashew nut shells (CNS) were collected from cashew processing industry at Akure, Owo, Auchi, Offa and sun-dried for 3 days to reduce the moisture content. The shell were crushed at the university feed mill to about 1 mm particle size, while cassava peels other conventional feed ingredients were purchased in a reputable feed mill within Akure metropolis. A concentrate diet was formulated to meet NRC (2007) nutrient requirements recommended for growing goats. While the raw cashew nut shell (CNS) meal was included as 0% (diet A), 5% CNS (diet B), 10% CNS (diet C) and 15% CNS (diet D). The gross composition of the four experimental diets are shown in Table 1.

Table-1: Gross composition of the experimental diets

Ingredients	A	B	C	D
RCNS	0.00	5.00	10.00	15.00
Cassava Peel Meals	50.00	45.00	40.00	35.00
Brewer Dried Grain	15.00	15.00	15.00	15.00
Wheat Offal	5.00	5.00	5.00	5.00
Palm Kernel Cake	27.00	27.00	27.00	27.00
Salt	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00
Total	**100.00**	**100.00**	**100.00**	**100.00**

RCNS- Raw cashew nut shell meal

Experimental Layout and Animal Management

A total of twenty WAD bucks of about 6 to 7 months of average weight of 6.74 ± 0.33 kg were randomly allotted to four dietary treatments of five replicate per treatment in a Completely Randomized Design. The bucks were housed in individual pens, which were thoroughly washed and disinfected. The animals were vaccinated against PPR and prophylactically treated against endo- and ecto-parasite before the commencement of the experiment. The goats were given daily ration at 3% of their body weight. *Panicum maximum* was given as basal diet along with experimental diets. The feeding trial lasted 63 days excluding 2 weeks of adaptation. All the animals were managed according to the guidelines and ethical approval of NENT (2016).

DATA AND SAMPLE COLLECTION

The animal's growth response to the experimental diets was monitored by taking their initial body weights, followed by weighing on weekly basis prior to feeding. The daily feed intake was determined by measuring the quantity of the feed given daily and subtracting the remnant at the end of the day.

Feed intake = Feed given – Remnant/left over.

Blood sample of 5ml was collected from each goat via the jugular vein puncture (Frandson, 1986) at the end of the experiment. The blood samples were collected in sterilized Ethylene Diaminetetra Acetate Acid (EDTA) bottles to prevent coagulation for haematological assay (Opara *et al.,* 2010). Blood samples collected into EDTA bottles was analyzed for Packed Cell Volume (PCV), White Blood Cell (WBC), Red Blood Cell (RBC), Haemoglobin (Hb) etc according to the method of Byanet *et al.* (2008) while another 5ml sample was collected in bottles without EDTA for serum biochemical indices. Total protein, albumin, triglyceride, Alanine aminotransferase (ALT), Serum Aspartate aminotransferase (AST), Alkaline phosphate (ALP), cholesterol, urea and creatinine were done using the method described by Cork and Halliwell, (2002); (Opara *et al.,* 2010). Globulin was calculated as the difference between total protein and albumin.

Analytical Procedures

All data collected were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, 2015) and the means were separated using Duncan Multiple Range Test of the same statistical package. Significant means were accepted at $P < 0.05$.

RESULTS

Table 2: Chemical composition of raw cashew nut shell diets fed to WAD bucks.

The chemical composition of raw cashew nut shell diet fed to WAD bucks is presented in Table 2. The dry matter (DM) content of the experimental diets increased with increased inclusion levels of raw cashew nut shell (CNS); ranging from 74.49% (diet A) to 82.87% (diet D). The crude protein (CP) content increased with increased inclusion of raw cashew nut shell, the highest value was recorded for diet D (7.89%) and diet A (7.16) had the least. Crude fibre (CF) content of the experimental diet increased with increased inclusion of raw CNS; ranging from 22.45% (diet A) to 24.01% (diet D). The ether extract content of the diets decreased with increased inclusion of raw cashew nut shell and the values ranged from 3.70% (diet D) to 3.94% (diet A). Ash content decreased with increased inclusion of raw CNS and varied from 7.01% (diet D) to 7.34% (diet A). Diet A had the highest nitrogen free extract (59.32%) while diet D had the least (57.19%). The carbohydrate content of the diets ranged from 26.39% (diet A) to 27.91% (diet D). The organic matter content of the diet was highest in diet D (35.89%) and least in diet A (33.34%). The neutral detergent fibre (NDF) ranged from diet A (52.69%) to diet D (57.03%). The acid detergent fibre (ADF) ranged from diet C (24.90%) to diet A (34.81%).The acid detergent lignin (ADL) ranged from diet D (3.92%) to diet B (8.16%). Hemicellulose ranged from 17.51% (diet B) to 32.13% (diet C). Cellulose content was highest in diet C (28.98%) and least in diets a (18.45%).

Table-2: Chemical composition of raw cashew nut shell diets fed to WAD bucks

Parameters	A (0%)	B (5%)	C (10%)	D (15%)	P-value
Dry matter	74.49 ±0.27^{d}	75.86 ±0.18^{c}	76.66 ± 0.09^{b}	82.87 ±0.09^{a}	0.03
Crude protein	7.16 ±0.00^{ab}	7.35 ±0.05^{ab}	7.84 ±0.20^{a}	7.89 ±0.15^{a}	0.02
Crude fibre	22.45 ±0.13^{ab}	23.16 ±0.05^{ab}	23.80 ±0.20^{a}	24.01 ±0.13^{a}	0.04
Ether extract	3.94 ±0.01^{a}	3.79 ±0.01^{ab}	3.75 ±0.10^{b}	3.70 ±0.02^{b}	0.05
Ash	7.34 ±0.23	7.28 ±0.25	7.25 ±0.07	7.01 ±0.09	0.11
NFE	59.32 ±0.16^{a}	58.61 ±0.30^{a}	57.36 ±0.03^{ab}	57.19 ±0.05^{ab}	0.01
Carbohydrate	26.39 ±0.12^{ab}	26.95 ±0.06^{ab}	27.55 ±0.00^{a}	27.91 ±0.16^{a}	0.02
Organic matter	33.34 ±0.01^{c}	34.11 ±0.16^{b}	35.39 ±0.11^{a}	35.89 ±0.14^{a}	0.01
NDF	52.69 ±0.08^{b}	47.16 ±0.06^{c}	57.03 ±0.14^{a}	57.03 ±0.14^{a}	0.01
ADF	34.81 ±0.16^{a}	29.66 ±0.20^{b}	24.90 ±0.21^{d}	27.52 ±0.14^{c}	0.01
ADL	5.83 ±0.09^{c}	8.16 ±0.18^{a}	6.45 ±0.26^{b}	3.92 ±0.05^{d}	0.01
Hemicellulose	17.88 ±0.24^{c}	17.51 ±0.14^{c}	32.13 ±0.35^{a}	29.51 ±0.39^{b}	0.04
Cellulose	28.98 ±0.25^{a}	21.50 ±0.02^{c}	18.45 ±0.05^{d}	23.60 ±0.20^{b}	0.01

a, b, c = means within the same row with different superscripts are significantly different (P < 0.05). NFE: Nitrogen free extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin.

Table 3. Haematological indices of WAD goats fed raw cashew nut shell diets

The result of the haematological indices of WAD goats fed raw cashew nut shell diets is presented in Table 3. The observed values showed that there is no significant (P>0.05) difference in the haematological profile in the lymphocyte. The erythrocyte sedimentation rate (ESR) of the bucks ranged from 2.67 mm/hr (diet B) to 4.07 mm/hr (diet D). The highest pack cell volume (PCV) was observed in bucks fed diet B (31.00%) and the least value was observed in diet C (24.33%). Red blood cell (RBC) range from 5.36 ×10^{6}/L (diet A) to 8.32 ×10^{6}/L (diet D). The white blood cell ranged from 10.32 ×10^{6}/L (diet B) to 13.13 ×10^{6}/L (diet C). The highest observed value of haemoglobin was recorded in buck fed diet D (10.10 Hbg/dl) while it was least in buck fed diet C (8.13 Hbg/dl). Lymphocytes ranged from 45.67% (diet D) to 61.67% (diet A); which decreased with increased substitution of cashew nut shell. The highest observed value of Neutrophils was obtained in goats fed diet D (41.00%) while it was least in goats fed diet A (33.00%). The value of monocytes ranged from 3.00% (diet A) to 7.00% (diet B, C and D). Diet B, C, and D being numerically the same. The eosinophils value was highest in goats fed diets C and D (6.33%) while it was least in goats fed diet A (2.33). Mean cell haemoglobin (MCH) recorded the least value in diet D (1.49 pg/cell) while it was highest in diet B (17.99 pg/cell). The highest observed value of Mean cell volume (MCV) was obtained in bucks fed diet B (54.15) and least in diet D (35.74). Mean cell haemoglobin concentration was highest in diet D (34.44%) and least in diet A (33.01%).

Table-3: Haematological indices of WAD goats fed raw cashew nut shell diets

Parameters	A (0%)	B (5%)	C (10%)	D (15%)	P-value
ESR (mm/hr)	3.33 ±0.88	2.67 ±0.67	3.03 ±0.03	4.07 ±0.93	0.59
Pack cell volume (%)	26.33 ±3.38	31.00 ±1.73	24.33 ±2.33	29.33 ±2.60	0.33
Red blood cell (×10^{6}/L)	5.36 ±0.51	5.79 ±0.43	5.99 ±1.32	8.32 ±1.03	0.17
White blood cell (×10^{9}/L)	11.05 ±2.46	10.32 ±1.76	13.13 ±0.70	11.87 ±1.03	0.67
Haemoglobin (Hbg/dl)	8.78 ±1.13	10.30 ±0.58	8.13 ±0.78	10.10 ±0.61	0.25
Lymphocytes (%)	61.67 ±1.20^{a}	47.00±2.08^{b}	46.00 ±1.53^{b}	45.67±1.86^{b}	0.02
Neutrophils (%)	33.00 ±1.00	40.00 ±2.31	40.67 ±1.45	41.00 ±1.86	0.20
Monocytes (%)	3.00 ±0.33	7.00 ±0.33	7.00 ±0.00	7.00 ±0.00	0.06
Eosinophils (%)	2.33 ±0.33	6.00 ±0.33	6.33 ±0.33	6.33 ±0.33	0.16
MCH (pg/cell)	16.29 ±0.61	17.99 ±1.78	14.53 ±2.26	12.49 ±1.55	0.19
Mean Cell Volume	48.85 ±1.84	54.15 ±5.35	43.55 ±6.94	35.74 ±2.30	0.10
MCHC (%)	33.01 ± 0.33	33.23 ± 0.01	33.42 ± 0.16	34.44 ± 2.08	0.68

a,b = means within the same row with different superscripts are significantly different (P < 0.05). ESR: Erythrocyte sedimentation rate; MCH: Mean cell haemoglobin; MCHC: Mean cell haemoglobin concentration.

Table 4. Serum biochemical indices of WAD goats fed raw cashew nut shell diets

The serum biochemical indices of WAD goats fed raw cashew nut shell diets is presented in Table 4. The observed values showed that there is no significant (P>0.05) difference in the serum biochemical profile in high density lipoprotein (HDL). The total protein ranged from 44.05mg/dl

(diet A) to 44.61mg/dl (diet D). The highest observed value of albumin was observed in goats fed diet A (11.99mg/dl) while the least were observed in diet C and D (11.69mg/dl). Globulin value ranged from 32.19mg/dl (diet A) to 32.92mg/dl (diet D). Glucose value ranged from 31.01mg/dl (diet D) to 34.10mg/dl (diet A). The highest observed value of aspartate amino transferase (AST) was recorded in diet B (29.17u/l) while the least was recorded in diet C (20.00u/l). The highest observed value of alanine transferase (ALT) was recorded in diet C (10.67 u/l) and least in diet D (10.00 u/l) while alkaline phosphatase (ALP) ranged from diet D (383.64 u/l) to diet A (417.68 u/l). Cholesterol value ranged from 20.11mg/dl (diet D) to 44.07mg/dl (diet A), it reduced with increase in inclusion level of cashew nut shell. Urea ranged from 21.04mg/dl (diet A) to 26.94mg/dl (diet D). The highest observed value of high density lipoprotein (HDL) was recorded in diet A (92.09mg/dl) while the least value was observed in diet D (32.28mg/dl). Triglycerides ranged from 30.42mg/dl (diet C) to 59.34mg/dl (diet B).

Table-4: Serum biochemical indices of WAD goats fed raw cashew nut shell diets

Parameters	A (0%)	B (5%)	C (10%)	D (15%)	P-value
Total protein (mg/dl)	44.05 ± 1.34	44.48 ± 1.32	44.57 ± 1.11	44.61 ± 1.16	0.63
Albumin (mg/dl)	11.86 ± 0.09	11.99 ± 0.02	11.69 ± 0.06	11.69 ± 0.15	0.15
Globulin (mg/dl)	32.19 ± 0.40	32.49 ± 0.32	32.87 ± 0.15	32.92 ± 0.10	0.37
Albumin/Globulin	0.37 ± 0.23	0.37 ± 0.06	0.36 ± 0.40	0.36 ± 1.50	0.41
Glucose (mg/dl)	34.10 ±0.21	34.23 ±0.10	31.98 ±0.12	31.01 ±0.45	0.33
AST (U/L)	26.83 ± 3.17	29.17± 2.93	20.00 ± 3.50	28.67 ± 8.29	0.43
ALT(U/L)	10.47 ± 2.07	10.20 ± 3.10	10.67 ± 2.68	10.00 ± 0.72	0.85
ALP (U/L)	417.68±28.56	414.00±28.56	392.84±36.94	383.64±9.96	0.85
Cholesterol(mg/dl)	44.07 ± 4.13	37.41 ± 9.17	21.57 ± 3.31	20.11 ± 9.51	0.11
Urea (mg/dl)	21.04 ± 1.90	25.31 ± 0.54	26.60 ± 3.30	26.94 ± 1.84	0.26
HDL (mg/dl)	92.09 ± 8.99^{a}	76.12±10.01^{ab}	58.11±14.84^{b}	32.28±14.42^{c}	0.04
TRIG (mg/dl)	50.00 ±26.28	59.34 ± 6.81	30.42 ± 9.48	43.68 ±16.58	0.67

abc = means within the same row with different superscripts are significantly different (P < 0.05). HDL: High density lipoprotein; TRIG: Triglycerides; AST: Aspartateamino transferase; ALP: Alkaline phosphatase; ALT: Alanine transferase.

Table 5. Serum electrolytes (mg/dl) of WAD goats fed raw cashew nut shell diets

The results of serum minerals of WAD goats fed raw cashew nut shell diets were presented in Table 5. The values of the parameters observed were not significantly (P > 0.05) influenced by the diets. Serum calcium and phosphorus values were highest in goats fed diet D (14.30mg/dl) and (4.75mg/dl) respectively while it was least in goats fed diet A (12.02mg/dl) and (4.40mg/dl) respectively. Sodium ranged from 160.14mg/dl (diet C) to 161.84mg/dl (diet A). The highest magnesium value was recorded in goats fed diet B (13.00mg/dl) while it was least in goats fed diets A (10.16mg/dl).

Table-5: Serum electrolytes (mg/dl) of WAD goats fed raw cashew nut shell diets

Minerals	A (0%)	B (5%)	C (10%)	D (15%)	P-value
Calcium	12.02 ± 3.05	12.05 ± 2.95	13.80 ± 2.43	14.30 ± 2.86	0.86
Phosphorus	4.40 ± 0.42	4.49 ± 0.69	4.71 ± 1.32	4.75 ± 0.82	0.70
Sodium	161.84 ± 0.96	160.62 ± 1.40	160.14 ± 0.47	161.65 ± 0.46	0.79
Magnesium	10.16 ± 3.82	13.00 ± 5.56	12.96 ± 1.88	10.93 ± 1.82	0.79

DISCUSSION

Chemical composition of raw cashew nut shell diets fed to WAD goats

The chemical composition of raw cashew nut shell (RCNS) presented in Table 2 showed that dry matter (DM) increased with increasing inclusion level. RCNS dry matter was within the range (71.5 – 74.3%) reported by Adeyeye *et al.,* (2007) and the values were still in the normal range for ruminants. The crude protein (CP) content of the diets increased with increased supplementation of raw cashew nut shell (CNS). This implied that the protein (7.16 – 7.89%) contribution from cashew nut shell improved the CP of the diet. The CP was high than the range (5.00 – 6.05%) obtained by Ocheja *et al.,* 2011; Ocheja *et al.,* 2016a where steam-treated cashew nut shell was fed to WAD goats. The recorded crude protein were above the 7% CP recommended by McDonald, (1995) to enact the activities of the rumen microbes and for maintenance of the animal. The crude fibre increased gradually with increased inclusion level of

raw CNS. This might be due to the high lignocellulosic content of the raw cashew nut shell meal. Ether extract decreased with increased inclusion of raw CNS and this implied that the energy density of the feed is low. The ash content of the diets were higher than the range (1.09%) reported by Ocheja *et al.,* (2011). High ash content might be due to silica content and even the debris of dead microorganism (McDonald, 1995; Ogunjemite and Ibhaze, 2020). The values obtained in this study showed that the fibre content of the diet might lead to slow rate of degradation in the rumen and this could intake by the animals. The high neutral detergent fibre (NDF) implied that the cell wall of cashew nut shell might be rich in pectin which can be totally digested in the digestive tract of small ruminant.

Haematological indices of WAD goats fed raw cashew nut shell diets

The value of erythrocyte sedimentation rate (ESR) obtained in the study suggests that raw cashew nut shell (CNS) with combination with other ingredients did not have any allergic effect on the health status of the goats. The pack cell volume (PCV) represents the total percentage of the blood that constitute the red blood cells. The values obtained in this study showed that all the PCV concentrations of the goats fed the experimental diets were within the recommended value of 21 – 37% reported for healthy goats and sheep (Daramola *et al.,* 2005; Plumb 1999; Kalio *et al.,* 2014). Pack cell volume value below normal range could be an indication of anaemia and poor quality of protein in the diet (Radostis *et al.,* 1994). However, the results in this study showed that the values obtained might be due to high crude protein content of the diets (Radostis *et al.,* 1994). The red blood cells (RBC) are responsible for the transport of oxygen from the lungs to body cells (Ibhaze and Fajemisin, 2017). The values recorded in this study were within the range of 9.9 – 18.77 $\times 10^6$/L reported by Taiwo and Ogunsanmi (2003) as normal count for goats, however, were higher than 6.67– 7.73 $\times 10^6$/L reported by Oloche *et al.* (2014). The white blood cells are indicators to immune response to foreign bodies in the organism (Ibhaze and Fajemisin, 2017). The values obtained which are within the normal ranged suggests that the goats didn't experience any stress that would have ensured more production of white blood cell for defense. Haemoglobin is the iron-containing oxygen-transporting protein in the red blood cells. The result of obtained is lower than 11.4 Hbg/dl reported by Tambuwal *et al.* (2000) for Red Sokoto goats but was within the range of 8 – 12 Hbg/dl reported by Plumb, (1999) for healthy goats. This means that the goats had adequate blood pigment for proper transportation of oxygen, thereby preventing microcytic hypochromic anaemia which is caused by iron deficiency (Olafadehan, 2011). The lymphocytes helps in protection of the body from viral infections and high levels are an indication of an exhausted immune system (Plumb, 1999); (Ibhaze *et al.,* 2021). The values (45.67 – 47.67%) observed suggests that there was no depressed immune system and no experience of any form of active infection that could have elevated the lymphocytes concentration. The neutrophil which is also a defender of the body against infection and antigen has moderate values (33.00 – 41.00%) indicating that there was no incidence of neutrophilia which could occur when an animal is under stress or neutropenia which could occur with a very severe infection. The result of this study showed that the eosinophil values were within the normal range (1-8%) for goats as reported by Plumb, (1999). This low count indicates a normal condition of the goats. The mean cell haemoglobin (MCH), mean cell volume (MCV) and mean cell haemoglobin concentration (MCHC) values obtained in this study compared favourably with the report of Adejinmi and Akinboade, (1999) when the haematological parameters of WAD goats were assessed. A low MCV is an indication of chronic disease and haemoglobin disorder such as thalassaemia, anaemia due to blood cell destruction or bone marrow disorders and also an indicator of iron deficiency, however, the goats used in this study had normal MCV and are not anaemic.

Serum biochemical indices of WAD goats fed raw cashew nut shell

The serum biochemical analysis is used to determine the level of heart attack, liver damage and to evaluate protein quality requirements in animals. Serum clinical chemistry parameters also shows pathophysiological states and therefore leads to identification of pathogenesis and causes of diseases (Olafadehan *et al.,* 2014). Oboh *et al.* (2011) and Omotoso *et al.* (2017) stated that serum total protein of an animal is an indirect indices for measuring the nutritional protein adequacy of the animal. In this study, there was no significant ($P > 0.05$) differences in the serum biochemical indices of WAD goats fed the raw cashew nut shell diets, though they differ numerically. Total protein values obtained in increased with increased inclusion level and it agreed with 44 mg/dl reported by Tambuwal *et al.* (2002) for Red Sokoto goat. Albumin helps to hasten blood clot during injury, this is due to its ability to prevent haemorrhage, thereby reducing loss of blood and the higher the value, the better it is to the animal (Ibhaze *et al.,* 2021); (Omotoso *et al.,* 2017). Although the values were slightly lower than the normal range and this might be due to the fact that cashew nut shell was fed raw which might have affected feed intake but the globulin values

compared favourably with the normal range (24 - 44 mg/dl) as reported by Tambuwal *et al.* (2002) and also corroborated the findings of Ibhaze *et al.* (2021) in experiment where WAD goats were fed maize cob and husk with mixtures of microorganism. The serum enzymes values obtained were lower than the ranged 76.95 -138 u/l for AST and 23.09 – 95.28u/l for ALT in WAD goats fed pulverize bio-fibre wastes-based diets as reported by Ibhaze and Fajemisin, (2017) and was also lower than the normal range of 43 – 132 u/l and 7 - 24 u/l, respectively (Sirois, 1995), this might be due to the high concentration level of anti-nutrient present in raw cashew nut shell. But however, the AST value was in line with the range (21.02 – 43.78 u/l) Oloche *et al.* (2019) reported for Kano brown goats fed *Gmelina arborea* leaves and supplemented with diets containing water soaked sweet orange (*Citrus sinensis*), while the ALT values obtained were higher than the range 10.10 – 12.98 u/l also reported by Oloche *et al.* (2019). Cholesterol and urea values fell within the normal range as prolonged deposit of cholesterol may cause atherosclerotic plague and hyperadrenocorticism which may block important blood vessels and result in a myocardial infarction or heart attack (McDonald *et al.,* 1995). Blood urea is considered in ruminant to reflect the protein quality of the diet (Oloche *et al.,* 2015). High level of serum urea concentration may suggest an increase in activities of urea enzymes (ornithine, carbonyl transferase and orginase) which may indicate kidney damage (Merck's Veterinary Manual, 1979); (Omotoso *et al.,* 2017).

Serum electrolytes (mg/dl) of WAD goats fed raw cashew nut shell

Minerals plays an important role in growth, health and reproductive functions of livestock (Gonul *et al.,* 2009) and has been recognized as potent nutrients and deficiency can impair utilization of other nutrients (Szefer and Nriagu, 2007) and their performance. The results of this study showed that there were no significant ($P > 0.05$) differences in the values of minerals obtained, but are numerically different. The serum calcium level were slightly lower but did not differ from the range reported for Red Sokoto goats (Tambuwal *et al.,* 2002); however these values were comparable to the range 4 – 8 mg/dl for goats and sheep (NRC, 2007). This implied that the diets was adequately furnished with the required calcium. The phosphorus concentrations were in the same range (4.52 – 6.06 mg/dl) reported by Yatoo *et al.* (2013). The serum magnesium concentration of WAD goats fed experimental diets ranged between 10.16 - 13.00 mg/dl and these values were higher than the average value (1.97 mg/dl) reported by Kalio *et al.* (2014). Serum sodium concentration was also optimum.

CONCLUSION

Based on the findings of this study, it can be concluded that raw composite cashew nut shell in the diets of WAD goats up to 5% inclusion level is tolerable and had no detrimental effect on the blood profile of the animals and as well helped in conversion of this agricultural waste into better quality ruminant feed.

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