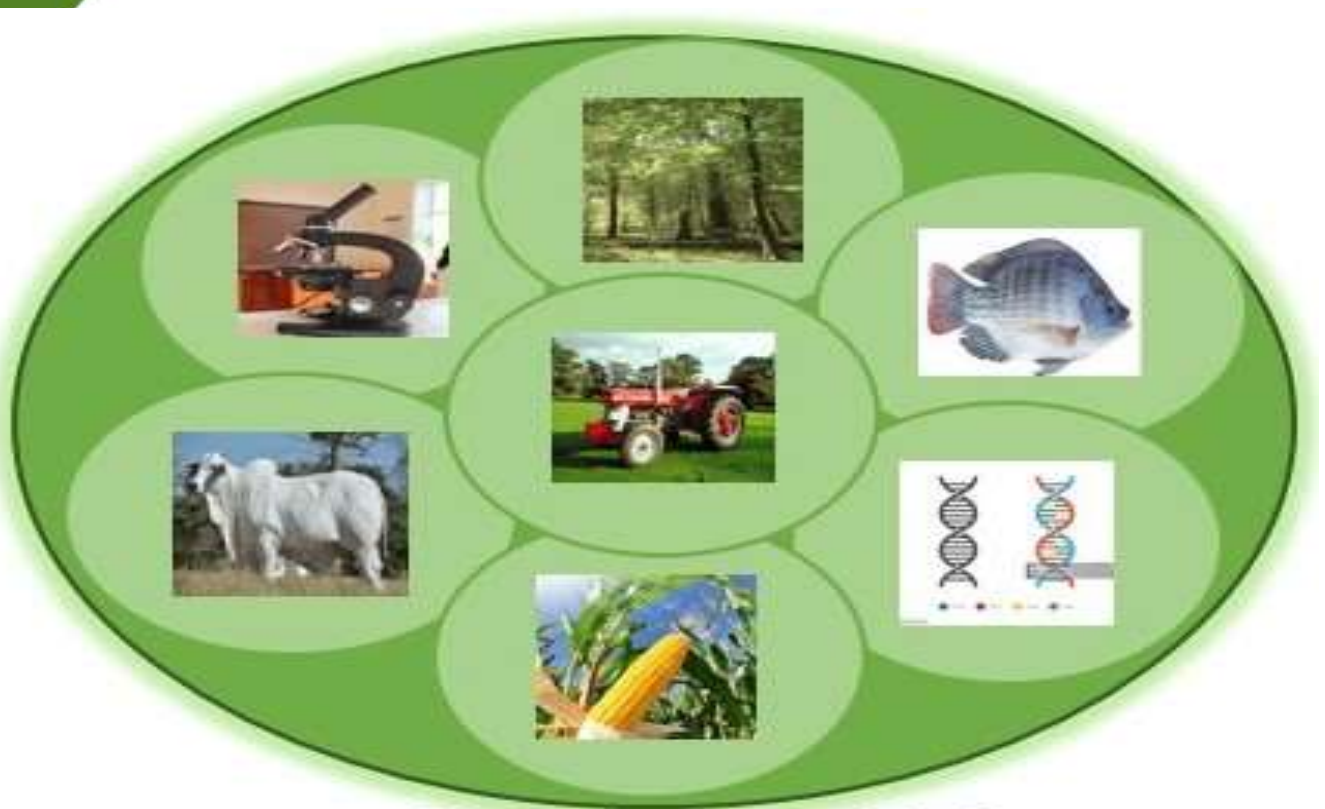




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## HAEMATOLOGICAL PARAMETERS AND SERUM BIOCHEMISTRY OF UDA SHEEP FED ENSILED MILLET PANICLE HUSK MEAL IN REPLACEMENT OF COWPEA HUSK

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### ABSTRACT

This study evaluated the haematological and serum biochemical responses of Uda sheep fed diets containing ensiled urea-treated millet panicle husk meal (EUTMPHM) as a replacement for cowpea husk. Sixteen (16) growing Uda rams were randomly assigned to four dietary treatments in a completely randomized design, with EUTMPHM replacing cowpea husk at 0%, 10%, 20%, and 30% inclusion levels. Blood samples were collected at the end of the feeding trial to assess haematological indices and serum metabolites. Results indicated that most haematological parameters, including red blood cell count, mean corpuscular volume, and white blood cell count, remained within normal physiological ranges across all treatments. Notably, haemoglobin concentration and packed cell volume improved significantly at moderate inclusion levels, suggesting enhanced oxygen-carrying capacity. Serum biochemical analysis revealed stable lipid profiles and renal function, although reductions in total protein, albumin, and cholesterol were observed at higher inclusion levels. The findings suggest that EUTMPHM can be safely incorporated up to 30% in the diets of Uda sheep without compromising health status. However, nutritional supplementation may be necessary to optimize protein and energy balance. This study supports millet panicle husk as a sustainable feed resource in small ruminant production systems.

**Keywords:** Haematological Parameters, Serum Biochemistry, Uda Sheep, Millet Panicle Husk, Cowpea husk, sustainable Feed Resource.

## Introduction

Global demand for animal protein is driving the intensification of short-cycle livestock systems, emphasizing species such as goats, sheep, and micro-livestock like the grass cutter, which require minimal management inputs (Smith and Jones, 2021). Sheep (*Ovis aries*) were first domesticated in Southwest and Central Asia around 8,000–10,000 years ago and are particularly suited to arid and semi-arid regions where cattle productivity is limited (Zeder, 2020). In Nigeria's predominantly extensive small-ruminant sector, seasonal feed shortages impose nutritional stress, contributing to post-weaning mortality rates of 30–40 percent (Adeyemi and Okoro, 2022). Early-life undernutrition not only reduces survival but also impairs growth performance and carcass yield. Carcass traits and by-products remain sensitive indicators of dietary adequacy and feeding regimen (Nguyen and Lee, 2020). Escalating costs of conventional concentrates have prompted exploration of abundant fibrous residues estimated at over 340 million tonnes annually in Africa as alternative feed resources (FAO, 2021). Millet panicle husk, a by-product of dehulling operations in Northern Nigeria, is largely underutilized despite its potential as ruminant, poultry, and swine feed (Heuzé *et al.*, 2015). Urea treatment enhances crude protein content and disrupts lignocellulosic bonds via ammonia-mediated alkalization, improving palatability and ruminal digestibility (Aruwayo *et al.*, 2023). Ensiling further conserves and augments the nutritive value of fibrous feeds, increasing voluntary intake in sheep and goats (Babayemi and Oluwaseun, 2021).

Haematological and serum biochemical indices are established, noninvasive markers for monitoring nutritional status, immune competence, and physiological stress in livestock (Evans *et al.*, 2022; WHO, 2019).

Reference values have been updated for cattle, sheep, and goats to reflect current breeds and management practices (Khan *et al.*, 2021; Olawale and Ayoade, 2020). This study evaluates the haematological and biochemical responses of Uda sheep fed ensiled, urea-treated millet panicle husk to determine its efficacy as a sustainable feed resource.

## Materials and Methods

### Experimental site

The study was carried out at the Livestock Teaching and Research Farm of Adamu Augie College of Education, Argungu, Kebbi State. Argungu serves as the headquarters of Argungu Local Government Area of Kebbi State, established in 1976. It is also the seat of the Argungu Emirate Council, which has existed since 1515, founded by Muhammadu Kanta. Argungu LGA is situated between latitudes 12°30'0" N and 12°50'0" N and longitudes 4°10'0" E to 4°50'0" E, at an elevation of 241 meters above sea level (Usman *et al.*, 2022).

### Procurement of Experimental Ingredients

The millet panicle husks were obtained from farms and threshing stations within the Argungu axis of Kebbi State. Supplementary feed components, including soybean, wheat offal, cowpea husks, urea, and common salt, were procured from the Argungu central market.

### Silage Preparation:

The millet panicle husk was ensiled with urea following a specific procedure described by Roy and Rangnekar (2006). Urea was dissolved in water, sprinkled on the husk, and ensiled for 21 days using a 1000-liter plastic water reservoir as a silos. The silos were sealed with polythene sacks and left open for three days to allow ammonia gas to escape before being mixed with other ingredients for animal

feed.

**Table 1: Gross Composition of Ensiled Urea-Treated Millet Husk**

Ingredient	Quantity
Millet panicle Husk	<b>100 kg</b>
Urea	<b>4 kg</b>
Clean Water	<b>60 L</b>

**Source: Adapted from Roy and Rangnekar (2006)**

### Experimental Diet Formulation and Design

A total of four complete diets were formulated as a replacement for cowpea husk in the ration of growing Uda rams. The inclusion levels of

ensiled millet husk were set at 0%, 10%, 20%, and 30%, corresponding to treatments T1, T2, T3, and T4, respectively. Each of the four diets was allocated to a group of four Uda rams, resulting in a total of sixteen animals. The feeding trial was conducted over a period of nine weeks (63 days) using a completely randomized design (CRD), with treatments serving as the independent variable and each ram representing a replicate within its assigned group. Animals were offered their respective diets and clean drinking water *ad libitum* throughout the trial period. The gross ingredient composition of the diets and their calculated chemical analyses are presented in Table 2.

Table 2: Gross Composition and Nutrient Estimates of Experimental Diets (%)

<b>Ingredients</b>				
	<b>T1 (0%)</b>	<b>T2 (10%)</b>	<b>T3 (20%)</b>	<b>T4 (30%)</b>
Urea-Ensiled Millet husk				0
10		20	30	
Cowpea Husk				30
20		10	0	
Wheat Offal				35
35		35	35	
Soybean meal				24
24		24	24	
Common salt				1
1		1	1	
Total				
100	100	100	100	100
<b>Calculated Chemical Analysis</b>				
ME (%)				
2146.14		2060.27	1587.03	
1573.75				
CP (%)				
13.21		12.70	12.23	
11.59				
CF (%)				
27.65		28.40	30.19	
31.45				

### Experimental Animals and Management

Sixteen Uda rams aged 12 –18 months with a mean live weight of 18 kg were used for the study. Before the commencement of the experiment, the rams were given injections consisting Oxytetracycline and Vitamin B complex at 1ml/10 kg body weight of the animal. The animals were also drenched with 1ml/10 kg body weight of Albendazole and treated against ectoparasites with 0.5 ml/10 kg of Ivomec. The animals were ear-tagged for identification and quarantined for 2 weeks. Adequate feed and clean fresh water were provided to the animals *ad libitum*.

### Blood Sample Collection

Following the feeding trial, 10 mL of blood was aseptically drawn from each ram's jugular vein using sterile tubes. Samples for hematology were collected in K<sub>2</sub>-EDTA bottles to prevent clotting, while serum biochemistry samples were placed in plain bottles to allow coagulation. After 30 minutes, serum tubes were centrifuged at 3,000 × g for 10 minutes. The separated serum was aliquoted into sterile containers and stored at –20 °C. All procedures followed veterinary biosafety

standards to prevent contamination (Mitchell *et al.*, 2023; Virginia Tech IACUC, 2017).

### Haematological Analysis

Haematological parameters were evaluated using established methods by Mitruka and Rawnsley (1977), Schalms *et al.* (1975), and Kelly (1979). Packed cell volume (PCV) was measured by microhematocrit centrifugation, while hemoglobin concentration was determined via the cyanmethemoglobin technique. Red and white blood cell counts were manually performed using a Neubauer hemocytometer following dilution in Natt–Herrick solution to enhance cell visibility. These procedures reflect current standards in ruminant diagnostics and offer key indicators of animal health (Fanta *et al.*, 2024; Ortín *et al.*, 2025).

### Biochemical Analysis

Serum biochemical parameters were assessed using standardized clinical chemistry methods. Total protein was measured via the biuret assay, while albumin was quantified using the bromocresol green dye-binding technique. Globulin was calculated by subtracting albumin from total protein, and the albumin-to-globulin (A/G) ratio was derived accordingly. Renal function indicators—blood urea nitrogen (BUN) and creatinine—were determined using enzymatic urease–glutamate dehydrogenase and modified Jaffé methods, respectively. Glucose levels were measured enzymatically via the hexokinase–glucose-6-phosphate dehydrogenase assay, and total cholesterol was assessed using cholesterol oxidase–peroxidase reagents. All analyses employed species-specific commercial kits and adhered to manufacturer protocols to ensure precision and reliability (Whitbread *et al.*, 2024; IDEXX Laboratories, 2024).

### Statistical Analysis

Data were analyzed using one-way ANOVA in SAS/STAT software (Version 9.4; SAS

Institute Inc.), and treatment means were compared using Duncan's multiple range test.

### Results and Discussions

The haematological responses of Uda rams fed diets containing graded levels of ensiled urea-treated millet panicle husk meal are presented in Table 1.4. Significant differences ( $P < 0.05$ ) were observed in haemoglobin (Hb), packed cell volume (PCV), white blood cell (WBC) count, and eosinophil levels, while other indices including red blood cells (RBC), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), monocytes, lymphocytes, and basophils remained unaffected (Adepoju and Yusuf, 2024; Zhao *et al.*, 2024). Haemoglobin concentrations ranged from 11.30 g/dL (T3) to 12.50 g/dL (T1), aligning with reference values for tropical sheep (Mahmud, 2024; Alabi and Ososanya, 2024). The elevated Hb in T1 suggests enhanced erythropoiesis, likely due to improved nitrogen utilization (Nguyen and Tran, 2024). PCV values (33.42–37.38%) exceeded those reported for West African rams (Abdullahi *et al.*, 2023) but remained within physiological norms (Radostits *et al.*, 2022), indicating increased erythrocyte mass and oxygen transport capacity (Fanta *et al.*, 2024). White blood cell counts were higher in T2 ( $5.68 \times 10^9/\mu\text{L}$ ), suggesting mild immunostimulation without inflammation, consistent with improved rumen function (Zhao *et al.*, 2024). Eosinophil levels were highest in T1 ( $0.75 \times 10^9/\text{L}$ ), possibly reflecting minor antigenic stimulation under the basal diet (Adepoju and Yusuf, 2024). Basophil counts ( $0.02\text{--}0.03 \times 10^9/\text{L}$ ) remained stable across treatments, consistent with their limited role in ruminant immunity (Tuncer, 2021). RBC counts ( $8.76\text{--}9.50 \times 10^{12}/\text{L}$ ), MCH ( $8.75\text{--}9.40$  pg), MCV (30.18–30.76 fL), and MCHC (32.29–32.61 g/dL) remained within



normal ranges (Merck Veterinary Manual, 2024; Mahmud, 2024; Arekatla *et al.*, 2021),

indicating preserved erythrocyte integrity and haemoglobin synthesis.



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Table 3: Haematological Parameters of Uda Rams Fed Graded Levels of Ensiled Urea-Treated Millet Panicle Husk Meal

Parameter	T1	T2	T3	T4	SEM	Ref. Range
Haemoglobin (g/dL)	12.50 <sup>a</sup>	11.75 <sup>ab</sup>	11.30 <sup>b</sup>	11.60 <sup>b</sup>	0.28	9 – 15
PCV (%)	37.38 <sup>a</sup>	35.30 <sup>ab</sup>	33.42 <sup>b</sup>	34.80 <sup>ab</sup>	1.30	27 – 45
RBC ( $\times 10^6/\mu\text{L}$ )	9.39	9.11	8.76	9.50	0.28	9 – 15
MCH (pg)	9.22	9.31	8.75	9.40	0.67	8 – 12
MCV (fl)	30.50	30.18	31.40	30.76	0.55	28 – 40
MCHC (g/dL)	32.61	32.50	32.50	32.29	0.45	31 – 34
WBC ( $\times 10^9/\text{L}$ )	4.18 <sup>b</sup>	5.68 <sup>a</sup>	4.70 <sup>b</sup>	4.31 <sup>b</sup>	0.33	4 – 12
Monocytes ( $\times 10^9/\text{L}$ )	0.75	0.73	0.71	0.70	0.22	0 – 0.8
Lymphocytes ( $\times 10^9/\text{L}$ )	2.31	2.40	2.32	2.38	0.28	2 – 9
Eosinophil ( $\times 10^9/\text{L}$ )	0.75 <sup>a</sup>	0.41 <sup>b</sup>	0.44 <sup>b</sup>	0.38 <sup>b</sup>	0.09	3 – 8
Basophils ( $\times 10^9/\text{L}$ )	2.60	2.50	2.70	2.34	0.25	0 – 1

Note: *ab* = means in the same rows with different superscripts are significantly different ( $P < 0.05$ ) at 5%.

Table 4 presents the serum biochemical responses of Uda rams fed diets containing graded levels of ensiled urea-treated millet panicle husk meal. No significant differences ( $P > 0.05$ ) were observed in serum albumin, globulin, total protein, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) urea concentrations. However, triglycerides, creatinine, and total cholesterol showed significant effects ( $P < 0.05$ ). Serum albumin ranged from 2.17 to 2.41 g/dL, below the ovine reference range (2.4 – 3.0 g/dL) (Merck Veterinary Manual, 2024), suggesting mild hypoalbuminemia potentially linked to limited dietary protein or hepatic stress (Yuan *et al.*, 2023). Globulin levels (3.61–3.87 g/dL) remained within normal limits, indicating stable humoral immunity. Total protein declined with increasing husk inclusion, reaching 5.82 g/dL at 20%, below the recommended 6.7–8.4 g/dL range, highlighting the need for additional rumen-degradable protein (Adepoju and Yusuf, 2021). Lipoprotein concentrations were unaffected by treatment. HDL-C (0.64–0.77

mmol/L) and LDL-C (0.80–0.89 mmol/L) remained within expected ranges (Smith *et al.*, 2022), indicating preserved lipid transport and metabolism. In contrast, triglycerides decreased significantly with husk inclusion (0.70–0.85 mmol/L vs. 1.17 mmol/L in controls), possibly reflecting altered energy metabolism or reduced hepatic VLDL synthesis (Lin *et al.*, 2023).

Creatinine levels varied significantly ( $P < 0.05$ ), declining to 85.7  $\mu\text{mol/L}$  at 20% inclusion before rising to 90.1  $\mu\text{mol/L}$  at 30%, though all values remained within the normal range (70–150  $\mu\text{mol/L}$ ) (Kebede and Gebremariam, 2022). These fluctuations may indicate changes in muscle turnover or renal function under high-fiber diets. Total cholesterol peaked at 1.95 mmol/L in the 10% husk group and dropped to 1.11 mmol/L at 20%, with control and 20% values slightly below the ovine reference (1.2–2.0 mmol/L) (Nguyen and & Tran, 2024). Serum urea remained stable (3.62–3.81 mmol/L), suggesting efficient ruminal ammonia utilization and hepatic ureagenesis (Zhang *et al.*, 2024).

Table 4: Biochemical Parameters (Serum Chemistry) of Uda Rams Fed Graded Levels of Ensiled Urea-Treated Millet Panicle Husk Meal

Parameter	T1	T2	T3	T4	SEM	Ref. Range
Albumin (g/dl)	2.41	2.38	2.17	2.30	0.39	2.4 – 3.0 <sup>1</sup>
Globulin (g/dl)	3.87	3.61	3.65	3.65	0.38	3.6 – 4.9 <sup>1</sup>
Total protein (g/dl)	6.28	5.99	5.82	5.95	0.62	6.7 – 9.0 <sup>2</sup>
HDL (mmol/L)	0.77	0.65	0.68	0.64	0.11	> 1.0 <sup>3</sup>
LDL (mmol/L)	0.85	0.80	0.89	0.80	0.09	< 3.0 <sup>3</sup>
Tryglycerides (mmol/L)	1.17 <sup>a</sup>	0.70 <sup>b</sup>	0.77 <sup>b</sup>	0.85 <sup>b</sup>	0.08	0.45 – 1.81 <sup>4</sup>
Creatinine (umol/L)	103.00 <sup>a</sup>	95.20 <sup>ab</sup>	85.70 <sup>c</sup>	90.11 <sup>bc</sup>	2.79	53 – 106 <sup>5</sup>
Cholesterol (mmol/L)	1.25 <sup>b</sup>	1.95 <sup>a</sup>	1.11 <sup>b</sup>	1.43 <sup>ab</sup>	0.18	1.3 – 1.97 <sup>6</sup>
Urea (mmol/L)	3.70	3.62	3.76	3.81	0.50	2.5 – 7.8 <sup>5</sup>

a,b,c: Means in the same row with different superscripts are significantly ( $P < 0.05$ ) different.

The decline in serum protein and energy-related metabolites at higher levels of ensiled urea-treated millet panicle husk meal suggests a nutritional imbalance, likely due to poor synchronization of nitrogen and energy release in the rumen. This mismatch can impair microbial protein synthesis and reduce metabolic efficiency, especially in diets rich in fibrous by-products with limited fermentable substrates (Zhang *et al.*, 2020).

To address this, targeted supplementation is recommended. Increasing rumen-degradable protein (RDP) through sources like urea, soybean meal, or alfalfa improves nitrogen availability for microbial growth and enhances nitrogen utilization (Tang *et al.*, 2025). Adjusting the RDP-to-rumen-undegradable protein (RUP) ratio also supports digestibility and microbial protein synthesis, even under low crude protein conditions.

Adding readily fermentable carbohydrates (RFCs) such as molasses, maize, or citrus pulp provides energy to fuel microbial activity. When balanced with adequate nitrogen, RFCs improve fermentation and microbial efficiency (Zhang *et al.*, 2020). However, excessive RFCs may lower rumen pH and inhibit fiber digestion, requiring careful formulation (Owens *et al.*, 1998).

Integrating rumen-degradable protein (RDP) and readily fermentable carbohydrate (RFC) sources promotes a more synchronized rumen environment, improving nutrient absorption and metabolic outcomes. This strategy enhances the value of millet husk-based diets and supports sustainable ruminant production. Further research should explore optimal combinations and inclusion rates across different physiological stages.

### Conclusion

This study confirms that ensiled urea-treated millet panicle husk meal (EUTMPHM) can be safely included in the diets of growing Uda rams at levels up to 30% without negatively affecting blood health or serum biochemistry. Key haematological markers such as RBC, MCV, MCH, MCHC, and immune cells remained within normal ranges, indicating stable blood formation and immune function. Moderate inclusion levels even improved haemoglobin, PCV, and WBC counts, suggesting better oxygen transport and mild immune stimulation.

Serum biochemistry showed that lipid metabolism and kidney function remained unaffected, with HDL-C, LDL-C, creatinine, and urea within healthy ranges. However, higher inclusion rates resulted in decreased

serum albumin, total protein, triglycerides, and cholesterol, indicating possible deficiencies in protein quality and energy content.

### Recommendation

Ensiled urea-treated millet panicle husk meal (EUTMPHM) can be safely incorporated into Uda sheep diets at inclusion levels of up to 20%, without compromising haematological or biochemical health indices. This inclusion rate offers a practical and nutritionally viable alternative to cowpea husk in small ruminant feeding systems.

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