ANIMAL SCIENCE (ANIMAL NUTRITION)

Effects of Urea-Treated Sorghum Stover on Growth Performance, Nutrient Digestibility, Haematology and Serum Biochemistry of West African Dwarf Grower Bucks

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Abstract

This study evaluated the combined Growth, Nutrient Digestibility, Haematological and Serum biochemical responses of West African Dwarf (WAD) grower bucks fed varying levels of urea-treated sorghum stover. Fifteen healthy bucks aged 6–7 months, with an average initial body weight of approximately 6.8 kg, were allocated to five treatments in a completely randomized design, with three animals per treatment. The dietary treatments comprised 0%, 1%, 2%, 3% and 4% urea-treated sorghum stover (T1–T5), offered with a basal concentrate diet. Following a 14-day acclimatization period, the feeding trial lasted 28 days, followed by a 7-day digestibility trial. Growth, apparent nutrient digestibility, haematological indices and serum biochemical parameters were assessed. Data were analysed using one-way analysis of variance, with Duncan's Multiple Range Test used to compare means at $P < 0.05$. T2 (1% inclusion) produced the highest total weight gain (0.53 kg), average daily gain (18.93 g/day), weekly gain (132.50 g/week) and the lowest feed conversion ratio (21.45). T3 (2%) had the highest feed intake (12.43 kg), crude fibre digestibility (74.58%) and carbohydrate digestibility (83.28%), whereas T4 (3%) recorded the highest dry matter digestibility (72.97%) and crude protein digestibility (78.59%). Haematological values were generally most favourable at T2, including packed cell volume (33%), haemoglobin (10.9 g/dL), red blood cell count (13.1×10^6/µL), white blood cell count (96.60×10^3/µL) and platelet count (166×10^3/µL). Serum total protein and albumin were highest in the control, while blood urea nitrogen and alkaline phosphatase were highest at 4% inclusion. Therefore, 1% inclusion gave the most favourable combined growth and haematological response in this dataset, although the serum biochemical responses were not linear across treatments. These findings support further evaluation of urea-treated sorghum stover as a locally available feed resource for WAD bucks.

Keywords: West African Dwarf goats; urea-treated sorghum stover; growth performance; nutrient digestibility; haematology; serum biochemistry

1 Introduction

Goat production contributes to household food supply, income generation and livelihood security in Nigeria. The West African Dwarf (WAD) goat is particularly important in humid and sub-humid areas because of its adaptability and suitability for smallholder production systems (Daramola et al., 2005). Nevertheless, productivity may be constrained by seasonal shortages of good-quality forage and dependence on fibrous agricultural residues (Devendra, 2013; FAO, 2023).

Sorghum stover is a locally available crop residue that can contribute to ruminant diets, but its feeding value is limited by structural fibre, low nitrogen content and relatively poor digestibility when untreated (Sundstøl and Owen, 1984). Urea treatment is used to improve the utilization of

fibrous residues. During treatment, urea hydrolysis releases ammonia, which can alter plant cell-wall associations and improve access to structural carbohydrates by rumen microorganisms (Van Soest, 1994). The extent of the response depends on treatment conditions, diet composition and the balance between available nitrogen and fermentable energy (Fazaeli et al., 2006; Sarnklong et al., 2010).

Assessment of a feed intervention should extend beyond growth alone. Body-weight change, feed intake and feed conversion describe productive response, while apparent digestibility indicates the proportion of consumed nutrients not recovered in faeces (Daramola et al., 2005). Haematological indices provide information on blood-cell status, and serum biochemical measurements can help describe protein and nitrogen metabolism and selected enzyme activities. These indicators therefore provide complementary evidence when evaluating the suitability of treated crop residues for growing goats (McDonald et al., 2022).

This study examined growth performance and nutrient digestibility, and haematological and serum biochemical indices, in WAD grower bucks fed varying levels of urea-treated sorghum stover. The objective was to identify the inclusion level associated with the most favourable overall response under the reported experimental conditions.

2 Materials and methods

2.1 Experimental site, animals and management

The experiment was conducted at the Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria. Fifteen healthy WAD grower bucks aged 6–7 months, with an average initial body weight of approximately 6.8 kg, were sourced from a farm within Igboora. The animals underwent a 14-day acclimatization period before the feeding trial. They were managed under similar housing conditions, treated against internal and external parasites according to the source project reports, housed in well-ventilated pens and provided clean drinking water ad libitum.

2.2 Experimental design and dietary treatments

The animals were allocated randomly to five dietary treatments in a completely randomized design, with three animals per treatment. Treatments consisted of sorghum stover treated with 0%, 1%, 2%, 3% or 4% urea and were designated T1, T2, T3, T4 and T5, respectively. Each treatment group received its assigned sorghum stover alongside a basal concentrate diet. Feed was offered twice daily, with the quantity described in the source documents as approximately 5% of body weight.

2.3 Preparation of urea-treated sorghum stover and basal concentrate

Sorghum stover was collected after harvest, air-dried and chopped. For each treatment, 5 kg of stover was treated with the assigned quantity of urea dissolved in 5 L of water: 0 g for T1, 50 g for T2, 100 g for T3, 150 g for T4 and 200 g for T5. The solution was distributed evenly over the stover and mixed. The material was placed in covered plastic containers and allowed to ferment for 28 days. After opening, the treated stover was exposed to air briefly before feeding.

The composition of the basal concentrate diet is given in Table 1.

Table 1. Composition of the basal concentrate diet.

Ingredient	Inclusion (%)
Cassava peel	45.00
Wheat offal	26.00
Palm kernel cake	17.50
Groundnut cake	8.00
Bone meal	2.50
Salt	1.00
Total	100.00

Calculated nutrient composition: crude protein 11.32%; crude fibre 9.08%; metabolizable energy 2,405.85 kcal/kg.

2.4 Feeding trial and growth measurements

The feeding trial lasted 28 days after acclimatization. Feed offered and refusals were measured daily; daily intake was calculated as feed offered minus feed refused. Body weight was measured at the start and at weekly intervals. Total weight gain was calculated as final minus initial body weight, average daily gain as total gain divided by 28 days, and feed conversion ratio as total feed intake divided by total weight gain.

2.5 Digestibility trial

A seven-day digestibility trial followed the feeding trial, with an adaptation period reported in the source project. Each buck was housed individually in a metabolism cage. Feed offered, refusals and daily faecal output were recorded. Representative feed, refusal and faecal samples were pooled, oven-dried at 65°C, ground through a 1-mm sieve and stored for proximate analysis. Apparent digestibility was calculated from nutrient intake and the corresponding nutrient recovered in faeces.

2.6 Blood collection and laboratory analyses

At the end of the 28-day feeding period, approximately 5 mL of blood was collected from each buck through the jugular vein. Samples for haematology were placed in labelled tubes containing EDTA. Samples for serum biochemistry were collected in plain tubes, allowed to clot, centrifuged at approximately 3,000 rpm for 10–15 minutes, and the serum was stored at about −20°C until analysis. Haematological measurements included packed cell volume (PCV), haemoglobin (Hb), red and white blood cell counts (RBC and WBC), platelet count, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and differential leukocyte counts. Serum measurements included total protein, albumin, globulin, albumin:globulin ratio, blood urea nitrogen (BUN), creatinine, glucose, AST, ALT, ALP and cholesterol. The source projects report the use of an automated haematology analyser and standard biochemical methods/reagent kits.

2.7 Statistical analysis

The source studies report analysis of variance (ANOVA) using SAS (2002), followed by Duncan's Multiple Range Test to separate treatment means at the 5% significance level ($P < 0.05$). Results are presented as reported in the source tables, including standard errors of the mean (SEM) and reported P-values where available.

3 Results and discussion

3.1 Growth performance and nutrient digestibility

Table 2 shows that dietary treatments significantly affected the growth performance, feed intake, and feed conversion efficiency of WAD grower bucks ($P < 0.001$). T_2 (1% inclusion) recorded the highest total weight gain (0.53 kg), average daily weight gain (18.93 g/day), and weekly weight gain (132.50 g/week), alongside the lowest FCR (21.45). T_3 (2% inclusion) had the highest feed intake (12.43 kg), while T_5 (4% inclusion) recorded the lowest (10.28 kg). T_2 (1% inclusion) recorded the highest weight gain and most favourable feed conversion ratio, consistent with findings by Mijinyawa et al. (2024), Akinbode et al. (2021) and Hyelda et al. (2017). Table 3 shows that urea-treated sorghum stover significantly influenced nutrient digestibility in WAD grower bucks. T_4 (3% inclusion) recorded the highest dry matter (72.97%) and crude protein (78.59%) digestibility. T_3 (2%) had the highest crude fibre (74.58%) and carbohydrate (83.28%) digestibility, while T_1 (0%) recorded the highest ether extract digestibility (75.59%). T_2 (1%) had the highest ash digestibility (72.81%). Urea treatment can improve nitrogen availability and fibre degradation, although its effectiveness depends on inclusion level and dietary energy balance (Van Soest, 1994; Woyengo et al., 2004; McDonald et al., 2022). T_4 (3%) recorded the highest dry matter and crude protein digestibility, while T_3 (2%) had the highest crude fibre and carbohydrate digestibility, supporting findings by Mertens (2002) and Okeniyi et al. (2021).

Table 2. Growth performance of West African Dwarf grower bucks fed varying levels of urea-treated sorghum stover.

Parameters	T_1 (0%)	T_2 (1%)	T_3 (2%)	T_4 (3%)	T_5 (4%)	SEM	P-value
Initial weight (kg)	7.65^a	6.80^b	6.90^b	6.67^b	6.04^c	0.23	0.01
Final weight (kg)	7.68^a	7.33^b	7.22^b	6.75^c	6.49^d	0.19	0.001
Total weight gain (kg)	0.03^d	0.53^a	0.32^c	0.08^c	0.45^b	0.07	0.001
Average daily weight gain (g/day)	1.07^e	18.93^a	11.43^c	2.86^d	16.07^b	2.50	0.001
Weekly weight gain (g/week)	7.50^e	132.50^a	80.00^c	20.00^d	112.50^b	17.50	0.001
Feed intake (kg)	11.75^b	11.37^c	12.43^a	10.93^d	10.28^e	0.32	0.001
FCR (feed intake/gain)	391.67^a	21.45^c	38.84^c	136.63^b	22.84^c	18.25	0.001

Means within the same row with different superscript letters differ significantly ($P < 0.05$). SEM, standard error of the mean; FCR, feed conversion ratio.

Table 3. Apparent nutrient digestibility (%) of West African Dwarf grower bucks fed varying levels of urea-treated sorghum stover.

Parameter (%)	T_1 (0%)	T_2 (1%)	T_3 (2%)	T_4 (3%)	T_5 (4%)	SEM	P-value
Dry matter digestibility	70.13^a	65.44^b	68.67^a	72.97^a	68.42^a	1.23	0.05
Crude protein digestibility	71.57^b	59.92^c	64.61^{bc}	78.59^a	67.19^b	3.18	0.01
Crude fibre digestibility	71.46^a	65.36^b	74.58^a	73.97^a	72.90^a	1.66	0.05
Ether extract digestibility	75.59^a	42.10^c	64.80^b	58.00^b	51.20^{bc}	5.82	0.05
Ash digestibility	48.21^b	72.81^a	39.22^c	49.29^b	49.21^b	5.59	0.05
Carbohydrate digestibility	78.28^{ab}	63.14^c	83.28^a	81.90^a	76.89^b	3.58	0.01

Means within the same row with different superscript letters differ significantly ($P < 0.05$). SEM, standard error of the mean.

3.2 Haematological and serum biochemical indices

Table 4 shows that urea-treated sorghum stover significantly affected all haematological parameters ($P < 0.05$). T_2 (1% inclusion) recorded the highest PCV, haemoglobin, RBC, WBC, platelet count, MCV, MCH, MCHC and lymphocyte percentage. T_1 (0%) had the lowest PCV and MCHC, while T_4 (3%) recorded the lowest MCV, MCH and lymphocyte percentage and the highest neutrophil percentage. Monocyte percentage was highest in T_3 and T_5, while eosinophil percentage was highest in T_1. The results in Table 5 indicate that varying levels of urea-treated sorghum stover significantly affected all measured serum biochemical parameters ($P < 0.05$). T_1 (0% inclusion) recorded the highest total protein, albumin, AST, ALT, glucose and cholesterol values. T_5 (4%) had the highest ALP activity (302 U/L) and blood urea nitrogen (14.0 mg/dL), while T_2 (1%) recorded the highest creatinine concentration (1.6 mg/dL). T_4 (3%) had the lowest total protein, albumin, A:G ratio, AST, ALT, glucose and cholesterol values.

Serum biochemical responses varied across treatments, with the control recording the highest total protein, glucose and cholesterol, while T_5 (4%) recorded the highest blood urea nitrogen and ALP. These biochemical variations are consistent with reports by Okpanachi et al. (2019), Ibhaze et al. (2021), Afolayan et al. (2024), Oduye et al. (1976), Jiwuba et al. (2022), Plumb (1999), Ahmad et al. (2012) and Tawose et al. (2024). Haematological parameters were most favourable at T_2 (1%), which recorded the highest PCV, haemoglobin, RBC, WBC, platelet count, MCV, MCH and lymphocyte percentage. Similar dietary effects on blood indices have been reported by Wuanor and Carew (2018), Daramola et al. (2005), Chineke et al. (2006), Soul et al. (2019) and Idowu et al. (2026). Further supporting evidence was reported by Ibhaze et al. (2021), Jiwuba et al. (2022) and Afolayan et al. (2024), indicating that blood responses do not necessarily improve as treated-stover inclusion increases. Therefore, 1% inclusion produced the most favourable growth, feed conversion and haematological responses, whereas 2–3% improved the digestibility of selected nutrients, demonstrating the importance of appropriate inclusion and dietary balance.

Table 4. Effect of varying levels of urea-treated sorghum stover on haematological indices of West African Dwarf grower bucks.

Parameter	T_1 (0%)	T_2 (1%)	T_3 (2%)	T_4 (3%)	T_5 (4%)	SEM	P-value
PCV (%)	20^{c}	33^{a}	28^{b}	22^{c}	20^{c}	2.47	0.014
Hb (g/dL)	6.3^{c}	10.9^{a}	9.2^{b}	7.1^{c}	6.6^{c}	0.82	0.011
RBC ($\times 10^6$/µL)	8.4^{c}	13.1^{a}	12.3^{b}	10.2^{bc}	9.1^{c}	0.88	0.015
WBC ($\times 10^3$/µL)	63.95^{b}	96.60^{a}	64.50^{b}	44.15^{c}	43.85^{c}	9.69	0.019
MCV (fL)	23.81	25.19	22.76	21.57	21.98	0.65	0.017
MCH (pg)	7.50	8.32	7.48	6.96	7.25	0.23	0.020
MCHC (%)	31.50	33.03	32.86	32.27	33.00	0.30	0.021
Platelets ($\times 10^3$/µL)	124^{b}	166^{a}	119^{b}	106^{c}	120^{b}	10.07	0.016
Lymphocytes (%)	56^{c}	64^{a}	60^{b}	55^{c}	58^{bc}	1.53	0.013
Neutrophils (%)	37^{a}	32^{b}	34^{b}	40^{a}	36^{ab}	1.35	0.017
Monocytes (%)	2^{ab}	1^{a}	3^{b}	1^{a}	3^{b}	0.45	0.019
Eosinophils (%)	5^{a}	3^{b}	4^{ab}	4^{ab}	4^{ab}	0.32	0.019

Means within the same row with different superscript letters differ significantly (P < 0.05). SEM, standard error of the mean; PCV, packed cell volume; Hb, haemoglobin; RBC, red blood cells; WBC, white blood cells; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration.

Table 5. Effect of varying levels of urea-treated sorghum stover on selected serum biochemical indices of West African Dwarf grower bucks.

Parameter	T_1 (0%)	T_2 (1%)	T_3 (2%)	T_4 (3%)	T_5 (4%)	SEM	P-value
Total protein (g/dL)	7.8^{a}	7.3^{c}	7.6^{b}	6.8^{d}	7.6^{b}	0.17	0.015
Albumin (g/dL)	3.5^{a}	3.2^{c}	3.4^{b}	2.7^{d}	3.3^{bc}	0.14	0.018
Globulin (g/dL)	4.3^{a}	4.1^{b}	4.2^{ab}	4.1^{b}	4.3^{a}	0.05	0.034
A:g ratio	0.8^{a}	0.7^{b}	0.8^{a}	0.6^{c}	0.7^{b}	0.04	0.027
Ast (U/L)	236^{a}	171^{c}	220^{b}	169^{c}	224^{b}	13.48	0.013
Alt (U/L)	143^{a}	121^{c}	132^{b}	99^{d}	133^{b}	7.07	0.012
Alp (U/L)	121^{b}	53^{d}	84^{c}	91^{c}	302^{a}	42.77	0.014
Creatinine (mg/dL)	1.2^{ab}	1.6^{a}	1.1^{b}	0.9^{c}	1.1^{b}	0.12	0.022
Bun (mg/dL)	4.2^{d}	12.8^{bc}	13.7^{ab}	11.4^{c}	14.0^{a}	1.78	0.016
Glucose (mg/dL)	65^{a}	60^{bc}	62^{b}	57^{c}	61^{bc}	1.32	0.019
Cholesterol (mg/dL)	126^{a}	115^{b}	120^{ab}	78^{c}	119^{ab}	8.39	0.015

Means within the same row with different superscript letters differ significantly (P < 0.05). SEM, standard error of the mean; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; BUN, blood urea nitrogen; A:G ratio, albumin:globulin ratio.

4 Conclusion

The study concluded that urea-treated sorghum stover influenced the growth performance, feed utilization, nutrient digestibility, haematological and serum biochemical parameters of West African Dwarf grower bucks. T_2 (1% inclusion) produced the highest weight gain, most favourable feed conversion ratio and best overall haematological response. T_3 (2% inclusion) recorded the highest feed intake and improved crude fibre and carbohydrate digestibility. The variations in serum biochemical indices indicated differences in protein, nitrogen and energy metabolism across the dietary treatments. Overall, urea-treated sorghum stover can serve as an alternative feed resource for WAD grower bucks, with 1% inclusion showing the most favourable overall response under the conditions of this study.

5 Recommendations

Based on the reported outcomes, 1% urea-treated sorghum stover may be considered for WAD grower bucks under conditions comparable to those of the present study, with appropriate management and a balanced basal diet. This should be treated as a provisional recommendation rather than a universal optimum. Further trials should use larger numbers of animals, longer feeding periods and replicated measurements of growth, digestibility, blood indices and clinical health. Future reports should include the full statistical output, clear reference intervals for blood parameters, and an economic assessment of feed cost per unit of weight gain. The urea-treatment protocol should also be described precisely and consistently, including the basis for expressing inclusion percentage, moisture conditions and airing period before feeding.

References

[1] Afolayan FO, Ogunbosoye DO, Dare OA (2024). Haematology and serum biochemistry of West African Dwarf goats fed diets containing treated rice husk as a replacement for wheat bran. *Nigerian Journal of Animal Production*, 1727–1730. https://doi.org/10.51791/njap.vi.7283

[2] Akinbode RM, Adebayo KO, Aderinboye RY, Adefalujo HD, Akiode HO (2021). Nutrient digestibility, nitrogen balance and rumen fermentation parameters of West African dwarf goats offered treated maize stover supplemented with Gmelina arborea. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 122(1). https://doi.org/10.17170/kobra-202104133653

[3] Chiejina SN, Behnke JM (2011). The unique resistance and resilience of the Nigerian West African Dwarf goat to gastrointestinal nematode infections. *Parasites and Vectors*, 4, 12. https://doi.org/10.1186/1756-3305-4-12

[4] Daramola JO, Adeloye AA, Fatoba TA, Soladoye AO (2005). Haematological and biochemical parameters of West African Dwarf goats. *Livestock Research for Rural Development*, 17(8), 95.

[5] Devendra C (2013). Investments on pro-poor development projects on goats: Ensuring success for improved livelihoods. *Asian-Australasian Journal of Animal Sciences*, 26(1), 1–14.

[6] Fazaeli H, Mahmodzadeh H, Azizi A, Jelan ZA, Liang JB, Rouzbehan Y, Osman A (2006). Nutritive value of wheat straw treated with urea or urea plus soybean meal. *Animal Feed Science and Technology*, 127(3–4), 293–301.

[7] Food and Agriculture Organization of the United Nations (2023). The state of food and agriculture 2023. *Rome: FAO*.

[8] Hyelda J, Yahya MM, Gworgwor ZA (2017). Growth performance and nutrient digestibility of Red Sokoto goats fed urea-treated maize stover supplemented with graded levels of Balanites aegyptiaca leaf forage. *Asian Research Journal of Agriculture*, 6(2), 1–9.

[9] Ibhaze GA, Ogunjemite GE, Fajemisin AN (2021). Blood chemistry of West African dwarf goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms. *Bulletin of the National Research Centre*, 45, 63. https://doi.org/10.1186/s42269-021-00519-9

[10] Idowu OJ, Chaudhry AS, Adelusi OO, Adeboye JO, Ishola MY, Agboola OE, Olafaju JO, Tajelawi DD, Gwam KS (2026). Haematology and serum profile of West African Dwarf goats fed oyster mushroom (Pleurotus ostreatus) treated millet and cowpea chaff based diets. *Nigerian Journal of Animal Production*, 53(1), 71–80. https://doi.org/10.51791/njap.v53i1.9151

[11] McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG (2022). *Animal nutrition*. 8th ed. Harlow: Pearson.

[12] Mertens DR (2002). Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: Collaborative study. *Journal of AOAC International*, 85(6), 1217–1240.

[13] Okeniyi FA, Olawoye SO, Animashahun RA, Alabi OO, Shoyombo AJ, Falana MB, Aina ABJ, Onwuka CFI, Sowande OS (2021). Mineral balance, nutrient intake and digestibility of West African Dwarf goats fed urea-mixed milled maize stover diets. *ADAN Journal of Agriculture*, 1(1), 149–159.

[14] Sarnklong C, Cone JW, Pellikaan W, Hendriks WH (2010). Utilization of rice straw and different treatments to improve its feed value for ruminants: A review. *Asian-Australasian Journal of Animal Sciences*, 23(5), 680–692.

[15] SAS Institute Inc. (2002). SAS/STAT user's guide. *Release* 9.0. Cary (NC): SAS Institute Inc.

[16] Sundstøl F, Owen E, editors (1984). Straw and other fibrous by-products as feed. *Amsterdam: Elsevier*.

[17] Tawose OM, Oluwadele JF, Ekeocha AH (2024). Haematological and biochemical responses of West African Dwarf goats fed water hyacinth and cassava peel silage. *Nigerian Journal of Animal Production*, 50(3), 109–128. https://doi.org/10.51791/njap.v50i3.4030

[18] Van Soest PJ (1994). Nutritional ecology of the ruminant. *2nd ed*. Ithaca (NY): Cornell University Press.

[19] Woyengo TA, Gachuiri CK, Wahome RG, Mbugua PN (2004). Effect of protein supplementation and urea treatment on utilization of maize stover by Red Maasai sheep. *South African Journal of Animal Science*, 34(Suppl. 1), 1–4.