



Haematology and Serum Biochemistry of Yankasa Rams Fed Grounded, Untreated Corn Cobs Sun Dried Poultry Litter Mixture Ration with Different Energy Supplements

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ABSTRACT

Haematological examination has been used as one of the methods in the detection of some changes in health and physiological status, which may not be apparent during physical examination, but which affects the fitness of the animal. A feeding trial was conducted to determine the haematological and serum biochemistry of Yankasa rams fed grounded untreated corncob-sun-dried poultry litter mixture ration with different energy supplements. Sixteen (16) rams of about 10-12 months of age and having an average weight of 24kg were used in an 84-day feeding trial. The rams were randomly assigned into four (4) treatments with four (4) replicates per treatment in a completely randomized design (CRD). Four experimental diets were formulated and were used to feed the growing Yankasa rams. Results on blood haematological parameters revealed that all the parameters measured were significantly ($P < 0.05$) different across dietary treatments except RBC before feeding were not significantly ($P > 0.05$) affected across treatment groups. Rams fed diet T2, T3 and T4 recorded higher values for PCV and Hb (before and 2-hours after feeding), although statistically ($P > 0.05$) similar. Rams fed diets T1 and T2 had significantly ($P < 0.05$) higher values in RBC and WBC, respectively, compared to other treatments. The Erythrocyte index which comprises MCV, MCH and MCHC were all significantly ($P < 0.05$) higher in rams fed diet T4 compared to other treatments. Although, statistically ($P > 0.05$) similar values were observed in the erythrocyte values across dietary treatments. For the serum biochemistry, significant variation ($p < 0.05$) due to different energy supplementation was observed. Rams fed diet T1, T3 and T4 recorded significantly ($P < 0.05$) higher values in TBP. The results also showed that there were significant ($p < 0.05$) differences in the blood haematological and biochemical parameters (Packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cell (WBC), blood urea, blood protein, blood glucose and creatinine) before and 2 hours after feeding of the rams though they all fell within the normal range for rams. It can be concluded that feeding of corn cobs with energy and protein supplements to rams offers a potential result in the haematological and biochemical parameters of Yankasa rams without any deleterious effects, hence its potential in ruminant nutrition. According to the results of this study, feeding growing Yankasa rams with untreated corn cobs with sun dried poultry litter basal material with 150g WO has effect on growth performance compared to the other treatments.

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INTRODUCTION

Hematology is the scientific study of the nature, function and disease of blood which can provide important information for diagnosis and disease in animals while serum biochemistry refers to the chemical analysis of blood serum (1). Blood haematology and serum chemistry have been used as a tool in health assessments and nutritional status for a range of both wild and domestic animals and so can be an essential part of investigating the success or failure of reintroduction programs (2; 3). Hematology and serum parameters have been observed to be good indicators of the physiological status of animal and changes in them are important in assessing the response of animal to various physiological and nutritional situations (1). Blood biochemistry studies are usually carried out to establish the diagnostic baseline of blood characteristics for routine management practice of farm animals (4). Hematological factors are used to describe the health status of animal and stress due to environment, nutrition and pathological factors (1).

Ogbu *et al.*, (5) postulated that the parameters influencing the hematology and serum bio-chemistry of various animals are typically under two broad categories e.g. genetic and non-genetic parameters. Changes in metabolism, productivity and livestock health status can be monitored through blood tests (6). Ibhaze *et al.*, (7) speculated that blood elements are good pointers of the physiological and health status of individuals and can be used to predict health deviations caused by various factors. Blood functions basically in carrying nutrients, oxygen and waste excretory products to and from various cells and organs of the body, distributing nutrients and enzymes to cells and carrying away waste products thereby maintaining homeostasis of the internal environment (8). Blood constituents change in relation to health conditions (9). The determination of blood components by laboratory tests is an important procedure to assist in the diagnosis of various livestock diseases and disorders (10).

Common parameters observed in blood tests include erythrocyte profile, leucocyte profile,

hemoglobin, hematocrit, and erythrocyte index (11; 12). Erythrocyte index comprises mean corpuscular volume MCV, mean corpuscular hemoglobin MCH and mean corpuscular hemoglobin concentration MCHC (13). Thus, it is important to know these variations when assessing clinical blood parameters in livestock (10). Laboratory blood tests would be a vital tool to help detect any deviation from normal state of wellbeing of hence, it is important to establish standard values for the various blood parameters based on age aforementioned genetic and non-genetic parameters (14). The aim of this study was to determine the hematological and serum biochemical profile of apparently healthy Yankasa rams fed grounded untreated corn cob-sun-dried poultry litter mixture ration with different energy supplements.

MATERIALS AND METHODS

Experimental Site

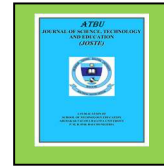
The study was conducted at the Animal Farm of Aminu Saleh College of Education Azare Bauchi State from January – April, 2022. Azare is the second largest town in Bauchi State. It is situated between latitudes 11° 42' and 11° 40' and longitude 10° 11' east (15), at an elevation of 436 meters above sea level. It is 250km north of the state capital, Bauchi. It has an estimated land area of 11200 square kilometers (16) located within the Sudan savanna agro-ecological zone of Nigeria. The annual rainfall is unimodal which averages about 700mm with a maximum temperature of 35°C. The mean monthly temperatures ranges from 20.10 - 22.50°C in December and January to 30.0 - 32.5°C in April and May. The temperature of the rainy season remains steady between 25°C - 27°C for the month of June to October. The soils in the area are formed normally from Aeolian and/or alluvial deposits, and belongs to the entisols or inceptisol orders and the soil temperature regime is isohypothermic. The geology of the area is made up of sedimentary rocks comprising the kerri-kerri (sandstone) and Chad formation (17).

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Collection of test ingredient

a. Corn cob

The test material (corn cob) was obtained from feed mill in Bauchi metropolis where the corn cob had already been grounded and bagged. To allow for more microbial digestion and passage out of the rumen, rumination and particle size reduction was considered essential functions to increase surface area of these feed particles (18). The feed was stored in appropriate, designated areas in an economical manner (19). Feed in sacks used were stored off the floor and away from the walls on pallets or racks, and each sack was labeled, as recommended by the (20).

b. Sun-dried poultry litter (SDPL)

Broiler litter (deep litter) was collected from poultry farms within Bauchi metropolis. The poultry litter was collected from a finished broiler pens farm after the birds had attained eight (8) weeks; where it had been stored in an enclosed container before subsequent drying and pelleting (21). The litter was a mixture of chicken faeces, residual feeds, feathers and material used as bedding such as wood shavings, sawdust and rice bran (22). The litter was spread (sun-dried) on cellophane sheets for air-drying for three days, referred to as sun-dried poultry litter SDPL (23). Management practices for poultry litter to reduce nutrient losses from production facilities were carried out as in Kleinman *et al.* (24) and were then packed into synthetic bags and transported to the animal farm and stored there for use.

Experimental diets

Four experimental diets were compounded using the corn cobs and the diets contained 150g MB + 150g SDPL, 150g RB + 150g SDPL, 150g MO + 150g SDPL and 150g WO + 150g SDPL supplements and corn cob was offered as basal diet, and these diets were tagged treatment T1, T2, T3 and T4 respectively.

Thus:

Treatment 1 *Ad lib* feeding of untreated corn cobs (Basal diet) + 150g MB + 150g SDPL)

Treatment 2 *Ad lib* feeding of untreated corn cobs (Basal diet) + 150g RB + 150g SDPL)

Treatment 3 *Ad lib* feeding of untreated corn cobs (Basal diet) + 150g MO + 150g SDPL)

Treatment 4 *Ad lib* feeding of untreated corn cobs (Basal diet) + 150g WO + 150g SDPL)

Experimental animals, housing and management

A total of sixteen (16) rams of average age of 10-12 months and average weight of 24 kg were bought from open market in a local market Bauchi and used for the study. Two weeks to the arrival of the animals, the experimental house was washed thoroughly using detergent and disinfectant (Izal) and allowed to dry. The feeding troughs and drinkers were also washed, sun-dried and kept in each compartment. After the arrival of the animals to the experimental site, all animals were thoroughly examined and closely monitored on the general health state (body temperature, food intake, behaviour, internal and external parasites and signs of their presence), and then especially on the respiratory system as described (25). The animals were quarantined for three weeks during which they were identified using numbered plastic ear tags for easy identification. On arrival to the farm, the animals were treated against endo and ectoparasites using ivermectin and vaccinated against *Peste des petits ruminants* (PPR) disease using the PPR vaccine.

The animals were weighed and randomly allotted into four (4) treatments groups and each treatment group had four (4) replicates. About 14 days were allowed for adjustment to the feed as well as the environment before data collection commenced. The animals were housed in individual pen equipped with concrete floor, feeders and drinkers under a common roof, constructed to minimize possibility of injury from aggressive behaviour or escape, to provide adequate ventilation, to enable animal to gain weight and other performance traits that may be depressed as a result of over-crowding, to allow for protection from wastes and to make appropriate postural adjustments (26). Daily, 150g of the concentrate supplements was offered to the animals at about 8:00 hour, the corn cob basal diet was served to the animals and this was *ad libitum*. Feeding of the corn cob basal diet was done twice,

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the first feeding was at about 10:00 hour while the second feeding was at 14:00 hour to help reduce wastage and encourage intake. All groups got minerals block or salt lick in pens which have advantages both in improving texture of food and in health (27). Animals were provided with fresh feed and water daily in a consistent manner, on a regular schedule, to give the animals the right to hygienic water and freedom from thirst in accordance with the requirements established for each species by the NRC (28) and as recommended for the geographic area. Feed intake was measured by subtracting the weight of the left-over feed from the total weight of feed supplied. The animals were weighed weekly in order to find out their body weight changes.

Sanitation, Health Management and Animal Welfare

All animals in this trial were managed according to guidelines recommended in the Guide for the Care and Use of Agriculture Animals in Agriculture Research and Teaching to ensure the animal incurs no undue pain or stress (29). Much attention as possible was shown to the needs and natures of animals (30). The aim was to provide a platform geared towards educating the scientific world on global best practices as it concerns humane handling and use of laboratory/experimental animals for research purposes (31). *Faeces and urine were removed every day from the feeding pens to ensure adequate ventilation, less ammonia (NH₃) accumulation, adequate cleanliness of the experimental pens and ensure minimum discomfort of the experimental animals.*

EXPERIMENTAL DESIGN

A one (untreated corn cob) by four (supplements) factorial experiment in a completely randomized design (CRD) was used for the experiment (32). There were four (4) treatments with four (4) rams per treatment (total of 16 rams).

Data collection and Laboratory Analysis Blood Sample Collection

At the eight (8) weeks of the experiment after disinfecting of the sampling area, about 6 mls of replicate blood sample was collected before and two hours after feeding from the jugular vein of each animal (punctured) using 10 ml disposable syringes and needles (21 gauge) in clean, evacuated from air and left for agglutination for haematology, serum-protein and urea analysis. Blood samples for haematology were collected into properly labeled, sterilized vacutainer tube containing EDTA (ethylene diamine tetra-acetic acid) as anticoagulant. The sample tubes were filled to the 2nd mark and gently inverted repeated after replacing the cap to avoid clotting. Blood samples were taken thereafter to a nearby laboratory to determine the packed cell volume (PCV), hemoglobin (Hb) count, the red blood (RBC) white blood cell counts (WBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), creatinine, blood glucose (BG), 2-hourly postprandial (2HPP), total blood protein (TBP) and blood urea nitrogen (BUN).

Haematological Analysis

A number of haematological indices such as PCV, RBC, WBC, Hb, MCV, MCH, MCHC are used to assess the functional status of the blood stream and as an indicator of heavy metal pollution (33), herbicide pollution (34). The blood samples collected and analyzed for haematological indices were determined as described by (35). Hematological studies are usually undertaken to establish the diagnostic baselines of blood characteristics for routine management practices of farm animals (36).

Other Blood Constituents

Blood constituents (Mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were calculated from packed cell volume, haemoglobin concentration and red blood cells values as described by (35):

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$$MCV (\mu^3) = \frac{\text{Packed cell volume}}{\text{Red blood cell count } (\frac{\text{millions}}{\text{mm}^3})} \times 10 \dots$$

$$MCH (\mu\mu^g) = \frac{\text{Hb in g/100ml blood}}{\text{Red blood cell count}} \times 10 \dots$$

$$MCHC (\%) = \frac{\text{Hb in } \frac{g}{100ml \text{ blood}}}{\text{Packed cell volume}} \times 100 \dots$$

Blood Biochemistry

Serological samples (for serum protein and urea) were collected into anticoagulant-free tubes (without EDTA) to allow blood clotting, and serum was decanted for the analysis. Serum was obtained after the blood was allowed to stand for 2 hours at room temperature and centrifuged at 3,000 revolutions per minute (rpm) for 30 minutes to separate the cells from the serum. The blood samples collected without coagulant were used to determine the biochemical components such as total blood protein (TBP). Serum total protein and its components were obtained as described by (37) and the metabolites (blood urea) were determined as described by Eun *et al.* (38) using biuret method. The samples for the serum biochemistry were centrifuged for five minutes so

as to separate the serum from the whole blood for the evaluation of serum biochemical indices as per the procedure of Kolo *et al.* (39). Concentrations of plasma glucose was determined with commercial kits (Pars Azmoon kits, Pars Azmoon, Tehran, Iran) and an automated chemistry analyzer (Dirui CS-400, Changchun, China) (40).

STATISTICAL ANALYSIS

All data obtained from the study were subjected to analyses of variance (ANOVA) procedure of completely randomized design (CRD) using using SPSS software version 25.0 (41). The results were presented as the mean values and standard error of the means. Differences between treatment means were tested by Duncan's multiple range test method and declared significant at $P < 0.05$ (42).

RESULTS AND DISCUSSION

The results of chemical composition i.e. moisture content, dry matter (DM), crude protein (CP), crude fibre (CF), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), cellulose, hemicellulose, lignin, ether extract (EE) and ash contents of all the feed ingredients used in the feeding trial is presented in Table 1.

Table 1: Chemical composition of experimental diets

Parameters	Diets				
	Corn cob (CC)	TRT 1 CC + MB + SDPL	TRT 2 CC + RB + SDPL	TRT 3 CC + MO + SDPL	TRT 4 CC + WO + SDPL
Moisture	4.57	4.19	3.71	4.57	5.36
Ash	1.80	1.74	1.45	1.89	2.15
CP	4.98	11.38	10.76	11.09	13.86
CF	35.08	31.09	26.42	24.56	21.18
DM	95.43	95.81	96.30	95.43	94.64
EE	4.80	5.87	10.70	10.81	9.96
NFE	48.76	45.72	46.98	47.09	45.51
NDF	41.22	36.48	31.06	28.89	26.96
Cellulose	10.10	9.13	7.77	7.10	6.75
Hemicellulose	9.91	10.40	14.58	14.40	13.34
Lignin	8.77	8.57	9.81	9.43	8.81
ADF	28.20	27.54	31.52	30.31	28.32

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CP = Crude proterin; CF = Crude fibre; DM = Dry matter; EE = Ether extract; NFE = Nitrogen free extract; NDF = Neutr detergent fibre; ADF = Acid detergent fibre; TRT = Treatment; CC = Corn cob
 The haematology for rams fed corn cob diets is shown in Table 2.

Table 2: Haematological parameters of Yankasa rams fed untreated corn cob with different energy sources

Parameters	Treatments				Ref. Value	SEM
	TRT 1	TRT 2	TRT 3	TRT 4		
PCV Before Feeding	29.49 ^b	34.20 ^a	32.57 ^{ab}	32.01 ^{ab}	21-35	1.88*
PCV 2 hours After Feeding	30.73 ^b	37.45 ^a	36.89 ^a	38.79 ^a		2.31*
Hb Before Feeding	9.83 ^b	11.41 ^a	10.86 ^{ab}	10.67 ^{ab}	9-15	0.63*
Hb 2 hours After Feeding	10.24 ^b	12.48 ^a	11.55 ^{ab}	12.93 ^a		0.78*
RBC Before Feeding	9.37	9.24	9.72	9.28	8.0-18.0	0.29 ^{NS}
RBC 2 hours After Feeding	10.48 ^a	10.27 ^{ab}	9.38 ^c	9.88 ^{bc}		0.29*
WBC Before Feeding	10.34 ^b	55.55 ^a	11.95 ^b	9.79 ^b	4.0-13.0	11.00*
WBC 2 hours After Feeding	83.59 ^a	92.15 ^a	10.70 ^b	11.30 ^b		15.65*
MCV Before Feeding	37.42 ^{ab}	36.13 ^b	39.03 ^a	37.78 ^{ab}	28.00–40.0	0.92*
MCV 2 hours After Feeding	39.30 ^b	38.70 ^b	50.86 ^a	52.34 ^a		4.57*
MCH Before Feeding	12.72 ^b	12.40 ^{bc}	11.10 ^c	14.58 ^a		0.74*
MCH 2 hours After Feeding	12.81 ^b	12.34 ^b	12.06 ^b	14.62 ^a		0.76*
MCHC Before Feeding	28.78 ^b	30.47 ^b	28.93 ^b	32.48 ^a	30.00–36.00	0.86*
MCHC 2 hours After Feeding	28.40 ^{ab}	29.63 ^a	25.77 ^b	27.37 ^{ab}		1.63*

^{abc}Means with different superscript within rows differed significantly (P<0.05), SEM = Standard Error of Mean. NS = Not significant, TRT = Treatment, MB = Maize bran, RB = Rice bran, MO = Millet ofal, WO = Wheat ofal, SDPL = Sun-dried poultry litter, BF = Before feeding, AF = After feeding, PCV = Packed cell volume, Hb = Haemoglobin, RBC = Red blood cell, WBC = White blood cell, MCV = Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration

The red blood cells (RBC), White Blood Cells (WBC), Packed Cell Volume (PCV), hemoglobin (Hb), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin concentration (MCHC), and Mean Corpuscular Volume (MCV) values BF and 2-hours AF sampling were significantly (P<0.05) different across the different energy supplement included diet groups except RBC BF was not significantly (P>0.05) different across treatments.

The mean values for PCV obtained before feeding (29.49 – 34.20%) and 2-hours after feeding (30.73 – 38.79%) were higher compared to 22.9 – 29.4 and 35.79 - 36.04%, and 30.69 - 37.94% reported by (43) for Yankasa rams, and West African dwarf sheep reported by (44), respectively. It is also higher than 27.21 – 30.02% for WAD rams fed silage combinations of maize forage and velvet beans (45), but fell within the normal range of 24-45% and 25-45% reported by (46) and (47), respectively, for healthy rams. The

observed increased PCV may be associated with improved nutritional components of the rations as reported by (48). This could also mean that Yankasa rams react to different rations differently (9). Bello *et al.* (50) attributed this difference as a result of age difference in animals used and also difference in species.

Similarly, (51) reported that PCV is generally used as an index of toxicity and its value is being influenced by breeds, age and sex of the animal. Increase in PCV values in this study may be attributing to increase in environmental temperature (52). Bello and Tsado (53) stated that normal value for PCV suggested that there was no presence of toxic factor (such as haemagglutinin) which has adverse effect on blood formation (43). The observed increased PCV may be associated with improved nutritional components of the rations as reported by (48). This could also mean that Yankasa rams react to different rations differently (49). The PCV provides a measure of

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toxicity in the blood, and a low value is often implicated in anaemia (54). This anaemic condition is characterized by reduced oxygen-carrying capacity of the blood, increased pulse rate, and consequently heart failure (55).

The Hb concentration values (9.83 – 11.41g/dL) before feeding and 10.24 – 12.93g/dl) 2-hours after feeding obtained in this study were significantly ($P < 0.05$) different across treatments and was found similar (9.47 – 12.22g/dl) to the work of (56). It is higher than 7.00-8.80g/dl reported by (57) on growing Yankasa ram lambs fed diets containing graded levels of sesame residue, and it is also higher than the value range (6.11– 9.87g/dl) reported for WAD ram fed ensiled *Mucuna pruriens* foliage and whole maize stover (45), but still falls within 8-16g/dL reported by (58) for sheep. Samira *et al.* (59) reported a mean value of 8.6 g/dl, which is slightly lower than the least value obtained in this study. Oloche *et al.* (60) observed higher Hb values (12.72 - 13.36g/dl). This is an indication that the diets did not have negative effect on blood synthesis (54; 61a). Okafor *et al.* (62) opined that Hb values within normal range imply that the dietary proteins fed to the experimental growing rams were of high quality and adequate indicating the absence of microcytic hypochromic anaemia caused by iron deficiency and improper utilization for the formation of Hb. Hb is the iron-containing oxygen-transporting protein in the RBCs (7).

Adejoro (63) opined that (Hb) is the iron-containing conjugated protein that transports oxygen and carbon dioxide (CO_2) across cells and tissues in the body. Jiwuba *et al.* (64) stated that increase in the Hb values is generally linked with the greater ability to the resistance of disease and the low level is an indication of disease infection and poor nutrition. The shortage of Hb in the RBCs lowers the blood oxygen-carrying capacity that could lead to anaemic condition in the individual (7). Klein (65) attributed lower level of Hb concentration to be an indicator of decreased capacity in the transport of oxygen, nutrients and others needed by body tissues, which results in metabolic disorders.

The mean value for RBC observed was 9.24 - 9.72g/l before feeding and 9.38 - 10.48 2-

hours after feeding were higher to 5.66 – 5.96 reported by (66), 4.1-4.5 reported by (67) for Djallonke rams fed haulms of four varieties of groundnut (*Arachis hypogaea L.*), but lower when compared to 11.04 – 12.68g/l reported by (56). It is also lower than 10.82 - 16.11 for West African dwarf rams reported by (68) and 10.00 – 18.81 $\times 10^6\text{mm}^3$ reported by (25) who fed fermented maize cob-based diets to WAD goats. The RBC values was similar to 10.35-10.95 for Red Sokoto does reported by (69). Higher RBC counts could imply that there would be adequate transport of oxygen and carbon dioxide in the body. Thus, (70) speculated that a reduced level of these constituent's RBC count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of CO_2 returned to the lungs. Renny Fatmyah Utamy *et al.*, (71) stated that increased levels of RBC count indicate that the oxygen content in the blood may increase, which has a positive impact on the body's metabolic activity. Udokainyang *et al.*, (72) had earlier postulated that lower RBC could be a wrong signal on the health status of the various age groups among animals. RBCs (erythrocytes) have the main function of transporting oxygen from the lungs to all body tissues and transporting CO_2 from the tissues to be excreted through the lungs, that function is well done-out by Hb (73).

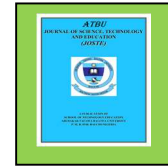
Fadare *et al.* (74) opined that sex and coat colour and sex significantly affected RBC and WBC in WAD sheep. Rahman *et al.* (75) also asserted that juvenile sheep have greater RBC mass than adults measured by high Hb and PCV level. Bunn, (76) alleged that when an animal moves to a higher attitude, the RBC count increases for several weeks. Bunn (76) also reported that lower than normal numbers of RBCs may be due to anaemia, bone marrow failure (for example, from radiation, toxins or tumour), erythropoietin deficiency (secondary to kidney disease), haemolysis (RBC destruction due to blood vessel injury or other causes) hemorrhage (bleeding), malnutrition, nutritional deficiencies or iron, copper, folate, vitamin B^{12} , vitamin B^6 , over-dehydration, pregnancy among others. Some drugs also decrease the RBC count. Nyaulingo (77) stated that normal red blood cell, pack cell

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volume and haemoglobin production in livestock requires diets containing protein, iron, copper, vitamin B², B⁶, B¹² and folic acids. Shittu *et al.* (61a) reported that the quality and amount of red blood cells in the animal's body depend on nutrient availability, state of health and physiological status of the animal. It was reported that ruminants with the good haematological composition are likely to exhibit better performance and productivity (78).

The values for WBC counts in this study ranged between 9.79 – 55.55 × 10³/μl before feeding and 10.70-92.15× 10³/μl 2-hours after feeding was higher compared to the work of others such as: 8.8 - 10.4 (66), 10.04 – 13.64 (56) and 9.60 – 12.00 (65). It is also higher than 6.63 and 8.25 × 10³/μl reported by (54) for WAD sheep fed different combinations of Guinea grass and ensiled *Alternanthera brasiliana* (L.) O. Kuntze based diets and 7.43 – 8.85 × 10³/μl reported for rams fed ensiled *Mucuna pruriens* and whole maize stover for healthy sheep (45). Also, the significant variations in the WBC counts of sheep on treatment diets in this study could be attributed in part to improved digestibility and utilization of nutrients in the diets (78). The values obtained which suggests that the animals did not experience any stress to have triggered the body's immune system to produce more WBCs for defense. The physiological values of WBC obtained in this study may suggest well developed immune system of the experimental rams or absence of foreign bodies or parasites in the circulatory system of experimental animals (63) and the rams did not experience any stress to have triggered the body's immune system to produce more WBCs for defense.

The WBCs are indicators to immune response to foreign bodies in the organism (72). The higher values of WBC reported in this study, indicates a strong ability to fight disease (79). The implication of this is that the diet did not predispose the animals to any stress and disease. The major functions of the white blood cell and its differentials are to fight infections, defend the blood by phagocytosis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response (80). Afolayan *et al.* (81) reported that animals with low

WBC are exposed to high risk of disease infection, while those with high counts have high degree of resistance to diseases and enhanced adaptability to local environmental and disease prevalent conditions. Braun (83) stated that high WBC count might be as a result from stress, disorder in the immune system, and infection.

Osita *et al.* (84) postulated that increased WBC counts might be related to the production of more immune cells (and thus antibodies) that play an important role in defending the biological system against diseases. MCV defines the size of the RBCs and is expressed as femtoliters (10⁻¹⁵; fl) or as cubic microns (μm³). MCV values for this study ranged from 36.13 - 39.03fl and 38.70-52.34fl before feeding and 2-hours after feeding, respectively were higher than the MCV values 17.17 to 22.17fl and 17.09 to 17.60fl reported by (61) and (60), respectively. It was also higher than 24.12 ± 0.30 - 24.37 ± 0.47 for ram lambs fed total mixed rations (TMR) containing different tree barks reported by (85) and 26.04 - 26.66fl for West African dwarf sheep fed diet with or without *Saccharomyces cerevisiae* supplementation reported by (84). MCV is an indication of high cell turn over, often increasing the probability of releasing immature RBC into the circulatory system (62). Mean corpuscular volume (MCV) is the expression of the average volume of individual red blood cells (86).

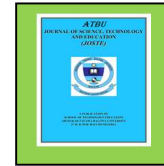
MCH quantifies the amount of Hb per RBC. The normal values for MCH are 29 ± 2 picograms (pg) per cell. The MCH values were significant (P<0.05) different across dietary treatments. The mean MCH values were 11.10 - 14.62Pg and 12.06 - 14.62Pg for before and 2-hours after feeding, respectively. The MCH values obtained in this study were lower compared to 22.82 ± 2.23 - 25.95 ± 2.94Pg reported by (13) for Bali cattle during the various periods of parturition. The values for MCH obtained in this study were higher compared to 8.22 ± 0.14 - 8.47 ± 0.20Pg for ram lambs fed total mixed rations containing different tree barks reported by (85). However, Merdana *et al.* (13) observed a slight decrease in MCH in Bali cattle and attributed the decrease to iron deficiency in animals after giving birth (87).

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MCH estimates the proportion of Hb to RBCs in a given volume of blood (88). MCH is one of the haematological parameters listed in the diagnosis of anaemia and also act as a useful guide to reveal the capacity of the bone marrow to produce RBCs, aside MCV and MCHC (89). The MCH is the concentration of Hb in a given volume of packed RBCs (86).

The MCHC values ranged between 28.78 - 32.48g/dl before feeding and 25.77 - 29.63g/dl 2-hours after feeding were lower than 37.85 ± 0.30 - 40.04 ± 0.27 reported by (90) in Norduz sheep, but similar with 33.00 and 34.25g/dl reported for WAD sheep fed different combinations of guinea grass and ensiled *Alternanthera brasiliensis* (L.) O. Kuntze based diets by (54). These values obtained in this study are within the range of 32.0 – 33.23g/dl reported for WAD goats (91) and 31 - 34 reference values reported by (92). Increased MCHC can be found in animals with severe ionic troubles or those who have been regaled with some drugs (93). Jones (94) stated that the most common cause of a slightly decreased MCHC is a strongly regenerative anemia, because immature red cells (polychromatophils) contain less than a full complement of Hb (94). He (94) further stated that

iron deficiency anemia may also cause a decreased MCHC, and hypochromasia (pale red cells) may be visible on the blood film. However, all the MCHC values obtained in this study are within the normal range for normal sheep.

Akanmu *et al.* (88) postulated that MCHC estimates the amount of Hb per unit volume in a single RBC by taking into account the volume or size of the RBC. The result of MCHC obtained in this study implies that the diets supported the sheep's good health status and indicated the absence of anaemia amongst the experimental treatment diets. The MCHC measures the concentration of Hb in a given volume of packed red blood cells (86). MCHC is very significant in diagnosis of anaemia and is an index of the capacity of the bone marrow to produce RBC (95). Etim (80) listed MCHC as one of the important haematological parameters for the diagnosis of anaemia and serve as a useful index of the capacity of bone marrow to produce RBCs. Rahman *et al.*, (74) asserted that all these variations in different parameters may be due to diet, water level of body, stress, hormonal influence, and surrounding environmental condition.

Table 3: Blood biochemistry of Yankasa rams fed untreated corn cobs with different energy sources

Parameters	Treatments				Ref Value	SEM
	TRT 1	TRT 2	TRT 3	TRT 4		
TBP BF	63.86 ^{ab}	60.91 ^b	67.07 ^a	66.43 ^{ab}		2.93*
TBP 2 hours AF	83.34 ^a	78.48 ^b	80.92 ^{ab}	80.07 ^{ab}		2.41*
TBU BF	8.05 ^b	8.92 ^a	7.89 ^b	7.63 ^b	3 – 10	0.35*
TBU 2 hours AF	9.74 ^a	8.45 ^b	8.44 ^b	8.35 ^b		0.40*
Glucose BF	1.02 ^a	0.58 ^c	0.77 ^b	0.73 ^b	2.4 – 4.0	0.06*
Glucose 2 hours AF	0.98 ^b	1.21 ^b	1.65 ^a	1.67 ^a		0.18*
Creatinine BF	124.02	137.72	133.06	143.13	88.4 – 159	12.26 ^{NS}
Creatinine 2 hours AF	150.15	135.85	145.06	148.73		10.16 ^{NS}

^{abc}Means with different superscript within rows differed significantly (P<0.05), SEM = Standard Error of Mean. NS = Not significant, TRT = Treatment, MB = Maize bran, RB = Rice bran, MO = Millet ofal, WO = Wheat ofal, SDPL = Sun-dried poultry litter, BF = Before feeding, AF = After feeding, TBP = Total blood protein, TBU = Total blood urea

The result of blood biochemical parameters of the experimental rams is presented in Table 3. Metabolic profile testing is a series of blood chemistry tests on animals, and are being

frequently measured as indicators of the nutritional status, physiological state, health conditions, metabolic functions and immune function of individuals or group of animals (97; 98). Generally, measuring the systemic concentrations

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of serum metabolites could be useful to the overall physiological characterization of animals divergent in breed and sex (99). Qiu *et al.*, (99) stated that serum metabolites are typically affected by several factors such as diet type, physiological status, and perhaps even animal genetics. There was significant ($P < 0.05$) differences in all the blood serum parameters (before and 2-hours after feeding) among different groups except for creatinine not significantly ($P > 0.05$) affected (before and 2-hours after feeding) across treatments.

Total protein concentrations before feeding 60.91 - 67.07g/l and 2-hours after feeding 78.48 - 80.92g/l. was significantly ($P < 0.05$) different across dietary treatments. Total protein (TP) was higher significantly ($P < 0.05$) in rams fed diet T3 (67.07g/dl before feeding and 80.92g/dl 2-hours after feeding) compared to other dietary treatments. The serum total protein obtained (60.91 - 67.07 and 78.48 - 83.34) before and 2-hours after feeding, respectively, were slightly lower than 65.00 - 94.82 and 88.71 - 97.54g/l observed in WAD goats fed treated maize cob and maize husk-based diets with mixture of microorganisms, respectively (7). It was higher than 53.03 ± 1.06 - 55.08 ± 1.29 g/l and 30.75 ± 4.47 - 43.25 ± 2.94 g/l for initiation and final TBP, respectively, reported (100) for fattening lambs fed diets containing finger millet straw and corn straw. This variation might be due to breed of animal, environmental condition, and concentration of protein in diet (101).

This shows that the test diets had adequate supply of protein, because total serum protein is an indicator of protein quality of feed. Such elevated serum TP levels could indicate dehydration, high temperature, kidney or liver disease, or increased intake of grains (102). Pazla *et al.* (103) opined that the increase in total protein indicates a positive thing that there is a decrease in the proteolytic process in the rumen by inhibiting the conversion of amino acids (AA) to ammonia (NH_3). Tothova *et al.* (104) also opined that the concentrations of total serum protein and cholesterol in the blood are regulated to balance physiological functions that cater for immunity, coagulation, small molecule transport and

inflammation, and any huge variation in the concentration of these serum variables might indicate impaired physiological function. Dietary protein has influence on the serum protein which in turn manifest on the total protein value (105). The high value obtained in this study may be attributed to vitamin A deficiency; the deficiency increased blood albumin levels which in turn increased serum protein (106). Mohammed *et al.* (107) opined that under extensive management, the serum TP levels could be high. Although, rams fed diet T1, T3 and T4 had statistically ($P > 0.05$) similar values. However, total protein of blood slightly increased when rams fed T1, T3 and T4 compared with T2 rams. The results were in accordance with previous report suggesting improved blood metabolism in lambs and in sheep (109).

The BUN values of the experimental rams ranged from 7.63 - 8.92 and 8.35 - 9.74 before and 2-hours after feeding, respectively. Although there was significant ($P < 0.05$) differences among the treatment means, BUN values seemed to slightly increase 2- hours after feeding across treatments. Blood urea was observed to be highest significantly ($P < 0.05$) for rams fed diet T2 (8.92 mmol/L) before feeding and rams fed diet T1 (9.74mmol/L) 2-hours after feeding compared to other treatments. The BUN values obtained in this study are lower to the BUN values 17.74 - 21.72mg/dl reported by (111) for WAD bucks fed *Vigna unguiculata L.* (cowpea) husk and *Gmelina arborea* Roxb as basal diet. Millam *et al.* (112) speculated that blood urea measurement is used specially to indicate renal disease and to a lesser extent liver dysfunction. Higher values obtained for blood urea were within the normal range (2.8 - 7.1mmol/L) recommended for sheep as reported by (113).

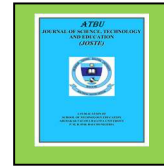
The lower urea concentrations recorded was attributed to a better synchrony and utilization of energy and N released in the rumen (114). Itodo *et al.* (115) stated that the increase in urea may be due to increase in protein catabolism in mammalian body or from inefficient conversion of NH_3 to urea. Oyibo *et al.* (116) opined that normal urea values indicate that the protein was well utilized, and that it also indicates that the quality of

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protein fed was high. BUN values are used to determine kidney functionality because urea is a waste product, which is removed during glomerular filtration unless re-utilized in the rumen via the urea cycle (88).

There was significant ($p < 0.05$) difference in blood glucose (BG) before and 2-hours after feeding across dietary treatments. The BG values obtained in this study ranged from 0.58 - 1.02 before feeding and 0.98 - 1.67 2-hours after feeding. Delany *et al.* (117) reported higher BG concentration in cows fed TMR as compared to those grazed in pasture and supplemented with concentrate. Glucose is the final and main product of the digestion of carbohydrates (CHOs) that circulate with the blood (103). Pazla *et al.* (103) postulated that apart from being a source of energy, glucose in ruminants is also crucial in maintaining body cells, especially blood and muscle. When there is an insufficient supply of glucose (from metabolism of feed or due to low insulin levels) to support normal energy demands, the body catabolizes its internal energy sources to produce ketone bodies, such as acetone, to compensate for the energy requirement (118; 119).

The creatinine concentration in this study which ranges between 124.02 - 143.13 and 135.85 - 150.15 before feeding and 2-hours after feeding, respectively, were not significantly ($P > 0.05$) different across dietary treatments. Kewan *et al.*, (120) asserted that when plasma creatinine concentrations are low, it suggests that damage to the kidney did not occur in animal. The serum creatinine concentrations in the rams fed diets T4 (143.13) before feeding was higher values than the other treatments while rams fed diet T1 (150.15 mg/dL) 2-hours after feeding had higher compared to other treatments. The differences in creatinine observed is most likely related to animal body size, muscle mass and exercise (121). Previous researchers reported that creatinine concentration was closely related to body size and muscle mass (122; 123). Creatinine is also positively correlated with muscle mass and negatively correlated with back fat in sheep (124). Furthermore, the status of creatinine concentration in the serum is also influenced by

muscle mass and exercise (125). Carlos *et al.* (126) and Santo da Cruz *et al.* (127) suggested that high creatinine concentration in adult animals has to do with the demand for phosphor-creatinine for muscle mass gain.

CONCLUSION

It may be concluded from the results of the current study that urea-treated or untreated corn cob based diets with energy and protein supplements could be fed to growing Yankasa rams without any adverse effects on the haemato-biochemical indices

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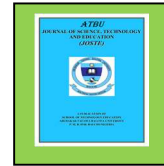
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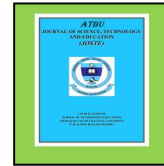
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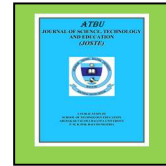
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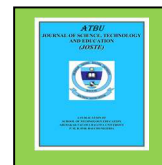
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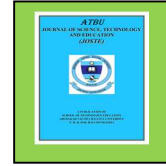
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