

Research Article

Effects of *Faidherbia Albida* Dry Pods Supplementation on Feed Intake, Digestibility, and Growth Performance of Boer x Gogo and Malya x Gogo Crossbreed Goats

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Abstract

A study evaluated the effect of *F. albida* dry pod supplementation as the main protein source on feed intake, digestibility, and growth performance of two goat crosses (Boer x Gogo and Malya x Gogo). Thirty six (36) goats aged 6-7 months with an average body weight of 11.02 ± 1.59 kg, were randomly allocated to three dietary treatment groups (T1, T2 & T3) in a completely randomized design. Goats in T1 and T2 were fed *Cenchrus ciliaris* hay as a basal diet and supplemented with a formulated concentrate with *F. albida* dry pods or Sunflower seed cake as the main protein source, respectively, while goats in T3 were allowed to graze and browse in natural pastures without supplementation. The experiment lasted for 90 days. Results indicate that T2 had higher dry and organic matter digestibility than T1. T1 had significantly ($P < 0.05$) higher total feed intake, CP intake, ME intake, and FCR. T1 also led to higher FCR, final weight, total weight gain, and growth rate than T2. Malya x Gogo cross had significantly ($P < 0.05$) higher final weight and FCR than Boer x Gogo. However, there was no significant difference in growth rate or daily gain between crosses. Feeding T1&T2 resulted in significantly ($P < 0.05$) higher final weight, total weight gain, and growth rate than T3. The experimental goal was to address dry season feed shortages by exploring *F. albida* pods as a locally available and affordable protein supplement. It can be concluded that *F. albida* can be used as an alternative protein source in feeding goats as it is palatable, cheap, and readily available in semi-arid areas of Tanzania.

Keywords

Goat, *Faidherbia Albida*, Growth Performance, Feed Intake, Boer x Gogo, Malya x Gogo

1. Introduction

Goat production plays a significant role in supporting the livelihoods of low and middle-income farmers in sub Saharan African countries, particularly in tropical and arid regions [1]. In most of these countries, small ruminants, especially goats,

are often preferred over cattle due to their small size, short reproductive cycle, fast growth rate, and adaptability to seasonal changes given their browsing behavior [2]. Small ruminants, such as sheep and goats, are also noted for their

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ability to thrive in challenging environments and their resistance to diseases that commonly affect cattle.

In Tanzania, the goat population is estimated at approximately 27.6 million, with the majority raised by smallholder farmers [3]. These domestic ruminants, especially within pastoral and agro-pastoral systems, largely depend on natural forages. While these forages are plentiful and nutrient-rich during the rainy season, they become limited and nutritionally deficient in the dry season [4, 5]. The shortage of quality feed during this period poses a major challenge to small ruminant production [6]. In the dry season, livestock primarily rely on standing hay and crop residues, which offer low nutritional value and are insufficient to meet their basic maintenance needs [6, 7].

At the onset of the dry season, feed quality deteriorates quickly, followed by a decline in availability due to increased grazing pressure and the natural aging of plants. For example, crude protein of mature grasses declines to 1-2% during the dry season; digestible protein and phosphorus are often less than 1 g/kg dry matter (DM), calcium 1.5 to 3.0 g/kg DM, and carotene is less than 1 mg/kg DM [8]. Even where forages are available, their digestible energy and protein content are very low, while lignin and indigestible fibers are higher than recommended [9]. These challenges result in year-round fluctuations in nutrient supply, which impair goat growth and productivity [10]. Malnutrition during the dry season weakens the immune system of goats, making them more prone to diseases [6]. Consequently, farmers may incur higher costs due to supplementary feeding or suffer losses from reduced animal productivity. For many poor smallholder farmers, commercial concentrates and industrial by-products are either inaccessible or unaffordable, making locally available high-protein feeds and mineral supplements a more practical alternative.

Goats typically spend 60-70% of their feeding time consuming fresh and dried leaves, ripe pods, and other parts of browse plants. These browse pods are rich in nutrients and can serve as effective supplements to low-quality roughages [11, 12]. Supplementing ruminants on poor quality roughage diets with tree legumes has been shown to enhance animal performance while reducing production costs [13]. One promising leguminous tree is *Faidherbia albida* (*F. albida*), which is widespread in the semi-arid regions of central Tanzania.

Faidherbia albida serves as a crucial source of browse for both wild and domestic ruminants, especially toward the end of the dry season [14]. As noted by [15], this drought tolerant tree provides a range of feed resources, including leaves, shoots, bark, and pods throughout the dry season. Its pods can be stored for long periods without degradation, offering a low-cost alternative to commercial protein supplements such as sunflower and cottonseed cake [16]. With their high crude protein (CP) and crude fiber (CF) content, *F. albida* pods are an essential protein supplement for ruminants, particularly when diets are deficient in CP during the dry season [17]. Despite these benefits, research on the effects of *F. albida* pod supplementation on goat performance in Tanzania remains limited. Therefore, this study aimed to assess the impact of feeding *F. albida* pods on

feed intake, nutrient digestibility, and weight gain in two goat crosses: Boer × Gogo and Malya × Gogo.

Goats spend 60-70% of their feeding time consuming fresh and dry leaves, ripe pods, and other plant parts from browse species. These browse pods are high in nutritive value and can be used as a supplement to low-quality roughages [11, 12]. Supplementation of ruminants fed low-quality roughage with tree legumes has been found to improve animal performance while at the same time lowering the costs of production [13]. One such promising legume tree is *F. albida*, which is widely spread in semi-arid areas of central Tanzania where it provides browse feed resources for wild and domestic ruminant animals, especially towards the end of the dry season [14]. According to [15] *F. albida* tree is known to resist drought and provide feed resources such as leaves, shoots, bark, and pods throughout the dry season. Its pods can also be stored without deterioration for a long time to be used during feed scarcity and are cheaply obtained compared to commercial protein supplements such as sunflower and cottonseed cake [16]. *F. albida* dry pods play an indispensable role as a protein supplement due to their higher CP and CF content, making them suitable as supplements to low CP feeds, particularly during the dry season [17]. Limited studies have been done in Tanzania to assess the effect of feeding *F. albida* pods on the performance of goats. This study was therefore carried out to determine the effect of feeding *F. albida* pods on feed intake, digestibility, and weight gain of two goat crosses Boer x Gogo (BG) and Malya x Gogo (MG).

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at the Tanzania Livestock Research Institute (TALIRI) in Mpwapwa district, located 120 km from Dodoma, the capital city of Tanzania. The district is at latitude 6°40'00" S and longitude 36°25'00" E, dominated by mountainous topography. The district has a dry savanna climate characterized by a marked seasonal rainfall distribution with a long dry season starting from late April to late November and a short wet season starting late November to the end of April. The average amount of rainfall for the year in Mpwapwa is 712.4 mm. The month with the most rainfall on average is January, with 136.7 mm of precipitation. The month with the least rainfall on average is August, with an average of 1.7 mm. The average temperature for the year in Mpwapwa is 23 °C. The warmest month on average is November with an average temperature of 29.7 °C. The coolest month on average is July, with an average temperature of 20 °C.

2.2. Experimental Feed Preparation

F. albida pods were harvested around the experimental site. Mature pods that had dropped from the trees and were picked

from the ground during the dry season were well dried in the sun and ground by a hammer mill machine to 3 cm, stored in sacks away from moisture. *Cenchrus ciliaris* grass was harvested at the end of the growing season at TALIRI, Mpwapwa, Ilolo pasture farm. The above ground plant parts were cut at ground level, sun dried in the field to make hay, and then chopped by a forage chopper into small pieces (about 3 cm) as recommended by [18].

2.3. Experimental Design

A completely randomized design was employed in this study, consisting of three dietary treatments: T1, T2, and T3. Goats in treatments T1 and T2 received *Cenchrus ciliaris* hay as the basal diet, supplemented with a formulated concentrate. In contrast, goats in T3 served as the control group and were managed according to traditional farmer practices, relying solely on grazing and browsing natural pastures without any supplementation. The concentrate in T1 included *Faidherbia albida* dry pods and sunflower seed cake as the primary protein sources, whereas in T2, sunflower seed cake was the sole protein source (Table 1). Diets for T1 and T2 were formulated to meet the nutritional requirements of growing goats, specifically targeting energy levels between 9-11 MJ/kg DM and crude protein content of 12-16%, as recommended by [19]. All other feed ingredients were sourced from local agro-processing mills and agro-veterinary stores. The ingredients were thoroughly mixed prior to feeding the animals.

Table 1. Feed ingredients and their proportions in the experimental diets.

Feed ingredients	Ingredient inclusion level in the diets (%)		
	T1	T2	T3
Hominy meal	35	48	0
Rice polish	25	27	0
Sunflower seed cake	18	23	0
<i>F. albida</i> dry pods	20	0	0
Mineral premix	1.5	1.5	0
Common salt	0.5	0.5	0
Total	100	100	0

T1= Treatment 1, T2 = Treatment 2 and T3 = Treatment 3

2.4. Experimental Animal Management and Feeding

Thirty six (36) goats with an average initial body weight of

11.02 kg, aged 6-7 months old were randomly selected from the TALIRI farm. Of these, 18 were a cross of MG, and the other 18 were a cross of BG. The goats were equally distributed across the three treatment groups (12 goats per group), maintaining equal representation of breed and sex. All experimental goats were dewormed with albendazole® to control endoparasites at a dosage rate of 3 ml/10kg BW repeated after two weeks. Acaricides were used to control ectoparasites. Experimental goats were housed in an individual pen (1.5 m x 2 m) in a well ventilated area. Each pen had a feed trough and a water trough. A 14 days adaptation period was observed to allow the goats to acclimatize to the feeding regimes and housing conditions. Animals in T1 and T2 were offered 500 g of hay daily with a 5-10% allowance for refusal and 200 g of supplementary experimental diet as recommended by [20]. Concentrates were fed twice daily at 10:00 and 16:00 hours, while hay was offered once daily at 08:00 hours. Clean drinking water was provided ad libitum throughout the experimental period. Animals in treatment three (T3) were grazed and browsed in the nearby grazing area for eight hours from 08:00 h in the morning to 16:00 h in the evening.

2.5. Determination of the Chemical Composition of Feed Ingredients, Formulated Diet, and Hay

Samples of feed ingredients, formulated concentrate diets, and hay were dried and ground to pass through a 1 mm sieve and then analyzed. The samples were analyzed for dry matter DM, ash, crude protein (CP), ether extract (EE), crude fiber (CF), neutral detergent fiber (NDF), and acid detergent fiber (ADF) at Tanzania Veterinary Laboratory Agency (TVLA) Central Veterinary Laboratory, Dar es Salaam using a near-infrared reflectance (NIR) spectrometer (Perkin Elmer, DA 7250™) calibrated according to the manufacturer's instructions for analysis of forage, feed ingredients and concentrate feeds. Nitrogen Free Extract was calculated from the above-obtained chemical composition by the formula $NFE\% = 100 - (\%Moisture + \%ash + \%CP + \%EE + \%CF)$. The metabolizable energy (ME) content of feed ingredients and concentrate diet was estimated using the equation developed by [21], which is $ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE$. The equation $0.15 (0.98 * DMD - 4.8)$ was used to determine the Metabolizable energy (ME) content of hay.

2.6. Digestibility Determination

The in vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of the concentrate diets and hay were determined using ground samples passed through a 2 mm sieve. Digestibility was assessed following the two-stage technique described by [22]. All analyses were conducted at the Animal Nutrition Laboratory, Department of Animal, Aquaculture, and Range Sciences, Sokoine Univer-

sity of Agriculture (SUA).

2.7. Determination of Feed Intake, Animal Weight Gain, Growth Rate, and Feed Conversion Ratio

The experiment lasted for 90 days after an adaptation period of 14 days. The leftovers of supplementary diet and hay were collected and measured before the animals were provided with a ration the following day. The differences between the feed DM offered and the refusal DM was taken as the voluntary DM feed intake. Total dry matter intake was taken as the sum of supplementary DM intake and hay DM intake.

Animal weights were recorded weekly at 07:00 AM, before the animals were fed or, in the case of T3, before they were taken out for grazing. Weight gain was determined at the end of the experiment by subtracting initial body weight from final body weight, where initial body weight was the average goat's weight for three consecutive days before starting the experiment, and final weight was the average goat's weight for three consecutive days at the end of the experiment. Average Daily Weight Gain (ADG) was determined by dividing weight gain by 90 days (experimental days). Feed Conversion Ratio (FCR) was calculated as total feed intake divided by total weight gain.

2.8. Statistical Analysis

Data on feed intake, nutrient intake, final weight, total weight gain, growth rate, and feed conversion ratio were

subjected to analysis of variance (ANOVA) and analyzed using the General Linear Model (GLM) procedure of SAS (2009). The statistical model included fixed effects of treatment, breed, and sex. Two and three way interactions between breeds, sex, and treatment were included in the model. The initial weight of each animal was used as a covariate. The effects of treatment, sex, and breeds were tested using an F-test at $p = 0.05$, and Tukey's test was used to separate the means at $p = 0.05$.

3. Results

3.1. Chemical Composition of Feed Ingredients, Formulated Diet, and Hay

The chemical composition of feed ingredients, formulated diets, and hay is presented in Table 2. The compounded diet in T1 had higher CP content (129.0 g/kg DM) compared to T2 (126.0 g/kg DM), as well as higher CF (89.0 g/kg DM) than T2 (77.0 g/kg DM). T2 had higher Metabolizable energy ME (11.8 MJ/kgDM) than T1 (11.5 MJ/kgDM). The *Cenchrus ciliaris* hay was found to have the lowest nutritional value among all feed ingredients, with a CP content of 75.0 g/kg DM and metabolizable energy of 8.3 MJ/kg DM. However, *Cenchrus ciliaris* hay had the highest content of NDF and ADF, with values of 757.0 g/kg DM and 445.0 g/kg DM, respectively. Additionally, its CF content was higher than that of all other feed ingredients and compound diets.

Table 2. Chemical composition of feed ingredients, compound diets, and hay used in the experiment.

(g/kg DM)	Feeds and ingredients						
	FAP	SSC	HM	RP	CCH	T1	T2
DM (g/kg)	913	937	909	941	933	895	894
Ash	37	61	34	157	106	64	61
CP	171	240	149	103	75	129	126
EE	26	158	122	141	14	57	66
CF	304	230	97	166	373	89	77
NFE	375	248	507	374	365	556	564
ME (MJ/kgDM)	9.6	12.4	13.2	11.7	8.3	11.5	11.8
NDF	604	425	495	57	757	230	207
ADF	542	349	117	18	445	145	131

FAP-F. albida pods, SSC-Sunflower seed cake, HM-Hominy meal, RP-Rice polish, CCH=*Cenchrus ciliaris* Hay, T1-Supplementary diet for treatment 1, T2-Supplementary diet for treatment 2, DM-Dry matter, CP-Crude protein, EE-Ether extract, NFE-Nitrogen free extract, ME-Metabolizable energy, NDF-Neutral detergent fiber, ADF-Acid detergent fiber

3.2. Concentrate Diet and Hay in Vitro Digestibility

In Vitro Dry Matter Digestibility (IDMD) and In Vitro Organic Matter Digestibility (IOMD) of basal diet and supplemented diet are shown in Table 3. Among the diets, T2 had higher DMD and OMD than T1. OMD was observed to be higher than DMD in both dietary treatments, while the IOMD in *Cenchrus ciliaris* hay was higher compared to IDMD (56.09% vs. 53.73%).

Table 3. In vitro Dry matter digestibility and Organic matter digestibility of basal diet and supplemented diet.

Hay (basal diet) and formulated diets	In Vitro DMD (%)	In Vitro OMD (%)
Cenchrus ciliaris hay	53.73	56.09
Diet T1	67.48	69.43
Diet T2	71.11	73.61

DMD-Dry matter digestibility, OMD-Organic matter digestibility, T1-Treatment 1, T2-Treatment 2

3.3. Feed Intake, Nutrient Intake, and Feed Conversion Ratio (FCR)

Dry matter feed intake, nutrient intake (CP and ME), and Feed Conversion Ratio (FCR) for different breeds and sexes under T1 and T2 are shown in Table 4. Animals under T1 had a higher hay intake, total feed intake, CP intake, and ME intake than animals under T2 ($P < 0.05$). The FCR differed significantly ($P < 0.05$) between treatments, and was higher for T1. Animals under T2 exhibited higher concentrate intake (223.29 gDM/day) ($P < 0.05$) than animals under T1 (217.10 gDM/day).

The results also show a significant ($P < 0.05$) difference between crosses in terms of FCR whereby the BG goat crosses had a lower FCR (5.63) compared to the MG goat (FCR of 6.10). Hay intake, concentrate intake, total feed intake, crude protein intake, and metabolizable energy intake did not differ between the crosses. There were no statistically significant differences ($P < 0.05$) in intake values or FCR between male and female goats. The Interactions among dietary treatments, breed, or sex were found not to be significant.

Table 4. Least square means ($\pm$ SE) for Feed Intake, Nutrient Intake, and Feed Conversion Ratio of Goats under Different Dietary Treatments.

Factor	Level	HI (gDM/day)	CI (gDM/day)	TFI (gDM/day)	CPI (g/day)	MEI (MJ/day)	FCR
TR	T1	304.09a	217.10b	521.19a	58.89a	5.99a	5.92a
	T2	277.44 ^b	223.29 ^a	500.73 ^b	57.28 ^b	5.87 ^b	5.81 ^b
	SE	11.91	6.97	11.74	1.17	0.12	0.15
	p-Value	0.1309	0.5378	0.2338	0.3439	0.4816	0.6227
BD	BG	305.41	210.86	516.27	58.20	5.91	5.63 ^b
	MG	276.12	229.53	505.64	57.98	5.95	6.10 ^a
	SE	11.91	6.97	11.74	1.17	0.12	0.15
	p-Value	0.0991	0.0745	0.5304	0.8945	0.8109	0.0415
Sex	F	285.51	212.74	498.25	56.64	5.78	5.99
	M	296.01	227.65	523.66	59.54	6.09	5.73
	SE	11.91	6.97	11.74	1.17	0.12	0.15
	p-Value	0.5407	0.1478	0.1434	0.0969	0.0795	0.2481

Means in the same column within a factor with different superscript letters are significant differences ($p < 0.05$)

TR-Treatment, BD-Breed, HI-Hay intake, CI-Concentrate intake, TFI-Total feed intake, CPI-Crude protein intake, MEI-metabolizable energy intake, FCR-Feed conversion ratio, BG-Boer x Gogo, MG-Malya x Gogo

3.4. Final Weight Gain, Total Weight Gain, and Growth Rate

Table 5 presents the mean weight gain, total weight gain, and growth rate for different goat crosses and sexes under treatments T1, T2, and T3. Significant differences ($P < 0.05$) were observed among treatments, with animals in T3 exhibiting lower final weight, weight gain, and growth rate compared to those in T1 and T2. However, no significant differences ($P > 0.05$) were found between T1 and T2 in terms of

final weight, weight gain, or growth rate.

The analysis further indicated that MG crosses had higher final body weights than BG crosses, although this difference was not statistically significant ($P > 0.05$). There were also no significant differences ($P > 0.05$) between the crosses in total weight gain and growth rate. Similarly, no significant differences ($P > 0.05$) were detected between sexes for final weight, weight gain, or growth rate. Additionally, interactions among dietary treatments, breed, and sex were not significant.

Table 5. Least square means $\pm$ SE for final weight, total weight gain, and growth rate of different goats under different treatments.

Factor	Level	FW (Kg)	TWG (Kg)	GR (g/day)
Treatment	T1	20.28 $\pm$ 9.26 ^a	9.26 $\pm$ 8.90 ^a	102.90 $\pm$ 98.99 ^a
	T2	20.13 $\pm$ 9.11 ^a	9.11 $\pm$ 9.42 ^a	101.33 $\pm$ 104.71 ^a
	T3	18.33 $\pm$ 7.31 ^b	7.31 $\pm$ 7.03 ^b	81.29 $\pm$ 78.12 ^b
Breed	BG	18.29 $\pm$ 7.12 ^b	8.37 $\pm$ 7.48	92.97 $\pm$ 83.18
	MG	19.78 $\pm$ 8.76 ^a	8.76 $\pm$ 7.14	97.38 $\pm$ 79.41
Sex	F	19.47 $\pm$ 8.45	8.45 $\pm$ 7.03	93.94 $\pm$ 78.12
	M	19.47 $\pm$ 8.45	8.67 $\pm$ 7.60	96.41 $\pm$ 84.47

Means in the same column within a factor with different superscript letters are significant differences at ($P < 0.05$)

FW-Final weight, TWG-Total weight gain, GR-Growth rate, BG-Boer x Gogo, MG-Malya x Gogo

4. Discussion

4.1. Chemical Composition of Feed Ingredients, Formulated Diet, and Hay

This study evaluated the effect of supplementing *F. albida* pods as a protein source on feed intake, digestibility, and growth performance in BG and MG goats under semi-arid conditions in Tanzania. The goal was to address dry season feed shortages by exploring *F. albida* pods as a locally available and affordable protein supplement. Proximate analysis to determine the chemical composition of *F. albida* pods, feed ingredients, formulated concentrate diets, and basal hay was conducted to assess nutritional adequacy, particularly in terms of CP, ME, and fibre fractions such as NDF and ADF, which are key indicators of feed quality for ruminants [23, 24]. The nutritional evaluation aimed to establish whether *F. albida* pods could meet or exceed the minimum dietary requirements needed to support microbial activity in the rumen and maintain growth in goats during the dry season [25, 26].

The CP content of experimental diets and hay reported in this study was above a minimum of 7% dietary crude protein, which is required for normal rumen bacterial growth and

function for ruminants as recommended by [25]. The author postulates that if dietary protein drops below 7%, forage intake and digestibility will be depressed. This means that the treatment diets were capable of providing the nitrogen required by microbes to synthesize volatile fatty acids for microbial protein synthesis [25]. The energy content of experimental diets was above 11 MJ/kg DM that is in agreement with [23] and [27] who reported that growing goats of 3-8 months old require metabolizable energy between 7-9 MJ/day for maintenance and production. Furthermore, the CP obtained in *F. albida* pods in this study was 171 g/kg DM, which is above 161 g/kg DM reported by [28] in West Africa. Similar to the findings of this study [29], in Tigray, Ethiopia, reported *F. albida* pods to have a CP content of 178 g/kg DM. The CP and overall nutritive value of *F. albida* are influenced by soil, climate, genetics, and management practices of the plant [30, 31]. In the present study CP content of the pod is slightly lower than that of sunflower seed cake, but higher than the minimum CP content of 80 g/kg DM recommended for small ruminants [32].

The NDF and ADF amounts in the diets used in this study are within the ranges recommended for small ruminants, which are 30% to 45% of the total diet dry matter for NDF and 19% to 25% for ADF [33]. Diets with NDF levels above this range may limit intake, while lower levels might not provide

sufficient fiber for proper rumen function. Diets with ADF levels exceeding this range can lead to reduced digestibility and energy intake. *Cenchrus Ciliaris* hay had 75% NDF and 44% ADF, which was in agreement with the recommended level as reported by [34] that high-quality forages with the required amount of NDF and ADF levels are essential for ruminants.

4.2. In Vitro Digestibility of Feeds and Hay

Digestibility of feed components, particularly hay and treatment diets, is a key factor influencing nutrient availability and animal performance. In this study, both organic matter and dry matter digestibility were evaluated to assess the quality and effectiveness of the feed used. Hay organic matter digestibility obtained in the study was different from that reported in the study by [35], in which the organic matter digestibility of *Cenchrus ciliaris* hay from Kongwa, also in semi-arid central Tanzania, was 58.3%. The lower value obtained in this study may be attributed to the stage of maturity at harvest, which likely affected digestibility. The hay in this study was harvested at a later growth stage. As plants mature, fiber content increases, leading to reduced digestibility as reported by [36, 37]. The study by [7] compared the effect of indigenous browses and sunflower seed cake supplementation on the intake and growth performance of dual-purpose goats fed *Cenchrus ciliaris* hay and found that dry matter digestibility of *Cenchrus ciliaris* was 46.1% which was lower than that obtained in this study, likely due to the use of lower quality hay in the experiment. The diet in T2, which had sunflower as a main protein source, had higher in vitro DMD and OMD than in T1. This is likely due to the high tannin content in *F. albida* pods, which acts as an antinutritional factor [38]. Tannin is known to reduce microbial fermentation in the rumen and is toxic to some rumen microbes, ultimately reducing total microbial biomass [39]. It is therefore important to consider the inclusion level to minimize the negative impact. The digestibility of diets in T1 was below that in T2 but was within the range that does not affect animal performance.

4.3. Dry Matter Intake, Nutrient Intake, and Feed Conversion Ratio (FCR)

Higher daily feed intake in goats supplemented with *F. albida* pods as the main protein source is similar to the findings of [40] and [41], who reported that increasing the level of *F. albida* pods in the diet increased daily feed intake up to 20% inclusion level. In this study, the T1 had a 20% inclusion level of *Faidherbia albida*. A similar trend of feed intake was reported in Sudan desert goats at different levels of *F. albida* pods inclusion in the experimental ration [42]. Small ruminants are known to prefer acacia pods due to the sweet taste and attractive smell that they contain [16]. According to [16], increasing pod supplementation enhances hay intake. These

findings agree with this study, where animals supplemented with pods had higher hay intake than non-supplemented ones. This was also observed by [43].

BG cross had a higher average daily total dry matter intake, CP intake, and ME intake than MG cross. This is in agreement with the study of [44] on the study of effects of Boer genotypes on intake and digestion by growing male goats in the central highlands of Ethiopia, where dry matter intake, CP intake, and ME intake increased in the order Local < 25% Boer < 50% Boer. Boer crosses exhibit higher feed intake compared to local goats and other crossbreeds, largely because Boer goats have been selectively bred for enhanced growth performance and meat production [45]. This genetic selection results in higher nutritional requirements to support rapid growth, leading to increased feed consumption [44]. Additionally, larger animals have higher absolute feed intakes to meet their energy and maintenance needs. Boer goats and their crosses typically have a larger body frame compared to indigenous breeds [46, 47], necessitating greater DMI.

Male goats exhibited a higher daily average DMI than female goats, which is in agreement with the findings of a study by [48]. This difference is attributed to the larger body size and higher growth rates of males, which are associated with increased metabolic demands and greater nutrient consumption. Animals under T1 exhibited higher FCR which is likely due to the presence of antinutritional factors, mainly tannin in *albida* pods, which can reduce digestibility, impair nutrient utilization, and consequently increase FCR [49]. The BG goats had lower FCR, reflecting more efficient feed utilization than the MG goats. This can be attributed to the superior growth rates and feed efficiency of Boer goats, which are well documented in comparison to indigenous and crossbred goats [50]. There was no difference in FCR among sexes, which is consistent with the findings by [51], who reported that sex is not the major factor influencing FCR; instead, FCR can primarily be affected by the type of feed and breed.

4.4. Final Weight Gain, Total Weight Gain, and Growth Rate

All goats under concentrate diet supplementation without grazing had significantly higher weight gain and growth rates than those in the control group (normal grazing and browsing) without supplementation. These results are in agreement with the studies of [52], who reported that supplementation "fills the voids" between nutrient demand and nutrients provided by the browse/forage. Supplements do provide protein, energy, minerals, and/or vitamins required by the goat to achieve the desired level of performance. [53] reported that higher supplementary goat feeding levels increase animal weights and body condition scores more than the lower levels and non supplementation. Concentrate supplementation feeding increased the growth rate of goats [54]. A study by [55] on Sangamneri goats in Karnataka, India, revealed that stall-fed goats achieved a significantly higher weight gain compared to

their grazing counterparts. The higher body weight gain and growth rate observed in goats subjected to concentrate diet supplementation (nongrazing) can be attributed to the presence of adequate nutrients in the diets, which enabled the animals to meet their nutritional requirements for maintenance as well as for body weight gain [56]. Similarly, [57], reported that grazing alone is insufficient for optimizing live weight gain and reproductive performance in goats. Grazing requires more energy expenditure, which ultimately affects negatively growth performance as reported by [58] in their study on the effects of the feeding system on weight gain of Black Bengal goats.

The MG crosses exhibited higher final body weight, total weight gain, and growth rate than the BG crosses. This finding is not in agreement with previous studies, which have reported that Boer crosses generally achieve greater weight gain and growth rates than indigenous or non-descript local breeds and their crosses [59-61]. The enhanced performance typically observed in Boer crosses is attributed to the Boer breed's genetic predisposition for rapid growth and efficient meat production. The discrepancy observed in the current study may be attributed to the poor adaptability of Boer crossbreds to local environmental conditions. Heat stress in Boer goats and their crosses has been associated with reduced feed intake relative to body requirements and subsequent body weight loss, as animals attempt to minimize metabolic heat production [62]. Additionally, studies have shown that Boer goats may exhibit heightened stress responses during handling compared to indigenous breeds, suggesting potential challenges in their adaptability under less intensive management systems [63].

The observation that males and females did not differ significantly in the final weight, total weight gain, and growth rate contrasts with the findings of [64]. It is expected that males generally achieve higher weight gains and growth rates than their female counterparts, which is influenced by hormone differences [65]. The observed controversy was attributed to behavioral changes and the stress effect of mixing male and female goats in the same building, that were not been mixed before. [66] reported that the presence of females can lead to increased sexual behaviors in males, potentially diverting energy from growth to reproductive activities.

5. Conclusion

Supplementation of goats with *F. albida* pods resulted in higher dry matter intake, live weight gain, and growth rate compared to a non supplemented diet. Goats receiving pod based supplementation showed greater growth performance than those managed under natural grazing and browsing conditions. These findings suggest that using locally available protein sources, such as *F. albida* pods, can be more beneficial than relying solely on commercial protein supplements like sunflower seed cake. Growth performance differences between crosses may suggest genetic differences in adaptability

and nutrient utilization.

Based on the findings of this study, it is recommended that another study should be done in a way than all goats should be allowed to graze freely and then receive targeted supplementation with either *F. albida* pods or sunflower seed cake as main protein source. This approach ensures that animals benefit from natural forage intake while still receiving the necessary nutrients to support growth and carcass development. This combined grazing and supplementation strategy supports sustainable and cost effective goat production under smallholder and extensive systems.

Based on the outcomes of this study, it is recommended that supplementation with *F. albida* pods be further explored and tested at different inclusion levels to determine the most effective and economical dosage for optimal goat performance in semi-arid conditions in Tanzania.

Abbreviations

ADF	Acid Detergent Fiber
ADG	Average Daily Weight Gain
ANOVA	Analysis of Variance
BG	Boer x Gogo
BW	Body Weight
CF	Crude Fibre
CP	Crude Protein
DM	Dry Matter
DMD	Dry Matter Digestibility
DMI	Dry Matter Intake
EE	Ether Extract
FCR	Feed Conversion Ratio
GLM	General Linear Model
IVDMD	In Vitro Dry Matter Digestibility
IVOMD	In Vitro Organic Matter Digestibility
ME	Metabolizable Energy
MG	Malya x Gogo
NDF	Neutral Detergent Fiber
NFE	Nitrogen Free Extract
NIR	Near Infrared Reflectance
OMD	Organic Matter Digestibility
SUA	Sokoine University of Agriculture
TALIRI	Tanzania Livestock Research Institute
TVLA	Tanzania Veterinary Laboratory Agency

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Author Contributions

Fredrick Thadei Karumuna: Conceptualization, Data curation, Formal Analysis, Methodology, Validation, Visualization, Writing - Original Draft

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Said Hemed Mbaga: Supervision, Writing - review & editing

Ethics Clearance Approval

This study was carried out with the permission of the Tanzania Livestock Research Institute (TALIRI) for Animal Research Ethical Clearance dated 19 September 2024, with Clearance Certificate Number TLRI/CC.21/034.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Patrick Baenyi, S., Owino Junga, J., Keambou Tiambo, C., Bwihangane Birindwa, A., Karume, K., Mekuriaw Tarekegn, G., & Winyo Ochieng, J. (2020). Production Systems, Genetic Diversity and Genes Associated with Prolificacy and Milk Production in Indigenous Goats of Sub-Saharan Africa: A Review. *Open Journal of Animal Sciences*, 10(04), 735-749. <https://doi.org/10.4236/ojas.2020.104048>
- [2] Lohani, M & Bhandari, D. (2021). The Importance of Goats in the World. *Professional Agricultural Workers Journal*, 6, 18. The Importance of Goats in the World. Vol. 6: No. 2, 4. <https://tuspubs.tuskegee.edu/pawj/vol6/iss2/4>
- [3] MLF. Ministry of Livestock parliament speech 0f (2024/2025) Tanzania. Available from: [https://www.mifugouvuvu.go.tz/uploads/speeches/docs/sw1715596084combinedd%20hotuba%20ya%20wizara%20ya%20mifugo%20na%20uvuvi%2013%20may%202024%20\(1\).pdf](https://www.mifugouvuvu.go.tz/uploads/speeches/docs/sw1715596084combinedd%20hotuba%20ya%20wizara%20ya%20mifugo%20na%20uvuvi%2013%20may%202024%20(1).pdf) (accessed 21 April 2025).
- [4] Mwilawa, A. J., Komwihangilo, D. M., & Kusekwa, M. L. (2008). Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania. *African Journal of Ecology*, 46(SUPPL. 1), 85-89. <https://doi.org/10.1111/j.1365-2028.2008.00934.x>
- [5] Fleischer J., S. E. and A.-K. K. (2000). Performance of sheep fed NaOH-treated straw with Browse compared with urea-treated straw. *Ghana Journal Agricultural Science*. Vol. 33 No. 2. <https://doi.org/10.4314/gjas.v33i2.1873>
- [6] Lamid. (2014). Dry season feeds and feeding: a threat to sustainable ruminant animal production in Nigeria. *Journal of Agriculture and Social Research*, Vol. 14, No. 1, 17-30. <https://www.researchgate.net/publication/301541823>
- [7] Komwihangilo, D. M., Chenyambuga, S. W., Lekule, F. P., Mtenga, L. A., & Muhikambele, V. R. M. (2005). Comparison of indigenous browses and sunflower seed cake supplementation on intake and growth performance of dual-purpose goats fed buffel grass (*Cenchrus ciliaris*) hay. *Asian-Australasian Journal of Animal Sciences*, 18(7), 966-972. <https://doi.org/10.5713/ajas.2005.966>
- [8] Msangi, R. B. R., & Hardesty, L. H. (1993). Forage Value of Native and Introduced Browse Species in Tanzania. *Journal of Range Management*, 46(5), 410. <https://doi.org/10.2307/4002658>
- [9] Adjorlolo, L. K., Adogla-Bessa, T., Amaning-Kwarteng, K., & Ahunu, B. K. (2014). Seasonal effect on rumen function in sheep on range in the Accra Plains of Ghana. *Tropical Animal Health and Production*, 46(7), 1223-1228. <https://doi.org/10.1007/s11250-014-0629-y>
- [10] Shija, D. S., Mtenga, L. A., Kimambo, A. E., Laswai, G. H., Mushi, D. E., Mgheni, D. M., Mwilawa, A. J., Shirima, E. J. M., & Safari, J. G. (2013). Preliminary evaluation of slaughter value and carcass composition of Indigenous sheep and goats from a traditional production system in Tanzania. *Asian-Australasian Journal of Animal Sciences*, 26(1), 143-150. <https://doi.org/10.5713/ajas.2012.12431>
- [11] Maphosa, J. L. N. S. V., & Mlambo, T. S. V. (2002). Use of local browse tree pods as dry season supplement for goats in the southwestern region of Zimbabwe. *Zimbabwe Journal of Agricultural Research*, November 2014, 193-195.
- [12] Osuga, I. M., Njeru, D. G., Musalia, L. M., & Abdulrazak, S. A. (2020). The nutritive value and palatability of selected browse forage mixtures from the arid and semi-arid areas of Kenya when fed to growing Small East African Goats. *Journal of Agriculture and Veterinary Science*, 13(3), 1-7. <https://doi.org/10.9790/2380-1303020107>
- [13] Yahaya, M. S., Takahashi, J., Matsuoka, S., Kibon, A., & Dibal, D. B. (2000). Evaluation of arid region browse species from northeastern Nigeria using pen fed goats. *Small Ruminant Research*, 38(1), 83-86. [https://doi.org/10.1016/S0921-4488\(00\)00134-6](https://doi.org/10.1016/S0921-4488(00)00134-6)
- [14] Dawson, I. K., Carsan, S., Franzel, S., Kindt, R., Graudal, L., Orwa, C., & Jamnadass, R. (2014). Agroforestry, livestock, fodder production and climate change adaptation and mitigation in East Africa: issues and options. *ICRAF Working Paper*, 178(January), 31. <http://www.worldagroforestry.org/downloads/Publications/PDFS/WP14050.pdf>
- [15] Hassan, L. G., Umar, K. J., Yuguda, H., Hassan, L. G., & Umar, K. J. (2007). Nutritional evaluation of *Faidherbia albida* seeds and pulp as a source of feeds for livestock. *African Journal of Food, Agriculture, Nutrition and Development*, 7(5), 1-11. <https://doi.org/10.18697/ajfand.16.1835>

- [16] Ntakwendela L, L Mtenga, A Peleka, W Chenyambuga, G. (2002). Effects, of Substituting Sunflower Seed Cake with Acacia tortilis, Pods. as Protein Source in Supplementary Diets of small East African Goats. Tanzania Journal of Agricultural Sciences, 5(1), 39-48. Available from: <https://www.ajol.info/index.php/tjags/article/view/115233> (accessed 15 April 2025).
- [17] Lebbie, S; Rey, B. I. E. K. (1994). Small Ruminant Research and Development in Africa. In Proceedings of the second Biennial Conference of the African Small Ruminant Research Network, AICC, Arusha, Tanzania, ILCA/ CTA. ILCA, Addis Ababa. Ethiopia 157 (Vol. 20, Issue 4). <https://doi.org/10.24989/medienjournal.v20i4.587>
- [18] Kaitho, R. J., Umunna, N. N., Nsahlai, I. V., Tamminga, S., Van Bruchem, J., Hanson, J., & Van De Wouw, M. (1996). Palatability of multipurpose tree species: Effect of species and length of study on intake and relative palatability by sheep. Agroforestry Systems, 33(3), 249-261. <https://doi.org/10.1007/BF00055426>
- [19] Cannas, A., Atzori, A. S., Boe, F., & Teixeira, I. A. M. de A. (2007). Energy and protein requirements of goats. Dairy Goats, Feeding and Nutrition, 118-146. <https://doi.org/10.1079/9781845933487.0118>
- [20] Saraswat, B. L., & Sengar, O. P. S. (2000). Nutrient requirements of goats - A review. Indian Journal of Animal Sciences, 70(12), 1236-1241. <https://doi.org/10.56093/ijans.v95i4.152309>
- [21] MAFF. (1975). Energy allowances and feeding systems for ruminants / Ministry of Agriculture, Fisheries and Food, Department of Agriculture & Fisheries for Scotland, Department of Agriculture for Northern Ireland. Technical Bulletin 33, 44(0), 62-67.
- [22] Tilley, J. M. A., & Terry, R. A. (1963). A Two - Stage Technique for the in Vitro Digestion of Forage Crops. Grass and Forage Science, 18(2), 104-111. <https://doi.org/10.1111/j.1365-2494.1963.tb00335.x>
- [23] NRC. (2007). Requirement of Small Ruminants Sheep and Goat. National Academy Press Washington DC.
- [24] Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for Dietary Fiber, Neutral Detergent Fiber, and Non-starch Polysaccharides in Relation to Animal Nutrition. Journal of Dairy Science, 74(10), 3583-3597. [https://doi.org/10.3168/jds.S0022-0302\(91\)78551-2](https://doi.org/10.3168/jds.S0022-0302(91)78551-2)
- [25] Gurung, N. (2020). Nutritional Requirements of Different Classes of Meat Goats. Professional Agricultural Workers Journal, 6(3), 10. <https://tuspubs.tuskegee.edu/pawj/vol6/iss3/10/>
- [26] Rodríguez, R., Sosa, A., & Rodríguez, Y. (2007). Microbial protein synthesis in rumen and its importance to ruminants. Cuban Journal of Agricultural Science, 41(4), 287-294. <https://www.researchgate.net/publication/276901672>
- [27] Martínez-Marín, A. L., Pérez-Hernández, M., Pérez-Alba, L. M., Carrián-Pardo, D., & Gómez-Castro, A. G. (2012). Nutrient limits in diets for growing dairy goats. Archivos de Medicina Veterinaria, 44(1), 13-20. <https://doi.org/10.4067/S0301-732X2012000100003>
- [28] Mohammed, I. D. (1980). Effects of feeding levels of dry *Faidherbia albida* pods as a supplement to a basal ration of cowpea husks on nutrient utilization by sheep. Available from: <https://www.globalacademicgroup.com/journals/knowledge%20review/Mohammed.pdf> (accessed 21 April 2025).
- [29] Gebru, N. (2014). Effects of supplementing chopped euphorbia tirucalli twigs and dry acacia albida pods on carcass characteristics of goats. CiteSeer, 2(2), 104-110. <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.680.3459&rep=rep1&type=pdf>
- [30] Debela, M., Animut, G., & Eshetu, M. (2017). Evaluation of the Nutritional Composition of Selected Indigenous Fodder Trees and Shrubs in Daro Labu District, Eastern Ethiopia. Journal of Biology, Agriculture and Healthcare, 7(19), 58-61. <https://core.ac.uk/download/pdf/234662437.pdf>
- [31] Stott, D. E., Mohtar, R. H., Steinhardt, G. C., Dangasuk, O. G., Gudu, S., Okalebo, J. R., & Dangask, O. G. (2001). Early Growth Performance of Sixteen Populations of *Faidherbia albida* in Semi Arid Baringo District of Kenya. Sustaining Global Farm, 412-418. https://www.doc-developpement-durable.org/file/Culture/Arbres-Bois-de-Rapport-Reforestation/FICHES_ARBRES/faidherbia%20albida/Early%20Growth%20Performance%20of%20Semi%20Populations%20of%20Faidherbia%20albida%20in%20semi%20arid%20Kenya.pdf
- [32] ANR. (2007). Nutrient Requirements of Sheep and Goats. In Extension Alabama A&M Auburn Universities.
- [33] Banakar, P. S., Kumar, A., Shashank, C. G., & Lakhani, N. (2018). Physically effective fibre in ruminant nutrition: A review. Article in Journal of Pharmacognosy and Phytochemistry, 18(4), 303-308. <https://www.researchgate.net/publication/349097299>
- [34] Schroeder, J. W. (2004). Forage nutrition for ruminants. Extending Knowledge Changing Life NDSU Extension, 1250(August).
- [35] Rhoses N, P. u. (1998). Promising tropical grasses and legumes as feed resources in Central Tanzania V. Effect of supplementing Cenchrus ciliaris hay with leaves from four legumes on intake and digestibility by growing Mpwapwa bulls. Animal Feed Science and Technology, 70(1-2), 111-122. <https://doi.org/10.2989/10220119.2023.2219700>
- [36] Buxton, D. R., & Redfearn, D. D. (1997). Plant limitations to fiber digestion and utilization. Journal of Nutrition, 127(5 SUPPL.), 814-818. <https://doi.org/10.1093/jn/127.5.814s>
- [37] Patil, P. & Patil, M. (2022). Factors Affecting Nutrient Digestibility in Animals. College of Veterinary & Animal Sciences, Udgir Dist. Latur-413517, Maharashtra Just Agriculture news letter, 2(7). <https://justagriculture.in/files/newsletter/2022/march/071.pdf>

- [38] Bouazza, L., Bodas, R., Boufennara, S., Bousseboua, H., & López, S. (2012). Nutritive evaluation of foliage from fodder trees and shrubs characteristic of Algerian arid and semi-arid areas. *Journal of Animal and Feed Sciences*, 21(3), 521-536. <https://doi.org/10.22358/jafs/66126/2012>
- [39] Frutos, P., Hervás, G., Giráldez, F. J., & Mantecón, A. R. (2004). Review. Tannins and ruminant nutrition. *Spanish Journal of Agricultural Research*, 2(2), 191-202. <https://doi.org/10.5424/sjar/2004022-73>
- [40] Bah, S. U. (2019). Effect of varying levels of *Faidherbia albida* pods supplements on intake and weight gain of Red Sokoto goats in the semi-arid zone, National Animal Production Research Institute, <https://www.researchgate.net/publication/334658318>
- [41] Tadesse, G., & Kumar, N. (2019). Effect of Replacement for Barley grain with *Faidherbia albida* pods on Growth and Hematological Performance in Highland Sheep in Arid Areas of Tigray, Ethiopia. *Ethiopian Journal of Veterinary Science and Animal Production (EJVSAP)* 3 (1): 45-52 (ISSN : 2616-4647), © CVS, Mekelle University. <https://journal.mu.edu.et/index.php/ejvsap/article/view/581>
- [42] Ibrahim, A., & Tibin, I. M. (2003). Feeding potential of *Faidherbia albida* ripe pods for Sudan desert goats. *Scientific Journal of King Faisal University (Basic and Applied Sciences)*, 4(1). <https://services.kfu.edu.sa/ScientificJournal/en/Home/ContentsDetails/56>
- [43] Hidosa, D., & Kibiret, S. (2020). Effects of Acacia tortilis Pod Feeding in Improving Performance of Goats Fed Grass Hay. *Asian Journal of Animal and Veterinary Advances*, 15(2), 50-59. <https://doi.org/10.3923/ajava.2020.50.59>
- [44] Tilahun, M., Kefelegn, K., Abebe, G., & Goetsch, A. L. (2014). Feed intake, digestibility, weight gain, and slaughter characteristics are influenced by the genetic percentage of Boer in goats and Dorper in sheep in the central highlands of Ethiopia. *Tropical Animal Health and Production*, 46(4), 593-602. <https://doi.org/10.1007/s11250-013-0532-y>
- [45] Brand, T. S., Van Der Merwe, D. A., Raffrenato, E., & Hoffman, L. C. (2020). Predicting the growth and feed intake of Boer goats in a feedlot system. *Arquivos Brasileiros de Psicologia*, 50(4), 492-500. <https://doi.org/10.4314/sajas.v50i4.1>
- [46] Das, S., Mohanty, G. P., Mishra, S. K., Pradhan, C. R., Dash, S. K., & Sahoo, S. P. (2015). Comparative study on the performances of locals and their crosses with Boer goats. *The Indian Journal of Animal Sciences*, 85(5), 489-493. <https://doi.org/10.56093/ijans.v85i5.48574>
- [47] Manirakiza, J., Hatungumukama, G., Besbes, B., & Detilleux, J. (2020). Characteristics of smallholders' goat production systems and effect of Boer crossbreeding on body measurements of goats in Burundi. *Pastoralism*, 10(1). <https://doi.org/10.1186/s13570-019-0157-5>
- [48] Peter, R. R., Ewa, W., George, F. F., Christopher, A. M., Boniface, R. K., Ismail, S. S., & Cecilia, K. (2022). Dry matter intake, dry matter digestibility and growth performance in goats fed grass-based diet (*Brachiaria* or *Cenchrus*) compared with a concentrate-based diet. *African Journal of Agricultural Research*, 18(1), 52-57. <https://doi.org/10.5897/ajar2021.15785>
- [49] Pimentel, P. R. S., Pellegrini, C. B., Lanna, D. P. D., Brant, L. M. S., Ribeiro, C. V. D. M., Silva, T. M., Barbosa, A. M., da Silva Júnior, J. M., Bezerra, L. R., & Oliveira, R. L. (2021). Effects of Acacia mearnsii extract as a condensed-tannin source on animal performance, carcass yield, and meat quality in goats. *Animal Feed Science and Technology*, 271(October 2020). <https://doi.org/10.1016/j.anifeedsci.2020.114733>
- [50] GOA. (1990). Factors Affecting Growth in Goats : Review of Literatures. In *Australian Journal of Experimental Agriculture and Animal Husbandry*.
- [51] Pirzado, S. A. (2016). Effect of different levels of protein diets on growth performance and carcass yield of pateri male goat kids. *Pure and Applied Biology*, 5(4), 1200-1206. <https://doi.org/10.19045/bspab.2016.50144>
- [52] Machen, R. (2005). Supplementation of Browsing / Grazing Goats. *Animal & Natural Resource Management*, 7. https://comanche.agrilife.org/files/2011/07/supplementation_goats_3.pdf
- [53] Msalya, G., G. T. Chalamila, and G. K. (2017). A Local Supplementary Diet Improves Reproductive Performance in Does and Growth in Kids of Small East African x Norwegian Landrace Goats. *African Journals Online*, 16(2), 80-89. <https://scispace.com/pdf/a-local-supplementary-diet-improves-reproductive-performance-5sl9k2q6w7.pdf>
- [54] Senthil Kumar, K., & Daisy, M. (2018). Effects of concentrate supplementary feeding on performance growth and reproduction in local goats. *International Journal of Chemical Studies*, 6(2), 265-267. <https://www.chemijournal.com/archives/2018/vol6issue2/PartD/6-1-362-861.pdf>
- [55] Pathan, A. C., Khanvilkar, A. V., Bhokre, S. M., Hande, S. T., Patodkar, V. R., & Bhalerao, S. M. (2017). Weight gain, feed, and water intake in relation to different rearing systems on Sangamneri goats. *International Journal of Environmental Science and Technology*, 6(6), 3315-3320. <https://www.researchgate.net/publication/341566722>
- [56] Maynard, L. A. (2018) *Animal Nutrition in Animal Nutrition*. <https://doi.org/10.5962/bhl.title.155283>
- [57] Hossain N, Shahajalal M, Khan J, B. A. (2003). Effect of Dietary Energy Supplementation on Feed Intake, Growth and Reproductive Performance of Sheep under Grazing Condition. *Pakistan Journal of Nutrition*, 2. <https://doi.org/10.3923/pjn.2003.148.152>
- [58] Moniruzzaman, M., Hashem, M. A., Akhter, S., & Hossain, M. M. (2002). Effect of feeding systems on feed intake, eating behavior, growth, reproductive performance and parasitic infestation of Black Bengal Goat. *Asian-Australasian Journal of Animal Sciences*, 15(10), 1453-1457. <https://doi.org/10.5713/ajas.2002.1453>

- [59] Ghimire, R., Shakya, Y., & Bhattarai, N. (2020). Evaluation of Effects of Genetic and Non-Genetic Factors on the Growth Performance of Boer Cross, Jamunapari Cross, and Local Khari Breeds of Goat in Jagatpur Farm, Chitwan, Nepal. *J Vet Sci Technol*, 2020(1), 595.
<https://www.google.com/maps/place/>
- [60] Parajuli, S. (2020). Performance of Boer and their Crossbreed Goats in Nepal - A Review. *International Journal of Environment, Agriculture and Biotechnology*, 5(6), 1449-1459.
<https://doi.org/10.22161/ijeab.56.7>
- [61] Tesema, Z., Alemayehu, K., Kebede, D., Getachew, T., Deribe, B., Tilahun, M., Kefale, A., Lakew, M., Zegeye, A., Belayneh, N., Yizengaw, L., Shibeshi, M., Tiruneh, S., Worku, G., Kiros, S., & Bishaw, M. (2021). Evaluation of growth and efficiency-related traits of different levels of Boer x Central Highland crossbred goats. *Heliyon*, 7(10).
<https://doi.org/10.1016/j.heliyon.2021.e08184>
- [62] Sarangi, S., & Subhashree Sarangi, C. (2018). Adaptability of goats to heat stress: A review Subhashree Sarangi. *The Pharma Innovation Journal*, 7(4), 1114-1126.
www.thepharmajournal.com
- [63] Ndou, S. P., Muchenje, V., & Chimonyo, M. (2010). Behavioural responses of four goat genotypes to successive handling at the farm. *African Journal of Biotechnology*, 9(47), 8118-8124. <https://doi.org/10.5897/ajb10.687>
- [64] Nuntapaitoon, M., Buranakarl, C., Thammacharoen, S., & Katoh, K. (2021). Growth performance of Black Bengal, Saanen, and their crossbred F1 as affected by sex, litter size, and season of kidding. *Animal Science Journal*, 92(1), 1-9.
<https://doi.org/10.1111/asj.13571>
- [65] Budiarto, A., Susanto, A., Ciptadi, G., Putri, A. R. I., & Sunaryo, M. A. (2021). Quantitative and Qualitative Characteristics of Boer x Local Goats Crossbred. *Animal Production*, 23(2), 77-83. <https://doi.org/10.20884/1.jap.2021.23.2.109>
- [66] Veliz-Deras, F. G., Meza-Herrera, C. A., De Santiago-Miramontes, A., Santos-Alvarado, A., Bustamante-Andrade, J. A., Flores-Salas, J. M., Arellano-Rodríguez, F., & Mellado, M. (2023). An Enhanced Body Condition Improved Sexual Behavior, Ovarian Structure and Function, and Reproductive Fitness in Rangeland-Crossbred Dairy Goats. *Agriculture (Switzerland)*, 13(7).
<https://doi.org/10.3390/agriculture13071337>