



Hematological and Serum Biochemical Responses of West African Dwarf Goats Fed Graded Levels of Urea–Molasses Treated Maize Cob

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Abstract

An 86-day feeding trial was conducted to evaluate the effects of graded replacement of wheat offal with urea–molasses treated maize cob (UMTMC) on hematological and serum biochemical indices of West African Dwarf (WAD) goats. Fifty growing goats aged 5–7 months were randomly allotted to five dietary treatments containing 0%, 25%, 50%, 75% and 100% replacement of wheat offal with UMTMC. Packed cell volume (PCV), hemoglobin (Hb), red blood cell (RBC), white blood cell (WBC), platelet count and leukocyte differentials, together with serum total protein, albumin, globulin, creatinine, cholesterol, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP), were determined at the end of the trial. Dietary treatment significantly affected all reported hematological and biochemical variables ($P < 0.05$). PCV increased from 21.84% in the control to 29.88% at 100% replacement, while Hb was highest at 50% replacement (8.96 g/dL) and RBC at 25% replacement ($12.82 \times 10^6/\mu\text{L}$). Serum protein fractions and enzyme activities also varied significantly among treatments. The findings indicate that UMTMC altered hematological and metabolic profiles without demonstrating a consistent pattern of severe systemic impairment. However, comparison with current goat reference intervals showed that some treatment means were outside generic laboratory ranges. The findings therefore should not be interpreted as proof that all inclusion levels were physiologically normal or that 50% replacement was an established optimum. UMTMC appears promising as a locally available feed resource, but pre-feeding baseline measurements, WAD-goat-specific reference intervals and longer-term health and performance assessments are required before definitive safety or optimum-inclusion claims can be made.

Keywords: West African Dwarf Goats; Urea–Molasses Treated Maize Cob; Haematology; Serum Biochemistry; Crop Residues; Goat Nutrition

Introduction

Small-ruminant production in tropical regions is constrained by seasonal fluctuations in feed availability, the high cost of conventional concentrate ingredients and the generally low nutritive value of many crop residues. Maize cob is an abundant cereal-processing residue, but its high structural-fibre content and relatively low protein concentration can limit its feeding value when used without treatment. Chemical treatment of crop residues with urea is an established strategy for increasing nitrogen availability and improving the utilization of fibrous materials by ruminants [1].

Recent evidence supports the use of treated maize residues in ruminant feeding. Akinfemi and Adebayo [2] demonstrated that urea treatment of maize cob increased crude protein and improved estimated organic matter digestibility and metabolizable energy. Similarly, Akinfemi, *et al.* [3] reported that urea–molasses treatment improved the chemical composition and fermentation characteristics of rice straw. These findings provide a nutritional basis for evaluating urea–molasses treatment as a means of upgrading maize cob before its incorporation into goat diets. Treatment of crop residues is particularly relevant in areas where maize-processing residues are readily available, but conventional feed ingredients are expensive.

Previous studies involving WAD goats have also shown that maize-cob-based diets can be used without necessarily producing adverse blood responses. Ogunleke, *et al.* [4] reported that corncob could be included in diets for WAD goats without deleterious effects on measured hematological and biochemical variables. Ibhaze, *et al.* [5] similarly reported that microbial-treated maize cob and maize husk could be incorporated into WAD-goat diets without adverse effects on the blood variables measured.

Molasses may complement urea treatment because it supplies readily fermentable carbohydrate that can provide energy for ruminal microbial utilization of non-protein nitrogen. In goats, dietary molasses has been shown to influence feed intake, blood metabolites and rumen fermentation, with responses depending on concentration and duration of feeding [6]. The combined application of urea and molasses may therefore improve the utilization of maize cob; however, nutritional improvement of a crop residue does not automatically establish its physiological safety when fed at increasing dietary levels.

Hematological and serum biochemical measurements are useful indicators of physiological and nutritional responses in livestock. However, interpretation of these variables requires attention to breed, age, sex, physiological state, environmental conditions, nutritional status and analytical method. A recent review of goat hematology in Sub-Saharan Africa emphasized substantial breed-related variation and the importance of developing appropriate reference information for individual production systems [7]. The review reported WAD-goat ranges of approximately $8.0\text{--}13.0 \times 10^6/\mu\text{L}$ for RBC, $8.0\text{--}12.0 \text{ g/dL}$ for Hb, 25–38% for PCV and $4.0\text{--}12.0 \times 10^3/\mu\text{L}$ for WBC, while also emphasizing variation among populations [7].

Current generic goat reference intervals published by the Merck Veterinary Manual provide PCV of 22–38%, Hb of 8–12 g/dL, RBC of $8\text{--}18 \times 10^6/\mu\text{L}$, WBC of $4\text{--}13 \times 10^3/\mu\text{L}$ and platelet counts of $300\text{--}600 \times 10^3/\mu\text{L}$ [8]. For serum biochemical variables, current goat ranges include 6.4–7.0 g/dL for total protein, 2.7–3.9 g/dL for albumin, 2.7–4.1 g/dL for globulin, 1.0–1.8 mg/dL for creatinine, 80–130 mg/dL for cholesterol, 167–513 U/L for AST, 6–19 U/L for ALT and 93–387 U/L for ALP [9]. However, these are general laboratory reference intervals rather than diagnostic ranges specifically established for growing WAD goats. Merck also emphasizes that reference ranges vary among laboratories and that the reference laboratory's own ranges should be used where available [8,9].

Recent evidence further supports caution in interpreting generalized reference intervals in WAD goats. Olaifa, *et al.* [10] reported differences in hematological and serum biochemical variables among juvenile, nursing and pregnant WAD goats maintained under similar environmental conditions. Thus, physiological stage can influence blood values independently of dietary treatment.

The objective of this study was therefore to determine the effects of graded replacement of wheat offal with UMTMC on selected hematological and serum biochemical indices of growing WAD goats and to assess whether the observed responses provide evidence of adverse physiological effects. The study was also intended to identify inclusion levels requiring further evaluation rather than to establish safety solely through comparison with generalized reference ranges.

Materials and Methods

Study area and animal management

The feeding trial was carried out at the Odoragunshin Farm Complex of Yaba College of Technology, situated along the Epe–Ijebu-Ode route in Lagos State, Nigeria (longitude 3°56′ E, latitude 6°32′ N). The area has a humid tropical climate characterized by substantial sunshine and rainfall and distinct wet and dry seasons.

Fifty growing WAD goats aged 5–7 months were randomly allocated to five dietary treatments representing 0%, 25%, 50%, 75% and 100% replacement of wheat offal with UMTMC, with 10 goats assigned to each treatment. Each goat was considered an experimental unit for the statistical analysis. Animals were acclimatized before the commencement of the feeding trial and managed under experimental conditions. Clean drinking water and Panicum maximum pasture were provided ad libitum.

The experimental procedures involving animals were approved by the Department of Animal Production Technology Ethical Committee on Ethical Procedure Involving Experimental Animals, Yaba College of Technology, under approval number OPT-ACUC-2026-001.

Diet formulation and feed preparation

The treatment quantities used for preparing the UMTMC were as follows: the urea-to-molasses ratio was 1 kg urea to 5 kg molasses, and the molasses-to-water ratio was 1 kg molasses to 10 L water. For T2, 2 kg urea was mixed with 10.0 kg molasses and 100.0 L water; for T3, 3 kg urea was mixed with 15.0 kg molasses and 150.0 L water; for T4, 4 kg urea was mixed with 20.0 kg molasses and 200.0 L water; and for T5, 5 kg urea was mixed with 25.0 kg molasses and 250.0 L water. For each of the 50 kg and 100 kg maize-cob batches, the corresponding treatment quantities were the same as specified above. T1 consisted of untreated maize cob and received no urea, molasses or treatment water.

UMTMC was prepared by ensiling ground maize cob with urea, molasses and water for 21 days following the treatment procedure previously described by Akinfemi, *et al.* [11].

The experimental diets were formulated by progressively replacing wheat offal with UMTMC. The ingredient composition is presented in Table 1.

Ingredient	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Maize bran	30	30	30	30	30
Palm kernel cake	10	10	10	10	10
Groundnut cake	10	10	10	10	10
Wheat offal	40	30	20	10	0
UMTMC	0	10	20	30	40
Common salt	1	1	1	1	1
Dicalcium phosphate	3.75	3.75	3.75	3.75	3.75
Soybean meal	3.75	3.75	3.75	3.75	3.75
Vitamin premix	1.5	1.5	1.5	1.5	1.5

Table 1: Ingredient composition (%) of experimental diets containing graded replacement of wheat offal with urea–molasses treated maize cob.

UMTMC = urea–molasses treated maize cob.

Reference intervals and interpretation

Published physiological values were used as contextual benchmarks rather than absolute diagnostic cut-offs. Current goat reference intervals indicate PCV of 22–38%, Hb of 8–12 g/dL, RBC of $8\text{--}18 \times 10^6/\mu\text{L}$, WBC of $4\text{--}13 \times 10^3/\mu\text{L}$ and platelet counts of

$300\text{--}600 \times 10^3/\mu\text{L}$ [8]. Current goat serum biochemical reference intervals include total protein of 6.4–7.0 g/dL, albumin of 2.7–3.9 g/dL, globulin of 2.7–4.1 g/dL, creatinine of 1.0–1.8 mg/dL, cholesterol of 80–130 mg/dL, AST of 167–513 U/L, ALT of 6–19 U/L and ALP of 93–387 U/L [9].

However, these ranges should not be regarded as WAD-specific diagnostic limits. A recent review reported WAD-goat ranges of 25–38% for PCV, 8–12 g/dL for Hb, $8\text{--}13 \times 10^6/\mu\text{L}$ for RBC and $4\text{--}12 \times 10^3/\mu\text{L}$ for WBC [7]. The same review emphasized the need for breed- and production-specific reference information. Consequently, interpretation in the present study emphasizes treatment effects, biological direction of response and comparison with previous WAD-goat feeding studies rather than treating generic reference limits as diagnostic thresholds.

Chemical composition of maize cob

The proximate composition and fiber fractions of maize cob were determined using standard AOAC procedures [12] and the detergent fiber system of Van Soest, *et al.* [13].

Parameter	Value
Moisture	9.8
Crude protein	2.9
Ether extract	1.6
Ash	2.7
Crude fiber	44.5
Nitrogen-free extract	48.5
Neutral detergent fiber	74.2
Acid detergent fiber	53.4
Acid detergent lignin	12.1
Cellulose	41.3
Hemicellulose	20.8

Table 2: Proximate composition and fiber fractions of untreated maize cob (% DM basis).

Note: Table 2 reports the composition of untreated maize cob used as the starting material for treatment.

The values are consistent with previously reported Nigerian maize-cob composition [11,14].

The proximate composition and fibre fractions reported in Table 2 are those of the untreated maize cob before application of urea, molasses and water. These values therefore characterize the untreated starting material rather than the UMTMC product.

Hematological analysis

Five milliliters of blood were aseptically collected from the jugular vein of each goat at the conclusion of the 86-day feeding

period and transferred into EDTA-containing tubes. PCV, Hb concentration, RBC count, WBC count, platelet count and leukocyte differentials were determined.

Hemoglobin concentration was determined using the cyanmethemoglobin technique, while PCV was determined by microhematocrit centrifugation. RBC and WBC counts were determined using a hemocytometer. Stained blood smears were examined microscopically for differential leukocyte counts.

Serum biochemical analysis

Blood samples collected into plain tubes were allowed to clot at room temperature and were centrifuged at 3,000 rpm for 15 min to obtain clear serum. Total protein, albumin, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) concentrations were determined spectrophotometrically using commercial diagnostic kits manufactured by Randox Laboratories Ltd. (Crumlin, Co. Antrim, UK). Serum globulin was calculated by mathematical difference as total protein minus albumin. Serum total cholesterol was estimated via enzymatic colorimetric methods using commercial test kits from Quimica Clinica Aplicada, S.A. (QCA, Amposta, Spain). All optical absorbance readings were performed on an automated clinical chemistry analyzer following standard calibration and quality control validation procedures. Because serum enzyme activities are highly sensitive to specific laboratory analytical platforms and assay temperature profiles, treatment comparisons were strictly emphasized during statistical parsing rather than interpreting absolute baseline enzyme values as definitive or standalone evidence of organic pathomorphology.

Results

Hematological parameters

The hematological responses of WAD goats to graded UMTMC replacement are presented in Table 3. Dietary treatment significantly affected PCV, Hb, RBC, WBC, platelet count, lymphocyte percentage and neutrophil percentage ($P < 0.05$).

PCV increased from 21.84% in the control to 29.51% at 25% replacement and 29.88% at 100% replacement. Hb increased from 7.53 g/dL in the control to 8.90 and 8.96 g/dL at 25% and 50% replacement, respectively. RBC was highest at 25% replacement ($12.82 \times 10^6/\mu\text{L}$).

WBC was highest at 100% replacement (16,201 cells/ μ L). Platelet counts were lowest in the control group (106,667/ μ L) and highest at 100% replacement (239,000/ μ L).

Lymphocyte percentage increased from 63.42% in the control to 67.70–67.82% in the UMTMC treatments, whereas neutrophil percentage was lowest at 50% replacement (24.64%).

Serum biochemical parameters

UMTMC significantly affected all measured serum biochemical variables ($P \leq 0.015$; Table 4). Total protein ranged from 6.00

g/dL at 25% replacement to 9.61 g/dL at 100% replacement. Albumin ranged from 2.35 g/dL in the control to 3.57 g/dL at 50% replacement, whereas globulin ranged from 3.40 to 6.60 g/dL.

Creatinine ranged from 1.97 to 2.55 mg/dL. Cholesterol ranged from 56.73 to 135.97 mg/dL. AST ranged from 92.44 to 183.88 IU/L, ALT from 10.49 to 57.48 IU/L and ALP from 58.42 to 64.73 IU/L.

Parameter	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM	P-value	Current goat reference range*
PCV (%)	21.84 ^b	29.51 ^a	23.51 ^b	27.84 ^a	29.88 ^a	0.52	0.001	22–38 [8]
Hb (g/dL)	7.53 ^b	8.90 ^a	8.96 ^a	8.46 ^a	8.43 ^a	0.16	0.001	8–12 [8]
RBC ($\times 10^6$ / μ L)	11.62 ^b	12.82 ^a	11.29 ^b	11.27 ^b	12.16 ^{ab}	0.19	0.003	8–18 [8]
WBC (cells/ μ L)	13,524 ^a	15,624 ^{ab}	14,371 ^c	15,371 ^{bc}	16,201 ^a	146	0.005	4–13 $\times 10^3$ [8]
Platelets (/ μ L)	106,667 ^c	235,667 ^a	190,000 ^{ab}	156,667 ^{bc}	239,000 ^a	1,282	0.001	300–600 $\times 10^3$ [8]
Lymphocytes (%)	63.42 ^b	67.70 ^a	66.64 ^a	66.68 ^a	67.82 ^a	0.78	0.012	50–70 [8]
Neutrophils (%)	32.64 ^a	28.45 ^{ab}	24.64 ^b	32.70 ^a	28.22 ^{ab}	1.26	0.006	30–48 [8]

Table 3: Hematological responses of WAD goats fed graded levels of UMTMC.

*Reference intervals are generic goat laboratory ranges and should not be interpreted as WAD-goat-specific diagnostic limits. Different laboratories may use different intervals [8].

Values within rows with different superscripts differ significantly ($P < 0.05$).

The biochemical responses were treatment-dependent rather than uniformly increasing or decreasing. Creatinine was highest at 25% replacement, while AST and ALT were highest at 50% replacement.

Parameter	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM	P-value	Current goat reference range*
Total protein (g/dL)	7.50 ^c	6.00 ^d	8.89 ^{ab}	8.39 ^{bc}	9.61 ^a	0.16	0.001	6.4–7.0 [9]
Albumin (g/dL)	2.35 ^b	2.87 ^{ab}	3.57 ^a	2.99 ^{ab}	3.43 ^a	0.14	0.001	2.7–3.9 [9]
Globulin (g/dL)	5.31 ^c	3.40 ^e	4.71 ^d	5.70 ^b	6.60 ^a	0.05	0.001	2.7–4.1 [9]
Creatinine (mg/dL)	1.98 ^b	2.55 ^a	2.15 ^b	2.05 ^b	1.97 ^b	0.07	0.002	1.0–1.8 [9]
Cholesterol (mg/dL)	91.05 ^c	132.83 ^a	115.98 ^b	56.73 ^d	135.97 ^a	0.68	0.001	80–130 [9]
AST (IU/L)	130.24 ^c	92.44 ^e	183.88 ^a	168.53 ^b	114.48 ^d	0.30	0.001	167–513 [9]
ALT (IU/L)	34.13 ^b	10.49 ^d	57.48 ^a	34.80 ^b	21.11 ^c	0.54	0.001	6–19 [9]
ALP (IU/L)	58.42 ^b	63.01 ^a	63.31 ^a	64.73 ^a	64.39 ^a	0.82	0.015	93–387 [9]

Table 4: Serum biochemical responses of WAD goats fed graded levels of UMTMC.

*Reference intervals are current generic goat laboratory ranges and are not WAD-goat-specific diagnostic limits [9].

Values within rows with different superscripts differ significantly ($P < 0.05$).

The increase in PCV and Hb at 25–50% replacement is noteworthy. The control PCV of 21.84% was slightly below the current generic goat reference interval of 22–38%, while PCV values in the UMTMC groups were generally within that interval [8]. Similarly, the control Hb of 7.53 g/dL was below the current generic goat interval of 8–12 g/dL, whereas the UMTMC groups generally fell within it [8]. These comparisons are presented only as contextual observations because the study did not obtain pre-feeding baseline values and the cited intervals are not specific to growing WAD goats.

The present study demonstrates that replacing wheat offal with UMTMC produced measurable changes in both hematological and serum biochemical indices of growing WAD goats. The direction of response was not uniform across inclusion levels. This is biologically plausible because urea treatment increases the nitrogen contribution of fibrous residues, whereas molasses provides readily fermentable carbohydrates that can support microbial utilization of non-protein nitrogen [2,3,6].

The RBC counts were within the current generic goat interval of $8-18 \times 10^6/\mu\text{L}$ in all treatments [8]. The highest RBC concentration occurred at 25% replacement. This response may reflect differences in nutrient supply or utilization, but the present study did not measure the mechanisms responsible. Therefore, the RBC findings are interpreted as treatment-associated changes rather than evidence of a specific hematological improvement.

However, these findings should not be interpreted as proof that UMTMC corrected anemia. No pre-feeding hematological measurements were available, and the study did not include iron status, erythrocyte indices beyond those reported, blood loss assessment or clinical diagnosis of anemia. Consequently, the more defensible interpretation is that UMTMC was associated with changes in erythrocytic variables.

Similarly, changes in lymphocyte and neutrophil percentages should not automatically be interpreted as evidence of enhanced or depressed immunity. Leukocyte distributions can respond to nutritional status, environmental stress, infection, physiological state and other factors. The present study did not measure immune function directly. Ibhaze, *et al.* [5], working with treated maize-cob and maize-husk diets in WAD goats, also observed treatment-related differences in blood variables without concluding that the treated residues produced adverse physiological effects.

The WBC response requires caution. WBC concentrations ranged from 13,524 to 16,201 cells/ μL and therefore exceeded the generic goat interval of $4-13 \times 10^3/\mu\text{L}$ in most treatments [8]. However, the recent Sub-Saharan African goat review reported a broader WBC range of $4-15 \times 10^3/\mu\text{L}$ and emphasized breed-specific variation [7]. Therefore, the observed values cannot be classified simply as pathological based on a single generalized range.

Although these changes may be related to altered nitrogen supply and utilization, it would be inappropriate to describe increased globulin as evidence of enhanced immune function without specific immunological measurements. Serum protein fractions are also influenced by hydration and physiological state. Recent evidence from WAD goats confirms that serum protein variables can vary with physiological stage [10]. Because no pre-feeding serum measurements were obtained, the present study supports an association between dietary treatment and the measured protein fractions, but not a definitive claim of improvement or abnormality.

The serum protein responses indicate substantial effects of UMTMC on protein-related metabolism. Total protein ranged from 6.00 to 9.61 g/dL. The highest value occurred at 100% replacement and exceeded the current generic goat interval of 6.4–7.0 g/dL [9]. Globulin showed a similar pattern, reaching 6.60 g/dL at 100% replacement compared with the current generic goat interval of 2.7–4.1 g/dL [9].

The renal indicators deserve particular caution. Creatinine ranged from 1.97 to 2.55 mg/dL and was above the current generic goat reference interval of 1.0–1.8 mg/dL in all treatment groups [9]. The highest concentration occurred at 25% replacement. Nevertheless, elevated creatinine alone does not establish renal injury because creatinine can be influenced by muscle mass, hydration status, diet and other physiological factors. Importantly, blood urea nitrogen, urinalysis and direct renal assessment were not included in the present study. Thus, the observed creatinine concentrations should be regarded as treatment-associated findings that warrant further investigation rather than as evidence of renal damage or renal safety.

Albumin values in most UMTMC groups were within or near the current generic goat range of 2.7–3.9 g/dL [9]. The control value of 2.35 g/dL was slightly below this interval. The increase in

albumin at 50% replacement may therefore represent a favorable metabolic response, but the absence of pre-feeding values prevents a definitive conclusion about improvement.

The renal indicators deserve caution. Creatinine ranged from 1.97 to 2.55 mg/dL and was therefore above the current generic goat reference interval of 1.0–1.8 mg/dL in all treatment groups [9]. The highest concentration occurred at 25% replacement. Nevertheless, elevated creatinine alone does not establish renal injury because creatinine can be influenced by muscle mass, hydration status, diet and other physiological factors. Importantly, blood urea nitrogen, urinalysis and direct renal assessment were not included in the present study.

Accordingly, the previous wording suggesting “confirmed renal safety” should be avoided. A scientifically defensible interpretation is that creatinine responded significantly to dietary treatment and that the elevated concentrations warrant further investigation using a broader renal assessment.

The discordance among AST, ALT and ALP illustrates why no single enzyme should be interpreted as proof of hepatic injury or hepatic safety. Furthermore, the study did not include bilirubin, gamma-glutamyl transferase, bile acids, liver histopathology or pre-treatment enzyme measurements. Therefore, statements such as “UMTMC caused no hepatotoxic effects” are stronger than the available evidence permits. The present results are more appropriately described as treatment-associated changes in selected liver-associated enzymes.

ALT displayed a different pattern. Values ranged from 10.49 to 57.48 IU/L, and several treatment means exceeded the current goat interval of 6–19 IU/L [9]. ALP values, however, were below the current generic goat interval of 93–387 IU/L [9].

The observed biochemical responses may reflect changes in dietary nutrient supply, rumen fermentation and energy–nitrogen synchronization. Urea treatment can increase nitrogen availability, while molasses can provide fermentable carbohydrate for rumen microbial activity [2,3,6]. Nevertheless, because the present study did not directly measure rumen fermentation, nitrogen balance or nutrient digestibility during the feeding trial, these mechanisms should be regarded as plausible explanations rather than demonstrated causal pathways.

The present findings therefore support further investigation of UMTMC as a locally available feed resource but do not establish 50% replacement as a definitive physiological optimum. The 25–50% range is of particular interest because several favorable hematological responses occurred within this range. However, some biochemical variables also showed substantial changes, particularly creatinine and ALT. These results reinforce the need to avoid definitive safety claims based on the selected biomarkers alone and to undertake broader physiological assessment in future work.

The observed biochemical responses may reflect changes in dietary nutrient supply, rumen fermentation and energy–nitrogen synchronization. Urea treatment can increase nitrogen availability, while molasses can provide fermentable carbohydrate for rumen microbial activity [2,3,6]. Nevertheless, because the present study did not directly measure rumen fermentation, nitrogen balance or nutrient digestibility during the feeding trial, these mechanisms should be regarded as plausible explanations rather than demonstrated causal pathways.

The present findings therefore support further investigation of UMTMC as a locally available feed resource but do not establish 50% replacement as a definitive physiological optimum. The 25–50% range is of particular interest because several favorable hematological responses occurred within this range. However, some biochemical variables also showed substantial changes, particularly creatinine and ALT. Thus, the apparent advantages of intermediate inclusion levels should be weighed against the need for more comprehensive health assessment.

Overall, the results demonstrate physiological responses to graded UMTMC inclusion rather than a simple linear relationship between treatment level and animal health. Previous work has demonstrated the nutritional potential of treated maize cob [2,3] and the feasibility of maize-cob-based feeding in WAD goats [4,5]. The present study extends that evidence by showing that graded UMTMC replacement can modify blood profiles, while also emphasizing the limitations of using generalized reference intervals to make definitive safety claims.

Conclusion

- Graded replacement of wheat offal with UMTMC significantly altered selected hematological and serum biochemical indices of growing WAD goats.

- The findings did not demonstrate a consistent pattern of severe systemic impairment during the 86-day feeding period; however, they also do not provide sufficient evidence to claim complete physiological normality, confirmed renal safety or confirmed hepatic safety. The interpretation is limited by the absence of pre-feeding baseline measurements and the lack of a full renal and hepatic biomarker panel.
- Serum protein fractions, creatinine, cholesterol, AST, ALT and ALP also responded significantly to dietary treatment, demonstrating that increasing UMTMC altered metabolic profiles.
- The findings did not demonstrate a consistent pattern of severe systemic impairment during the 86-day feeding period; however, they also do not provide sufficient evidence to claim complete physiological normality or confirmed renal or hepatic safety.
- The results do not establish 50% UMTMC replacement as a definitive optimum. Rather, the 25–50% replacement range warrants further investigation because several favorable hematological responses occurred within this range.
- UMTMC remains a promising locally available feed resource, but definitive conclusions concerning its long-term physiological safety require pre-feeding baseline measurements, repeated blood sampling, WAD-goat-specific reference information and a broader renal, hepatic and metabolic biomarker panel.
- **Pre-feeding baseline measurements:** Blood should be collected before dietary treatment begins and at defined intervals during the feeding period. This would permit treatment-induced changes to be distinguished from pre-existing physiological variation.
- **Breed-specific reference information:** Further research should contribute to establishing reference intervals specifically for growing WAD goats under Nigerian production conditions.
- **Treatment comparisons:** Future studies should compare untreated maize cob, urea-treated maize cob and urea–molasses-treated maize cob to determine the individual contribution of urea and molasses to the observed responses.
- **Practical application:** UMTMC has potential to reduce dependence on conventional feed ingredients where maize cob is locally abundant. However, adoption should be accompanied by standardized treatment procedures, quality control and economic evaluation because the nutritional value of treated crop residues depends strongly on treatment conditions.

Ethics Statement

The experimental procedures involving animals were approved by the Department of Animal Production Technology Ethical Committee on Ethical Procedure Involving Experimental Animals, Yaba College of Technology, under approval number OPT-ACUC-2026-001. All procedures were conducted in accordance with institutional guidelines and applicable requirements for the care and use of experimental animals, with efforts made to minimize animal suffering and the number of animals used.

Conflict of Interest

The authors declare no conflict of interest.

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This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data Availability

The data supporting the findings of this study can be obtained from the corresponding author upon reasonable request.

Recommendations

- **Further evaluation of 25–50% replacement:** The 25–50% UMTMC replacement range should receive priority in subsequent feeding trials because several favorable hematological responses occurred within this range. This should be regarded as a research priority rather than a definitive safety recommendation.
- **Monitoring at higher replacement levels:** At 75–100% replacement, future studies should closely monitor feed intake, body condition, growth, serum protein fractions and renal and hepatic biomarkers because the present blood responses remained treatment-dependent.
- **Expanded physiological assessment:** Future experiments should include blood urea nitrogen, bilirubin, gamma-glutamyl transferase, glucose, electrolytes, urinalysis and, where scientifically justified, tissue-level assessment.

Use of Artificial Intelligence

The authors used ChatGPT, an artificial intelligence language model developed by OpenAI, for limited language polishing and clarity improvement during manuscript preparation. The authors prepared, reviewed and took full responsibility for the scientific content, data, analysis, interpretation and final version of the manuscript.

Author Contributions

Akinfemi Abayomi designed the study. Adebayo Babatunde arranged the laboratory analysis. The statistical analysis was carried out jointly by the authors. Manuscript arrangement and preparation were undertaken by the authors. All authors contributed to the writing and approved the final manuscript.

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