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Effects of supplementing *Leucaena pallida* based multi-nutrient block on feed intake and body weight performance of goats fed poor-quality forage in semi-arid Tanzania during dry season

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Goats are vital for the economic development and food security of rural communities in arid and semi-arid regions due to their ability to provide income and essential animal protein to resource-poor farmers (Osman *et al*. 2020). They offer advantages over cattle, such as high prolificacy and a shorter generation interval (Ruvuga *et al*. 2022). However, goat production faces challenges, especially during dry seasons when quality forages are scarce. In these periods, goats are typically fed low-nutritive value crop residues and straws, leading to reduced feed intake, weight loss, and increased mortality (Ahmed and Shaarawy 2019). Research suggests that goats grazing on poor-quality forages may experience weight loss due to inadequate nutrient intake (Sankar *et al*. 2021) resulting in delayed reaching of market weight and reduced income for farmers.

Researchers have proposed solutions to challenges in goat nutrition, such as supplementing low-quality forages with commercial concentrates (Mira *et al*. 2019, Yerima *et al.* 2020). However, the unreliable supply and high costs of these concentrates limit their utilization (Ruvuga *et al*. 2022). To address this, the use of multi-nutrient blocks (MNBs) has been suggested as a viable alternative. MNBs formulated with various feed ingredients can provide essential nutrients like protein, minerals, and energy, which are often lacking in animal diets during dry seasons (Mira *et al*. 2019). These blocks can enhance the utilization of low-quality roughages and improve the health and reduce weight loss of goats during drought periods (Pujaningsih and Tampoebolon 2019). While MNBs have shown promise, many formulations in use rely on expensive protein sources like soya beans, cotton seed cake, sunflower seed cake, and urea (Yerima *et al*. 2020), making them unaffordable for smallholder farmers.

Incorporating *Leucaena pallida* leaf meal, a protein-rich ingredient from leguminous fodder trees in MNBs could be a cost-effective alternative to expensive ingredients. While *Leucaena pallida* leaf is recognized for its nutritional value (Mukangango *et al*. 2020), its specific role in MNBs for weight loss reduction in goats in Tanzania has not been extensively studied. The study aimed to assess the impact of supplementing MNBs with *Leucaena pallida* leaf meal and other protein sources on mitigating weight loss in goats consuming *Cenchrus ciliaris* hay as their basal diet under semi-arid conditions. The hypothesis suggested that MNB supplementation could improve feed intake and reduce weight loss in the studied goat population.

The study was conducted at Tanzania Livestock Research Institute (TALIRI) farm located at 6°-6° 6'S, 26° 22'-36° 30'E and 1067 m above sea level in Kongwa district, Dodoma, Tanzania. Average daily ambient temperature in the goat shed ranged from 24.8 to 30.9°C over the entire experimental period of 7 weeks (49 days) including 2 weeks (14 days) of adaptation and 5 weeks (35 days) of data collection. In this experiment, all procedures were in accordance with the TALIRI code for the Care and Use of Animals for experimental purposes.

Twenty male growing Tanzanian blended goats (Malya) were used for the experiment, aged 9 months with an average weight of 19.6±2.9 kg. These goats are a crossbreed of Kamorai, Boer, and Small East African goat breeds, known for their dual-purpose characteristics (Ruvuga *et al*. 2022). The goats were housed individually with access to water and were dewormed and treated for external parasites before the experiment. The study included four treatment diets: *Cenchrus ciliaris* alone, *Cenchrus ciliaris* + Urea based MNB (UBB), *Cenchrus ciliaris* + Sunflower seedcake based MNB (SCBB), and *Cenchrus ciliaris* + *Leucaena pallida* leaf meal based MNB (LPBB). The MNBs were prepared based on the NRC guidelines (Backialakshmi *et al*. 2024).

The experimental animals were grouped into five blocks based on their initial body weight and then randomly assigned to one of four treatment diets using a randomized

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block design. Initially, the bucks were fed only *Cenchrus ciliaris* chaff before being switched to the treatment diets. The treatment diets were prepared and weighed daily. The animals were fed *Cenchrus ciliaris* chaff as their basal ration at 3% of their live weight, given twice a day at 8.30 AM and 3.30 PM throughout the 7-week experimental period. Leftover *Cenchrus ciliaris* was collected and weighed daily before the next feeding. The formulation of MNBs utilized locally available ingredients, such as molasses, urea, sunflower seed cake, *Leucaena pallida* leaf meal, maize bran, common salt, Dicalcium phosphate, and cement (Table 1). The MNBs were manually mixed, molded, and left to dry for 4-5 days before being fed to the goats. The MNBs were weighed daily and hung inside each pen, except for the control pens. Goats were supplemented with UBB, SCBB, and LPBB, with the final weight of the MNBs measured each morning before the next offering. The ambient temperature in the goat shed was recorded daily in the morning and evening.

Feed refusals from each pen were collected every morning before offering fresh feed. All refusals were weighed and bulked into a single bag for each animal over 7 days, and then sub-samples were taken and dried in an oven at 65°C for 12 h to determine dry matter. Daily dry matter intake was calculated by taking the difference between feed offered and refusals over 7 consecutive days. Animals were weighed weekly in the morning before feeding using a digital weighing scale (MTC Smiley, India) calibrated with a known test weight prior to weighing. MNB intake was calculated daily by taking the difference between weight of MNB offered and the weight remained in the next day. Samples of treatment diets were analyzed at Tanzania Veterinary Laboratory Agency (TVLA) in Dar es Salaam, Tanzania using the methods described by Ruvuga *et al*. (2022). The metabolisable energy (ME) of the diets was determined using the equation:

$$11.78 + 0.0064 \times \text{Crude protein} + (0.000665 \times \text{Crude fat})\ 2 - \text{Crude fat}\ (0.0041 \times \text{Crude fat}) - 0.0118 \times \text{Ash}$$

Data were analyzed in R-Program version 4.0.1 (R Core Team 2020) using ANOVA mixed model:

$$Y = \text{Diet}_{(\text{fixed})} + \text{Week}_{(\text{fixed})} + \text{Diet*Week}_{(\text{fixed})} + \text{Animal}_{(\text{random})} + \text{Residual error}$$

All potential interactions between main effects were tested. Models were compared for significance and fit using likelihood ratio tests, and AIC and BIC were used as selection criteria. Treatment means were compared using a Bonferroni correction for multiple comparisons and results are reported as raw means. Differences were declared significant at $P<0.05$.

In general, the control diet (*Cenchrus ciliaris* grass) had lower levels of crude protein (CP), ME, inorganic ash, and crude fat compared to the MNBs. The urea-based MNB had the highest CP content, followed by the *Leucaena pallida*-based MNB and the sunflower seed cake-based MNB (Table 1).

The protein content values observed in the present study for MNBs exceeded those documented by Kumari *et al*. (2019) for molasses-based blocks provided to buffaloes, yet fell below the figures reported by Panadi *et al*. (2019). However, the protein content in MNBs as reported by Yerima *et al*. (2020) agrees with the findings of the current study. The levels of crude fiber (NDF and ADF) were higher in the basal diet compared to the MNBs, consistent

Table 1. Ingredients and chemical composition of different feed used during experimental feeding

Ingredients, % as per formulation	Group			
	Control	UBB	SCBB	LPBB
Sunflower seedcake	-	-	10	-
Leucaena pallida leaf meal	-	-	-	10
Urea	-	10	-	-
Molasses	-	40	40	40
Maize bran	-	35	35	35
DCP	-	1	1	1
Cement	-	10	10	10
Salt	-	4	4	4
Cenchrus ciliaris	100	3*	3*	3*
Chemical composition (%)				
Dry matter (%)	87.7	83.5	84.4	85.9
Crude protein	4.1	26.2	12.6	13.2
Neutral detergent fibre (NDF)	57	28.5	25.3	27.7
Acid detergent fibre (ADF)	34.1	19.2	11.4	13.4
Inorganic ash	6.8	16.5	19.3	19.1
Crude fat	1.3	3.3	5.3	4.3
ME (MJ/kg DM)	8.0	11.4	11.8	11.6

Control, *Cenchrus ciliaris* alone; UBB, Urea based MNB; SCBB, Sunflower seedcake based MNB; LPBB, *Leucaena pallida* based MNB; DCP, Dicalcium phosphate; ME, Metabolisable energy. *, Animals were fed *Cenchrus ciliaris* chaff as a basal ration at 3% of their body weight.

Table 2. Intake and body weight changes in different group of goats

Parameter	Group				
	Control (5)	UBB (5)	SCBB (5)	LPBB (5)	P-value
Basal feed DMI (g/day)	347.2 ± 8.9	372.7 ± 9.8	355.6 ± 13.2	384.7 ± 11.7	0.226
Feed block intake (g/day)	-	192.5 ± 14.7[ab]	147.7 ± 22.1[b]	240.4 ± 21.7[a]	0.006
Total feed intake (g/day)	347.2 ± 8.9[a]	565.2 ± 20.9[bc]	503.3 ± 16.3[b]	625.1 ± 21.5[c]	<0.001
CP intake (g/day)	14.2 ± 0.4[a]	65.7 ± 4[b]	33.2 ± 2.4[c]	47.5 ± 2.8[d]	<0.001
ME intake (MJ/day)	39.9 ± 1[a]	86.1 ± 2.7[b]	81.4 ± 3[b]	89.6 ± 2.3[b]	<0.001
Initial body weight (kg)	20.71 ± 1.7	19.26 ± 2.7	19.29 ± 2.9	20.69 ± 2.8	0.72
Final body weight (kg)	18.75 ± 0.9	18.32 ± 2.2	18.45 ± 2.3	20.04 ± 2.8	0.61
Weight change (kg)	-1.96 ± 0.9	-0.94 ± 0.8	-0.84 ± 0.8	-0.65 ± 0.7	0.12
Average weight loss (g/day)	-55.9 ± 0.1	-26.9± 0.1	-24 ± 0.1	-18.6 ± 0.1	0.12

DMI, Dry matter intake; Control, *Cenchrus ciliaris* chaff alone; UBB, Urea based MNB; SCBB, Sunflower seedcake based MNB; LPBB, *Leucaena pallida* leaf meal based MNB; SD, Standard deviation; CP, Crude protein. Different superscript letters within a row differ significantly (P<0.05).

with the previous findings of Sung ChinTial *et al*. (2023). The inorganic ash content of the MNBs in the current study was higher than the 12.19% reported by Pujaningsih and Tampoebolon (2019) but consistent with the results of Islam *et al.* (2022) in cows fed a straw-based diet. Discrepancies in protein, fiber, and inorganic ash contents among these studies may be attributed to variations in dietary composition, protein sources, ingredients used, and the protein and fiber levels present in those components (Mira *et al*. 2019, Yerima *et al.* 2020). In terms of ME, MNBs had higher ME compared to the control diet, possibly due to the significant inclusion of molasses and maize bran in the MNBs. This indicates that MNBs can serve as a beneficial source of protein and fermentable carbohydrates that may improve goat performance.

The study found that there was no significant difference in basal diet intake among the treatment diets (Table 2). While previous research also reported similar findings regarding basal feed intake when animals were supplemented with urea-molasses MNBs (Yerima *et al*. 2020). Goats supplemented with MNBs in the present study tended to consume more of the basal diet compared to those without supplementation, with LPBB showing the highest intake. This aligns with previous study that observed an increase in dry matter intake of the basal diet in does supplemented with urea-based MNBs (Mira *et al*. 2019). These results imply that MNBs can enhance the provision of rumen degradable proteins, leading to improved rumen microbial activity, faster feed breakdown and passage rates (Pujaningsih and Tampoebolon 2019). Goats received no supplementation exhibited lower basal diet intake, possibly due to the poor nutritional quality of *Cenchrus ciliaris* grass, which may have adverse effects on rumen microbial activity and feed degradation.

The intake of MNBs differed significantly (P<0.05) between the MNBs (Table 2), suggesting variations in palatability and acceptance among the different types of MNBs. *Leucaena pallida* based MNB (LPBB) had the highest intake while SCBB had the lowest value. The difference in intake is likely due to the aroma and fine texture of *Leucaena pallida* leaf meal, which is more appealing to the animals compared to sunflower seed cake. The lower intake of SCBB could be due to lipid oxidation, which can cause off-flavors and reduced palatability (de Evan *et al.* 2020). There were no significant differences (P>0.05) in MNB and total feed intakes between LPBB and UBB, indicating that *Leucaena pallida* leaf meal can be used interchangeably with urea in MNB production without negatively affecting intake. Goats supplemented with LPBB exhibited a higher total feed intake compared to those supplemented with SCBB, likely due to increased consumption of the basal diet and LPBB. The intake of CP and ME was significantly affected by the different diets given to the goats. Goats on the control diet had lower CP intake compared to those on the supplemented diets. Among the supplemented groups, there was a notable difference in CP intake, with the highest intake in UBB and the lowest in SCBB. Similarly, goats on the basal diet had lower ME intake compared to those on the supplemented diets. These variations could be attributed to differences in protein sources and the nutritional content of the ingredients used (Abdulsalam *et al*. 2024). However, the intake of ME was similar among goats that received supplementation.

No statistically significant differences (P>0.05) were found in the initial and final body weights of the animals in the study (Table 2), indicating that the supplementation of MNBs did not have a significant impact on weight change. Previous research has also shown similar results, where different types of MNBs with varying levels of urea (5% and 15%) did not affect body weight change in rams fed cowpea shell and maize offal as the basal feed (Yerima *et al*. 2020). The goats in the present study experienced weight loss across all treatment diets, suggesting that the nutrients provided were insufficient to meet maintenance requirements (Leo-Penu *et al.* 2022). The basal diet used was likely deficient in protein and energy, leading the animals to utilize body reserves and lose weight (de Evan *et al.* 2020). However, LPBB supplementation reduced the weight loss by 66.7% (37.3 g/day), indicating potential for weight gain if the trial were extended beyond 49 days.

These findings implied that LPBB can be utilized as a supplement for goats in the dry season when feed quality diminishes, and can help preventing weight loss in goats which would lead to poor body condition and even death. However, it is important to note that the evaluation of LPBB in this study was limited to a confined environment and a trial period of 49 days. Therefore, further research with longer trial periods is necessary to fully understand the effects of LPBB supplementation on goat performance.

SUMMARY

The study examined how three types of multi-nutrient blocks (urea-based multi-nutrient block, sunflower seedcake-based multi-nutrient block and *Leucaena pallida* leaf meal-based multi-nutrient block) affected the feed intake and growth performance of goats. While the dry matter intake of the basal diet remained unaffected by the multi-nutrient block supplements, the total feed intake was notably higher in the supplemented groups. *Leucaena pallida*-based multi-nutrient block had the highest intake while sunflower seedcake-based multi-nutrient block had the lowest. The preference for *Leucaena pallida*-based multi-nutrient block over sunflower seedcake-based multi-nutrient may be due to the appealing aroma and texture of *Leucaena pallida*. *Leucaena pallida*-based block supplementation reduced weight loss compared to the non-supplemented group. Overall, multi-nutrient blocks with *Leucaena pallida* could be a beneficial supplement for feeding growing goats during the dry season.

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