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Research Article

Effects of *Faidherbia albida* Dry Pods Supplementation on Carcass, Non Carcass Characteristics and Meat Quality of Boer x Gogo and Malya x Gogo Goats

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Abstract

A study was undertaken to evaluate the effects of *Faidherbia albida* dry pod supplementation as the main protein source on carcass characteristics, non-carcass components and meat quality of two goat's crosses (Boer x Gogo and Malya x Gogo). Thirty-six (36) goats aged 6-7 months weighing 11.02 ±1.59 kg, were randomly allocated to three dietary treatment groups. T1 comprised concentrate supplementary diet with *Faidherbia albida* dry pods as the main protein source, T2 comprised a concentrate supplementary diet with sunflower seed cake as the main protein source while T3 was grazing/ browsing in natural pastures without supplementation. The experimental period was 90 days. At 90 days six goats from each treatment were randomly selected and slaughtered from each treatment. Carcass and non-carcass characteristics were measured. Quality attribute included cooking loss, pH, shear force and chemical composition. Malya x Gogo goats had significantly heavier carcass weight, body weight and non-carcass weight ($P < 0.05$) than Boer x Gogo. Boer x Gogo and female had significant ($P < 0.05$) higher percentages of non carcass as proportional to slaughter body weight. Supplemented goats (T1 &T2) had significant ($P < 0.05$) better carcass characteristics than non-supplemented goats, (T3). Meat quality did not differ among breeds or sex of the goat. The result shows that supplementation of goats improves carcass characteristics and meat quality regardless of breed or sex. Thus, farmers can utilize *Faidherbia albida* pods as an alternative cheap source of protein in raising goats in semi-arid areas where the plant is found.

Keywords

Goat, *Faidherbia Albida*, Carcass, Boer x Gogo, Malya x Gogo

1. Introduction

Management aspects of goat production including feeding, watering, and housing are largely influenced by the prevailing production system which is determined by agro ecological conditions of specific areas. However, the majority of the indigenous goats in Tanzania are raised under traditional extensive production system which is characterized by seasonal shortage of feeds and water [1]. Though the indigenous goats are adapted to varying and often harsh climate. Extrinsic

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factors such as management and feeding affect the quality of meat produced [2].

Indigenous goats have low genetic potential for growth compared to improved types such as Boer, Kalahari etc. Thus, to improve desirable traits such as growth rate, carcass quality, and disease resistance cross breeding with high performing breeds has been explored [3]. Studies shows that Boer crosses and blended goats perform better on growth and carcass characteristics under supplementation than local goats [4-6]. Male goats are known for higher meat yield with less fat content despite the fact that they produce less tender meat [7].

In Tanzania ruminant feeding depends on natural pasture, browse trees, shrubs, standing hay and crop residues. Most of these feeding resources tend to decline in nutritive values during dry season hence, limiting the availability of critical nutrients to the animal [8, 9]. Deterioration in feed quality during dry season has also been associated with high grazing pressure and plant senescence [10]. Therefore, poor nutritional and health stresses can lead to lower dressing percentages, impairment of muscle development, and alteration of meat composition, including changes in fatty acid profiles, which negatively affect meat taste and nutritional value [11, 12]. Goats managed under poor pastures without proper supplementation tend to produce carcasses of low quality characterized by low carcass weight, poor conformation and reduced tenderness [13].

Generally raising young small ruminants on high concentrate diets result in higher daily weight gains, dressing percentage and carcass quality compared to a forage based system [14, 2]. Concentrate supplementation not only reduces slaughter age, but increases carcass quality and meat output thereby improving access to animal protein and income to households [15]. This suggests that finishing goats by supplementing them with locally available feed resources may contribute to improved household food security and income.

Faidherbia albida (Acacia) pods have been shown to enhance growth rates, meat quality when incorporated into ruminant diets [16, 9], and carcass characteristics, such as higher hot carcass weight, indicating enhanced meat production efficiency [17]. Despite the recognized benefits of Acacia pods, there are limited studies in Tanzania evaluating their effects on carcass characteristics in small ruminants, particularly goats. In addition, the two genotypes (Boer x Gogo and Malya x Gogo) have not been characterized in terms of carcass yield and meat quality characteristics under different feeding regime. This study was therefore carried out to determine the effects of feeding *Faidherbia albida* pods on carcass characteristics, dressing percentage and meat quality of Boer x Gogo and Malya x Gogo crossbred goats.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at a research farm of the Tanzania Livestock Research Institute (TALIRI) in Mpwapwa district. The district is located 120km from Dodoma capital city of Tanzania 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 annual rainfall is 712.4mm. January is the wettest month, receiving an average of 136.7mm of precipitation, while August is the driest month, with an average of only 1.7mm. The mean annual temperature in Mpwapwa is 23℃ with November being the warmest at 29.7℃ and July of the coolest at 20℃.

2.2. Experimental Feed Preparation

Faidherbia albida pods were harvested closer to experimental site. Mature pods which had dropped from the trees were picked during the dry season sun dried and grinded using a hummer mill machine to the size of approximately 3cm. The ground material was then stored in sack. *Cenchrus ciliaris* grass was harvested at the end of 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 using a forage chopper into small pieces (about 3 cm) as recommended by Kaitho [18].

2.3. Experimental Design

Table 1. *Feed ingredients and composition of the experimental diets.*

Feed ingredients and composition	Ingredient inclusion level in the diets (%) and composition		
	T1	**T2**	**T3**
Hominy meal	35	48	0
Rice polish	25	27	0
Sunflower seed cake	18	23	0
Faidherbia albida dry pods	20	0	0
Mineral premix	1.5	1.5	0
Common salt	0.5	0.5	0
Total	100	100	0
CP%	12.9	12.6	0
MJ/kg DM	11.5	11.8	0

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

A completely randomized design was used. in this experiment comprising three dietary treatments: T1, T2 and T3. Goats in T1 and T2 were fed *Cenchrus ciliaris* hay as a basal diet and supplemented with a formulated concentrate, while goats in T3 served as the control group and were managed under farmer's practice mainly grazing and browsing in natural pastures without supplementation. In T1, *Faidherbia albida* dry pods were used as the main protein source while in T2, the protein source was sunflower seed cake, representing a commercial diet. Both T1 and T2 diets were formulated to meet the nutritional requirements of growing goats as recommended by Cannas: energy levels between 9–11 MJ/kg DM and crude protein content of 12–16% CP [19] (Table 1). All other ingredients were purchased from the local agro processing mills and agroveterinary store. Ingredients were mixed thoroughly before being provided.

2.4. Experimental Animal Management and Feeding

A total of 36 goats with average initial body weight 11.02 kg, and aged 6-7 months old were randomly selected from TALIRI farm. Of these, 18 were a cross of Malya and Gogo (MG) and other 18 were cross of Boer and Gogo (BG). The goats were equally distributed across the three treatment groups (12 goats per group), maintaining equal representation of breed and sex. Goats were provided with prophylactic treatments against endoparasites, ectoparasites and bacterial infections 7 days before commencement of the experiment. All experimental goats were dewormed with albendazole® to control endoparasite at a dosage rate of 3ml/10kg BW repeated after two weeks. Acaricides were used to control ectoparasites. Experimental goats were housed in individual pen (1.5m x 2m). Each pen had feed trough and 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 500gm of hay every day with a 5-10% allowance for refusal and 200 gm of supplementary experimental diet as recommended by Saraswat [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 nearby grazing area for eight hours from 08: 00 h in the morning to 16: 00 h in the evening.

2.5. Slaughter Procedure and Carcass Yield Measurements

At the end of 90 days feed and growth experiment, 6 goats from each of the treatment were selected at random. Animals were fastened for 16 hours to obtain slaughter weight. All goats were slaughtered according to Halal procedure. The head was removed at the atlanto occipital joint and fore and hind feet removed at the carpal and tarsal joints, respectively. The esophagus was tied closer to the head to avoid leakage of gut content and slaughtered goat was suspended head down for complete blood drain.

Hot carcass weight (HCW) was measured after slaughter and removal of blood, skin, head, feet, gastrointestinal tract, and internal organs. The entire alimentary tract (stomach, small and large intestines) with its contents was removed and weighed. The internal contents of the gut were emptied, and weight of the empty gut was recorded. The difference in weight of full and empty gut was used to determine the gut content. Empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Dressing percentage (DP) as proportions of hot carcass weight to slaughter weight and empty body weight was computed as based on empty body weight DP=HCW/EBW*100 and based on slaughter weight DP=HCW/SW*100 according to procedures by Bonvillani [21].

Non carcass components comprised of blood, heart, kidney, liver, empty gut, spleen, lungs with trachea, head, skin, gut content, feet, gall bladder, feet and esophagus.

2.6. Determination of pH, Cooking Loss and Tenderness

The pH value of the carcasses was measured at *M. gluteobiceps* 45 min post mortem (PM) from the right half carcasses. A penetrating electrode of a portable pH meter was inserted at the geometrical center of the muscle. The choice of the muscle based on its massive nature and the incision for pH probe.

Two samples from each goat's *Longismuss dorsi* muscle were cut weighed (W1), placed in PVC bags then chilled in freezer until when they were taken to the lab for analysis. Muscle samples were thawed at 4℃ overnight before determination of cooking loss. Muscle samples in water tight PVC bags, were heated in a thermostatically controlled water bath set at 70.5℃ for 50 min. The heated samples were left to equilibrate with the room temperature for 2 h, and then transferred to a refrigerator set at 4℃ for 12 h. The samples were removed from the PVC bags, blotted dry with paper towel and weighed (W2). Cooking loss was then calculated as (W1−W2)/W1 ×100.

Four cubes each measuring 2 cm long with 1cm height and 1cm length were prepared from each muscle sample for Warner Bratzler Shear Force (WBSF) assessment. Preparation of each cube was done in such a way that muscle fiber direction was parallel to the cube length. Warner Bratzler shear blade, with a triangular slot cutting edge, attached to Zwick/Roell instrument was used to determine cutting force (N/cm^2) required to shear through a muscle cube. The Zwick was set with 1 kN load cell, with a crosshead speed of 100mm/min. The average shear force for 4 cubes per muscle sample was considered as a peak force for a particular muscle.

2.7. Determination of Carcass Chemical Composition

Carcass chemical composition was determined by dissecting lean and fat from the half carcass then the dissected meat samples were minced. Determination of Dry matter was done by determining water loss of 3 g minced meat samples dried in the oven for 48 h at 104℃ according to [22]. Ash content was determined by further ashing the dried samples using a muffle furnace at 600℃ for 6 h. The Kjeldahl method was used for crude protein determination. Analysis was carried out by following digestion, distillation and titration steps crude fat content was determined by the Soxhlet extraction method [22].

2.8. Statistical Analysis

Data collected on final live weight, slaughter weight, hot carcass weight, empty body weight, dressing percentage, non carcass components, carcass chemical composition (dry matter, crude protein, ether extract, and ash), and meat quality parameters (pH, cooking loss, and Warner-Bratzler shear force) were analyzed using SAS software (Version 9.4, SAS Institute Inc., Cary, NC, USA).

The General Linear Model (GLM) procedure was employed to evaluate the effects of dietary treatment (T1, T2, and T3), breed (BG and MG), and sex (male and female) on all measured traits. Dietary treatment, breed, and sex were included as fixed factors, while individual animals were considered random effects. For body weight measurements, the initial body weight was included as a covariate in the model to adjust for potential variation in starting weight among animals. Interaction effects between dietary treatment and breed, dietary treatment and sex, as well as breed and sex, were initially tested but excluded from the final model when found non-significant ($P > 0.05$).

The statistical model used was structured as follows:

$$Yijklm=\mu+Di+Bj+Sk+\beta(Xijklm)+(D\times B)ij+(D\times S)ik+(B\times S)jk+eijklm$$

where:

Yijklm = observed value of the dependent variable,

μ = overall mean,

Di = fixed effect of the i-th dietary treatment,

Bj = fixed effect of the j-th breed,

Sk = fixed effect of the k-th sex,

β(Xijklm) = linear regression coefficient for initial body weight (covariate),

(D×B)ij = interaction between dietary treatment and breed,

(D×S)ik= interaction between dietary treatment and sex,

(B×S)jk= interaction between breed and sex,

eijklme= random error term, assumed to be normally distributed with mean zero and constant variance.

Where significant effects were detected ($P < 0.05$), means were separated using Tukey's test at $p = 0.05$.

3. Results

3.1. Carcass Characteristics and Dressing Percentages

Means of SBW, EBW, HCW and DP for experimental goats are summarized in Table 2. The mean values of the slaughter body weight (SBW), empty body weight (EBW) and hot carcass weight (HCW) were significantly ($P < 0.05$) different and higher for goat supplemented with T2, medium weight was recorded in T1 and lowest weight recorded for un-supplemented goats (T3). The dressing percentages differed significantly ($p<0.05$) among the diets with T1 having higher value and T3 having lowest value.

Table 2. *Least Squares Means (LSM ±SE) for effect of Breed, Sex, and Treatment on Carcass Characteristics.*

Factor	Level	SBW (Kg)	EBW (kg)	HCW (kg)	D%SBW	D%EBW
TR	T1	19.7 ±0.6^{ab}	17.5 ±0.5^{ab}	9.8 ±0.4^{ab}	49.5 ±0.5^{a}	55.5 ±0.6^{a}
	T2	20.6 ±0.6^{a}	18.4 ±0.5^{a}	10.0 ±0.4^{a}	48.7 ±0.5^{b}	54.4 ±0.6^{b}
	T3	18.5 ±0.7^{b}	15.8 ±0.5^{b}	8.3 ±0.4^{b}	45.1 ±0.5^{c}	52.5 ±0.6^{c}
	P-value	0.1308	0.0320	0.0255	0.0003	0.0225
BD	BG	17.5^{b}	15.4^{b}	8.4^{b}	47.8	54.0
	MG	21.7^{a}	19.1^{a}	10.4^{a}	47.7	54.2
	SE	0.5	0.5	0.3	0.4	0.5
	P-value	0.0004	0.0003	0.0015	0.8969	0.8271
Sex	F	18.6 ±0.6^{b}	16.4 ±0.5^{b}	8.9 ±0.3	47.9 ±0.4	54.4 ±0.5
	M	20.5 ±0.5^{a}	18.1 ±0.4^{a}	9.8 ±0.3	47.6 ±0.4	53.8 ±0.5
	P-value	0.0396	0.0374	0.0976	0.5079	0.3953

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

SBW-Slaughter body weight, EBW-Empty body weight, HCW-Hot carcass weight, BG-Boer x Gogo, MG-Malya x Gogo

Table 2 also show that breeds differed significantly ($p<0.05$) in terms of HCW, SBW and EBW in favor of MG crosses. Male goats exhibited a higher SBW and EBW than female goats ($P < 0.05$). Meanwhile HCW and dressing percentages were found not to differ between sex. Interaction between dietary treatment, breeds and sex on carcass characteristics was tested and found to be not significant ($P > 0.05$).

3.2. Non Carcass Components

Non carcass components in this study includes blood, heart, kidney, liver, empty gut, spleen, lungs with trachea, head, skin, gut content, gall bladder, feet and esophagus. Effect of dietary treatment, breed and sex on the above components are shown in Table 3. Skin and head were significantly ($P < 0.05$) different and higher for goats supplemented with T2, medium weight was recorded in T1 and lowest weight recorded for un supplemented goats in treatment T3. All other non carcass components were significantly ($P < 0.05$) different and heavier for supplemented goats T1 and T2 than non supplemented grazing goats T3. Gut content was significantly ($P < 0.05$) different and heavier for T3 than T2 and T1. MG crosses had significant ($P < 0.05$) heavier non carcass components than BG crosses. With regard to sex blood, heart, kidney, liver empty gut, lung and trachea, esophagus and feet were significant ($P < 0.05$) different and higher for female than male. However, there was no significant ($P > 0.05$) difference for other non carcass components among sex. Total non carcass components were significantly ($P < 0.05$) different and heavier for T2, medium weight was recorded in T1 and lowest weight recorded for T3. MG had significant ($P > 0.05$) heavier total non carcass components than BG, while total non carcass components were significantly ($P < 0.05$) different and heavier for female crosses than male crosses. There were no significant ($P > 0.05$) difference for percentages of non carcass to slaughter body weight among treatments while. BG had significant ($P > 0.05$) higher percentages of non carcass to slaughter body weight than BG, while percentages of non carcass to slaughter body weight were significantly ($P < 0.05$) different and higher for female than male.

Table 3. *Least Squares Means (LSM ±SE) for Breed, Sex, and Treatment effects on non carcass components of experimental goats.*

PR (kg)	TR			P-value	BD		P-value
	T1	T2	T3		BG	MG	
BL	1.38 ±0.04^{a}	1.46 ±0.04^{a}	1.27 ±0.04^{b}	<.0001	1.23 ±0.03^{b}	1.50 ±0.03^{a}	0.0002
HT	0.16 ±0.00^{a}	0.16 ±0.00^{a}	0.13 ±0.01^{b}	<.0001	0.13 ±0.00^{b}	0.17 ±0.00^{a}	0.0004
KD	0.16 ±0.00^{a}	0.17 ±0.00^{a}	0.11 ±0.00^{b}	<.0001	0.13 ±0.00^{b}	0.16 ±0.00^{a}	0.0003
LV	0.59 ±0.02^{a}	0.62 ±0.02^{a}	0.37 ±0.02^{b}	<.0001	0.47 ±0.01^{b}	0.59 ±0.01^{a}	0.0003
HE	1.69 ±0.06^{ab}	1.77 ±0.06^{a}	1.57 ±0.06^{b}	<.0001	1.49 ±0.05^{b}	1.86 ±0.05^{a}	0.0005
EG	2.65 ±0.02^{a}	2.68 ±0.02^{a}	2.47 ±0.02^{b}	<.0001	2.55 ±0.01^{b}	2.65 ±0.01^{a}	0.0004
LT	0.33 ±0.01^{a}	0.35 ±0.01^{a}	0.25 ±0.01^{b}	<.0001	0.28 ±0.01^{b}	0.34 ±0.01^{a}	0.0003
SP	0.05 ±0.00^{a}	0.05 ±0.00^{a}	0.03 ±0.00^{b}	<.0001	0.04 ±0.00^{b}	0.05 ±0.00^{a}	0.0003
SKN	2.15 ±0.07^{ab}	2.27 ±0.07^{a}	2.00 ±0.08^{b}	<.0001	1.90 ±0.06^{b}	2.38 ±0.06^{a}	0.0004
GBL	0.01 ±0.00^{a}	0.01 ±0.00^{a}	0.01 ±0.00^{b}	<.0001	0.01 ±0.00^{b}	0.01 ±0.00^{a}	0.0002
GC	2.13 ±0.10^{b}	2.21 ±0.10^{b}	2.61 ±0.11^{a}	<.0001	2.09 ±0.08^{b}	2.55 ±0.08^{a}	0.0041
OSP	0.05 ±0.00^{a}	0.06 ±0.00^{a}	0.04 ±0.00^{b}	<.0001	0.05 ±0.00^{b}	0.06 ±0.00^{a}	0.0003
FT	0.59 ±0.02^{a}	0.62 ±0.02^{a}	0.37 ±0.02^{b}	<.0001	0.47 ±0.01^{b}	0.58 ±0.01^{a}	0.0002
TOTAL	11.94 ±0.34^{ab}	12.43 ±0.34^{a}	11.22 ±0.36^{b}	<.0001	10.82 ±0.29^{b}	12.90 ±0.29^{a}	0.0006
PSBW	60.87 ±0.29	60.66 ±0.29	60.84 ±0.31	<.0001	61.92 ±0.25^{a}	59.66 ±0.25^{b}	0.0001

PR (kg)	Sex		P-value
	F	M	
BL	1.43 ±0.03[a]	1.30 ±0.03[b]	0.0212
HT	0.16 ±0.00[a]	0.14 ±0.00[b]	0.0334
KD	0.15 ±0.00[a]	0.14 ±0.00[b]	0.0298
LV	0.55 ±0.01[a]	0.50 ±0.02[b]	0.0344
HE	1.75 ±0.05	1.60 ±0.05	0.0648
EG	2.63 ±0.01[a]	2.58 ±0.01[b]	0.0327
LT	0.33 ±0.01[a]	0.29 ±0.01[b]	0.0305
SP	0.05 ±0.00	0.04 ±0.00	0.0501
SKN	2.23 ±0.06	2.04 ±0.07	0.0641
GBL	0.01 ±0.00	0.01 ±0.00	0.0730
GC	2.45 ±0.08	2.19 ±0.09	0.0600
OSP	0.05 ±0.00[a]	0.05 ±0.00[b]	0.0395
FT	0.55 ±0.01[a]	0.50 ±0.01[b]	0.0285
TOTAL	12.34 ±0.27[a]	11.38 ±0.31[b]	0.0457
PSBW	61.19 ±0.26[a]	60.39 ±0.23[b]	0.0543

Means in the same row within the same factor with different superscript letters are significant differences ($P < 0.05$)
BG-Boer x Gogo, MG-Malya x Gogo, BL-Blood, HT-Heart, KD-Kidney, LV-Liver, EG-Empy gut, SP-Spleen, HE-Head, LT-Lung and trachea, SKN-Skin, GBL-Gallbladder, OSP-Esophagus, FT-Feet, GC-Gut content, PSBW-Percentages of non carcass to slaughter body weight, TR-Treatment, BD-Breed

3.3. Cooking Loss, pH, Shear Force and Chemical Composition

There were no significance differences ($P > 0.05$) in pH values among dietary treatments, breed and sex. Cooking loss and tenderness (Shear force) were significant ($P < 0.05$) different and lower in T1 and T2. The difference between T1 and T2 for these two parameters were not significant ($P<0.05$). Crosses (breed) showed no difference in pH, CL and SF. As regard to sex, females showed to have more tender meat than their male counterparts but, the two sexes had similar pH and CL.

In terms of chemical composition, the DM, CP and EE values were similar among treatments. EE differed significantly among treatment with T2 showing higher value followed by T1. Breeds showed differences ($P<0.05$) in terms of CP and EE values, whereby the MG registered higher CP and EE values than BG goats. Furthermore, DM content was similar for both sexes, though the parameters such as CP, EE and Ash differed ($P<0.05$) females showing higher values. Testing of interaction between diets, breed and sex showed no significance differences for the above parameters.

Table 4. Least Squares Means (LSM ±SE) for Breed, Sex, and Treatment Effects on pH, cooking loss, shear force and chemical composition.

					%Chemical composition			
Factor	**Level**	**pH**	**CL (%)**	**SF (N)**	**DM**	**CP**	**EE**	**Ash**
TR	T1	6.2	22.1[b]	23.7[a]	26.7	20.1	4.9[b]	1.3
	T2	6.3	20.6[b]	23.9[a]	26.3	21	5.4[a]	1.4
	T3	6.2	25.1[a]	31.6[b]	26.5	19.7	2.6[c]	1.2
	SE	0.1	0.5	0.6	0.2	0.4	0.1	0.1
	P-value	0.7182	0.0007	<.0001	0.3426	0.0658	<.0001	0.2359
BD	BG	6.2	23.0	25.7	26.4	19.8[b]	3.9[b]	1.3
	MG	6.3	22.2	27.1	26.7	21.3[a]	4.7[a]	1.3
	SE	0.1	0.4	0.5	0.1	0.3	0.1	0.1
	P-value	0.5194	0.2317	0.079	0.1698	0.0086	0.002	0.8001
Sex	F	6.2	22.2	25.5[b]	26.6	21.3[a]	4.6[a]	1.4[a]
	M	6.2	22.1	27.3[a]	26.5	19.8[b]	4.0[b]	1.3[b]
	SE	0.1	0.4	0.5	0.1	0.3	0.1	0.1
	P-value	0.964	0.2755	0.0367	0.7632	0.0109	0.0111	0.1481

Means in the same colum within a factor with different superscript letters are significant differences ($P < 0.05$)
CL-Cooking loss, SF-Shear force, DM-Dry matter, CP-Crude protein, EE-Ether extract, BG-Boer x Gogo, MG-Malya x Gogo

4. Discussion

This study evaluated the effect of supplementing *Faidherbia albida* pods as main protein source in comparison to sunflower-based diet and grazing without supplementation on slaughter characteristics, non carcass components, meat quality and proximate composition of meat of two goat crosses.

4.1. Carcass Characteristics

Supplementation in goats with acacia pods or sunflower-based concentrate increased meat yield slaughter body weight, empty body weight and hot carcass weight. Increased carcass weights resulting from concentrates supplementations to goats have been reported by different studies. The study of Small East African goats and their crossbreds with Norwegian goats [2, 13]. The study of Afar goats of Ethiopia [23]. Mubende goats of Uganda [24]. Similar patten was observed by Asizua on the study of growth performance and carcass of supplemented Mubende x Boer crossbred [4]. The study on Oman goats showed an increased slaughter weight, carcass weight, empty body weight and dressing percentage with increasing level of metabolisable energy in concentrate diets [25]. The increased proportions of these carcass components suggest a decreased proportion of non-carcass components at higher body weights. For the case of Acacia pods, findings in the current study concur with the observations of Gebru [26]. In the study by Gebru goats supplemented with a maximum mixture of 210 g DM/day/goat of *Acacia albida* pods (synonymous with *Faidherbia albida* pods) exhibited higher slaughter body weight, empty body weight, hot carcass weight, and dressing percentages than goats that received either no supplementation or lower levels of supplementation [26]. The results are also in agree with the finding, reported that supplemented goats exhibit higher hot carcass weights than non supplemented (grazing goats) in studies conducted on Somali goats and Ethiopian Central Highland goats [27, 28].

The higher SBW, EBW and HCW of the MG crosses compared to BG crosses in this study do not aligns with different studies reported best performance in meat attributes of Boer crosses compared to indigenous and other goat crosses [29, 30]. Poor adaptability of Boer crossbreds to local environments can be the major challenge [31]. Boer goats face several challenges in arid, semi-arid and tropical harsh environments despite the hardiness [32, 30]. When subjected to heat stress Boer and their crosses has been associated with decreased feed intake, body weight loss and poor meat quality as the animals attempt to reduce metabolic heat production [33, 34]. Furthermore, studies have shown that Boer goats may exhibit higher stress responses during handling compared to indigenous breeds, highlighting potential challenges in adaptability to certain management practices [34, 30]. Malya is a blended goat developed in Tanzania, for the same purpose being able to tolerate the harsh tropical environment. Hence, crossing Malya and Gogo has synergistic effect on adaptability [35, 36]. Male goats exhibited higher SBW and EBW in agree with many studies such as those by Mahgoub [7]. This is attributed to the fact that, male goats have a larger frame, more muscle mass, and greater bone density [37]. Testosterone promotes muscle growth and feed efficiency, allowing bucks to gain weight faster, while females allocate more energy toward reproduction (pregnancy, lactation) rather than pure body mass [37].

4.2. Dressing Percentages

DP is a key metric in meat production that reflects the proportion of an animal's body that results in usable carcass after slaughter as affected by diet, breed and sex. DP values on the empty body weight basis were higher than on slaughter weight basis similar to findings of most other studies [27, 28]. This is indicative of the influence of gut content on dressing percentage. Ingesta constitute a large proportion of the body weight even when the animals are fasted for long hours [38]. Gut fill could constitute 20-22% of live weight. In this study gut fill ranged between 14-16% due to the fact that both breeds are meat cross breed [39].

Diet comprising acacia pod synonymous *Faidherbia albida* improved dressing percentage than commercial diet and grazing non-supplemented this was in agree with the finding of Hidosa [40]. Hidosa reported higher dressing percentages of Woyto-Guji goats fed acacia pods than those fed hay and commercial supplement [40]. Generally supplemented goats had higher dressing percentage than non supplemented grazing goats consistent with different studies [41-44]. This can be attributed to better nutrition in terms of energy and protein intake which result in improved feed efficiency.

4.3. Non Carcass Characteristics

Information on yield of non-carcass components of animals is important especially in developing countries where they are more valuable for the households [2]. Genotype significantly influence weight of non carcass components of goat breeds [45]. A study evaluated non-carcass characteristics of Central Highland goats and their crosses with Boer goats under different supplementation levels, reviled that Boer crossbred exhibited higher total non-carcass components [46]. A similar trend was observed on Mubende ×Boer crossbred goats [4, 47]. A contradicting finding of this study may be attributed to better growth performance of Malya x Gogo goats characterized by higher final body weight, total weight gain, growth rate, and slaughter weight. All traits positively correlated with increased non carcass component's weight. The lower non carcass components weights observed in BG crosses was due to their poor adaptability to ecological conditions of the study location [34, 30].

Supplemented goats exhibited significantly heavier total non-carcass components compared to non-supplemented goats. This difference can be attributed to improved nutrient intake, which promotes the development of internal organs and greater deposition of internal fat reserves. Enhanced nutritional status also supports higher blood volume and development of external organs such as feet, head and skin. These findings are supported by several studies which report that dietary supplementation leads to significant increases in the weight of total non-carcass components [48, 49]. These results indicate that strategic supplementation not only improves growth performance but also enhances the physiological development of both carcass and non-carcass body components in goats.

Female goats exhibited higher total non carcass components than male, the finds were similarly to different reports, reported that female goats tend to exhibit heavier total non-carcass components than their male counterparts [7]. This difference is primarily attributed to sex-based physiological and hormonal differences, which influence organ size, fat deposition, and gut fill [48].

Percentage non carcass proportional to slaughter weight did not differ significantly among dietary treatments. Similarly, to findings of Atiba [48]. Reports on the study indicated that although supplementation increased total organ weights, the percentage contribution to slaughter weight was not significantly different between supplemented and control goat groups (non supplemented). Increasing supplement levels (0.5% to 1.5% BW) increase non-carcass weights, but their relative percentage to slaughter weight shows minimal variation [30]. Dietary supplementation usually increases the absolute (total) weight of non-carcass components, it does not always significantly affect the percentage of non-carcass components relative to slaughter weight, due to the fact that carcass and non-carcass components tend to increase with better nutrition.

Findings of this study indicated that BG had significant higher parentage of non carcass to slaughter body weight than MG, contradicting to different studies indicating that there is no significant different for percentage of non-carcass components relative to slaughter weight on different breeds, the only significant difference is on total non carcass. Boer goats have heavier carcasses but no significant differences in dressing percentages or relative carcass to body weight yields, implying that no carcass proportions remain stable as well [50]. While ½ Boer crossbreds have heavier non carcass component weights than indigenous goats, the non carcass component weight relative to empty body weight (slaughter weight) is similar across genotypes [47]. Asizua demonstrated greater absolute yields of viscera and organs in crossbreds but comparable percentages relative to empty body weight between Boer cross and indigenous lines [4]. The observed findings of this study may be attributed to the fact that T3 goats grazed/browsed under low quality forage without supplementation also T1 had higher fibre intake, their carcass muscle failed to reach their genetic potential, but organs and gut mass still grew, skewing the non-carcass percentage upward [7].

Female goats had higher percentage of non carcass to slaughter body weight in align with studies by Mtenga [15] in Tanzania on indigenous goats reported that females had about 54–58% carcass yield, while males had about 57–61%, meaning females had a higher non-carcass proportion. Female goats generally have a higher percentage of non-carcass components relative to slaughter body weight than males due to several physiological and anatomical factors. They retain reproductive organs such as the uterus and ovaries, which contribute to non-carcass weight [15].

4.4. Cooking Loss, pH and Shear Force

Meat quality attributes are determined by many intrinsic and extrinsic factors. Cooking loos shear force, pH and chemical composition are among intrinsic factors. The study aimed to evaluate effect of type of protein source, breed and sex on the above factors. The results indicated no significance difference of immediate post slaughter pH between dietary treatments. However, the pH values were within the range of 5.94-6.30 obtained by Simela [51], indicating that animals were not excessively stressed before slaughter. The findings are also in agree with pH value of 6.57 for small east African goats recorded 45 minutes post slaughter [52].

The present results on cooking loss are comparable to low cooking loss of 16.95% for goat meat from Boer x Spanish goats [53]. In addition, muscle pH also has shown to affect cooking loss that an increase in pH leads to a reduction in cooking loss. Hence, other studies reported a range of 26.5 to 29.2% in muscles with pH of 5.5 to 5.6 from different breeds of goats [54, 55]. This observation is observed for goats under T2 with highest pH 6.29 and lowest cooking loss of 20.64%.

Dietary supplementation, particularly with protein concentrates, can reduce cooking loss in goat meat, enhancing its water holding capacity and overall quality in agree with [56]. Generally, meat with a shear force values that exceed 55 N would be considered as objectionably tough both by a trained sensory panel and by consumers [57, 58]. Therefore, the pooled shear force values obtained in the present study for the muscles from experimental goats on different dietary groups can be considered acceptably tender. T3 had higher shear force (less tender meat) than supplemented goats (T1&T2) in agreement with different findings concluded that dietary energy intake affect meat tenderness [49].

The high shear force obtained in T3 (grazing goats) could be attributed to increased muscle activity which influence muscle fiber composition. Increased activity enhanced oxidative muscle fibers, potentially affecting meat tenderness. However, excessive activity could lead to muscle hypertrophy and tougher meat for grazing goats than non-grazing [59]. The results further show that MG crosses had higher pH which in turn can affected cooking loss and shear force by lowering CL and shear force agree with Madruga, reported higher ultimate pH lowered CL and shear force in different breeds of goats [54]. Effects of pH values on goat’s muscles where high pH values cause protein denaturation in the muscle and lead to shrinkage of myofibrillar components. Consequently, lesser amount of fluids expelled from muscle fibre, because the water is tightly bound in the muscles [55].

Male goats had higher shear force than female. in agree with finding of Simela [60], in the study of effect of sex, age, and pre slaughter conditioning on pH, temperature, tenderness and color of indigenous South African goats. The tenderness of female goat meat is due to lower collagen cross linking, smaller muscle fibers, higher fat content, and lower testosterone levels. These factors collectively lead to softer, juicier and more tender meat compared to males [61].

4.5. Carcass Chemical Composition

The observed higher levels of fatness expressed as ether extract in carcasses for concentrate supplemented goats, are basically due to higher intake of energy. These findings agree with various reports comparing effects of dietary energy density on carcass composition [2, 62]. Concentrate supplementation of protein supplement increase fat composition of the carcass [15]. Supplemented goats had higher carcass protein than non supplemented goats which is in agreement with findings of [63, 39]. Goats that received higher proportions of energy and protein experience better muscle development, improved nitrogen balance and enhanced feed efficiency, all of which contributed to higher protein content in their meat. Ash and dry matter were similarly to different reports that the two parameters are not significantly affected by diet [2, 63, 39,].

Female obtained higher carcass fat and ash content; the findings are in agree with Johnson [58]. Female goats typically exhibit higher carcass fat percentages compared to males due to hormonal differences, with estrogen promoting fat deposition while testosterone encourages lean muscle growth. Females also have a lower metabolic rate, store fat for reproductive needs and tend to grow slower with more fat accumulation. Higher proportion of CP in male than female was due to the fact that males are leaner, more muscular, and hormonally inclined to build protein rather than store fat [64].

5. Conclusion

There were no significance differences on non carcass components and important carcass chemical composition between goats supplemented with concentrate made up of *Faidherbia albida* pod as the main protein source and those supplemented with concentrate made up of Sunflower seed cake as the main protein source. Supplementation lead to better carcass characteristics and increased non carcass components compared to grazing/browsing goats.

Non supplemented grazed goats had poor meat quality attributes. MG goats showed better carcass characteristics, non carcass characteristics and overall meat quality in comparison to BG though this can be contributed by poor genetic adaptability of BG to local environments. Male goats were observed to have better carcass characteristics while female had more non carcass components. Meat quality was observed to be similar among the sex of goats.

Faidherbia albida pods can serve as an effective alternative to commercial supplements for improving meat yield and quality in goats. Their high protein content, and digestibility enhance feed intake, growth performance, and carcass characteristics, making them a sustainable and affordable option for smallholder farmers in tropical regions.

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 *Faidherbia 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 *Faidherbia 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

BG	Boer x Gogo
BW	Body Weight
CF	Crude Fibre
CL	Cooking Loss
CP	Crude Protein
DM	Dry Matter
DP	Dressing Percentage
EBW	Empty Body Weight
EE	Ether Extract
GLM	General Linear Model
HCW	Hot Carcass Weight
MG	Malya x Gogo
PM	Post Mortem
PVC	Polyvinyl Chloride
SF	Shear Force
SUA	Sokoine University of Agriculture
SW	Slaughter Weight
TALIRI	Tanzania Livestock Research Institute
WBSF	Warner Bratzler Shear Force

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Author Contributions

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

Athumani Shabani Nguluma: Writing - Review & Editing, Formal Analysis, Supervision

Said Hemed Mbaga: Review & Editing, Supervision

Ethics Clearance Approval

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

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Nguluma, A., Kyallo, M., Tarekegn, G. M., Loina, R., Nziku, Z., Chenyambuga, S., & Pelle, R. (2022). Typology and characteristics of indigenous goats and production systems in different agro-ecological zones of Tanzania. Tropical Animal Health and Production, 54(1). https://doi.org/10.1007/s11250-022-03074-1

[2] Mushi, D. E., Safari, J., Mtenga, L. A., Kifaro, G. C., & Eik, L. O. (2009). Effects of concentrate levels on fattening performance, carcass and meat quality attributes of Small East African × Norwegian crossbred goats fed low quality grass hay. Livestock Science, 124(1–3), 148–155. https://doi.org/10.1016/j.livsci.2009.01.012

[3] Chavala, B. C., Kifaro, G. C., Tungu, G. B., & Chasama, G. L. (2023). Genetic Parameters for Growth Traits of Malya Goats and Heterosis from Crossbreds of Malya and Sukuma Goats. Asian Journal of Research in Animal and Veterinary Sciences, 6(4), 492–502. https://doi.org/10.9734/ajravs/2023/v6i4277

[4] Asizua, D., Mpairwe, D., Kabi, F., Mutetikka, D., Kamatara,

K., Hvelplund, T., Weisbjerg, M. R., Mugasi, S. K., & Madsen, J. (2014). Growth performance, carcass and non-carcass characteristics of Mubende and Mubende×Boer crossbred goats under different feeding regimes. Livestock Science, 169(C), 63–70. https://doi.org/10.1016/j.livsci.2014.09.010

[5] Almeida, A. M., Schwalbach, L. M., Waal, H. O. D., Greyling, J. P. C., & Cardoso, L. A. (2006). The effect of supplementation on productive performance of Boer goat bucks fed winter veld hay. Tropical Animal Health and Production, 38(5), 443–449. https://doi.org/10.1007/s11250-006-4368-6

[6] Mohammed, S., Urge, M., Animut, G., Awigechew, K., Abebe, G., & Goetsch, A. L. (2012). Effects of level of concentrate supplementation on growth performance of Arsi-Bale and Boer × Arsi-Bale male goats consuming low-quality grass hay. Tropical Animal Health and Production, 44(6), 1181–1189. https://doi.org/10.1007/s11250-011-0056-2

[7] Mahgoub, O., Kadim, I. T., Al-Saqry, N. M., & Al-Busaidi, R. M. (2004). Effects of body weight and sex on carcass tissue distribution in goats. Meat Science, 67(4), 577–585. https://doi.org/10.1016/j.meatsci.2003.12.011

[8] Komwihangilo, D. M., Chenyambuga, S. W., Temu, V. W., & Mushi, D. (2005). Developments and challenges for sustainable productivity of goats in mixed production systems of East Africa. Annals of Arid Zone, 44(3–4), 297–313. https://epubs.icar.org.in/index.php/AAZ/article/view/66138

[9] Ntakwendela L, L Mtenga, A Peleka, W Chenyambuga, G. (2002). Effects, of Substituting'Sunflower Seed Cake with Acacia tortilis, Pods. as ProteinSource in Supplementary Diets of small East African Goats. Tanzania Journal of Agricultural Sciences, 5(1), 39–48. https://www.ajol.info/index.php/tjags/article/view/115233

[10] 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

[11] Ivanovic, S., Nesic, K., Pisinov, B., & Pavlovic, I. (2016). The impact of diet on the quality of fresh meat and smoked ham in goat. Small Ruminant Research, 138, 53–59. https://doi.org/10.1016/j.smallrumres.2016.04.005

[12] Kannan, G., Gadiyaram, K. M., Galipalli, S., Carmichael, A., Kouakou, B., Pringle, T. D., McMillin, K. W., & Gelaye, S. (2006). Meat quality in goats as influenced by dietary protein and energy levels, and postmortem aging. Small Ruminant Research, 61(1), 45–52. https://doi.org/10.1016/j.smallrumres.2005.01.006

[13] Safari, J., Mushi, D. E., Mtenga, L. A., Kifaro, G. C., & Eik, L. O. (2009). Effects of concentrate supplementation on carcass and meat quality attributes of feedlot finished Small East African goats. Livestock Science, 125(2–3), 266–274. https://doi.org/10.1016/j.livsci.2009.05.007

[14] Koşum, N., Alçiçek, A., Taşkin, T., & Önenç, A. (2003). Fattening performance and carcass characteristics of Saanen and Bornova male kids under an intensive management system. Czech Journal of Animal Science, 48(9), 379–386.

[15] Mtenga, L. A., & Kitaly, A. J. (1990). Growth performance and carcass characteristics of Tanzanian goats fed Chloris gayana hay with different levels of protein supplement. Small Ruminant Research, 3(1), 1–8. https://doi.org/10.1016/0921-4488(90)90025-2

[16] Kebede, K., & Hayelom, M. (2014). Body Weight Gain and Carcass Parameters of Tigray Highland Sheep Supplemented with Acacia Seyal Pods and Wheat Bran Mix in Hay Based Feeding. 4(17), 12–22. https://www.semanticscholar.org/574ac6281ca72e33f1bd4d1968866c3fa31e9f39

[17] Gebru, G., & Belay, S. (2018). Effect of supplementation of indigenous browse tree pods on weight gain and Author 's personal copy Effect of supplementation of indigenous browse tree pods on weight gain and carcass parameters of Abergelle rams. Tropical Animal Health and Production, April. https://doi.org/10.1007/s11250-017-1483-5

[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://www.researchgate.net/publication/286615834

[21] Bonvillani, A., Peña, F., de Gea, G., Gómez, G., Petryna, A., & Perea, J. (2010). Carcass characteristics of Criollo Cordobés kid goats under an extensive management system: Effects of gender and liveweight at slaughter. Meat Science, 86(3), 651–659. https://doi.org/10.1016/j.meatsci.2010.05.018

[22] AOAC. (1990). Official methods of analysis. Association of Official Analytical Chemist Incooparation, 1(Volume 1), 69–87. https://doi.org/10.1201/9781003354116-6

[23] Terefe, E. (2013). Market weight and carcass characteristics of intact yearling afar goats under semi-intensive feeding management. International Journal of Livestock Production, 4(6), 95–101. https://doi.org/10.5897/ijlp12.023

[24] Okello, K. L., Ebong, C., O.-A. (1996). Effectoffeedsupplements on weightgainandcarcasscharacteristicsofintactmale-Mubende goats fedelephantgrass (Pennisetum purpureum) ad libitum in Uganda. In SmallRuminantResearchandDevelopmentinAfrica. FAO corporatedocumentrepository. (Vol. 11, Issue 1). http://dx.doi.org/10.1016/j

[25] Mahgoub, O., Lu, C. D., Hameed, M. S., Richie, A., Al-Halhali, A. S., & Annamalai, K. (2005). Performance of Omani goats fed diets containing various metabolizable energy densities. Small Ruminant Research, 58(2), 175–180. https://doi.org/10.1016/j.smallrumres.2004.09.008

[26] 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

[27] Melaku, S., & Betsha, S. (2008). Bodyweight and carcass characteristics of somali goats fed hay supplemented with graded levels of peanut cake and wheat bran mixture. Tropical Animal Health and Production, 40(7), 553–560. https://doi.org/10.1007/s11250-008-9133-6

[28] Belay Deribe & Mengistie Taye. (2013). Growth performance and carcass characteristics of central highland goats in Original article Growth performance and carcass characteristics of central highland goats in Sekota District, Ethiopia. Journal Homepage: 24(43). https://doi.org/10.14196/aa.v2i8.902

[29] Kumar, D., Scholar, M. S., Rana, K., Kameswari, V., & Chaudhary, S. (2019). International Conference on "Food Security through Agriculture & Allied Sciences" Livelihood opportunities through agriculture and allied field in the mid-hills of Uttarakhand. Journal of Pharmacognosy and Phytochemistry, 1978, 5. https://www.phytojournal.com/archives/2019/vol8issue5S/PartB/SP-8-5-25-150.pdf

[30] Kuraz Abebe, B. (2022). A review of the potential and constraints for crossbreeding as a basis for goat production by smallholder farmers in Ethiopia. Bulletin of the National Research Centre, 46(1). https://doi.org/10.1186/s42269-022-00763-7

[31] Sejian, V., Silpa, M. V, Nair, M. R. R., Devaraj, C., Krishnan, G., Bagath, M., Chauhan, S. S., Suganthi, R. U., Fonseca, V. F. C., König, S., Gaughan, J. B., Dunshea, F. R., & Bhatta, R. (2021). Heat Stress and Goat Welfare: Adaptation and Production Considerations. Animals, 11, 1–24. https://doi.org/10.3390/ani11041021

[32] Hunduma, D., Worku, T., Moti, W., & Feyesa, R. (2010). Preliminary Study on Major Health Problems of the Newly Introduced Boer Goat Breed in Ethiopia. World Applied Sciences Journal, 11(7), 803–807. https://www.researchgate.net/publication/230556089 (retrived June 2025).

[33] 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

[34] 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

[35] Das S, S. S. (1990). Comparative performance of improved meat goats in Malya, Tanzania. Comparative Performance of Improved Meat Goats in Malya, Tanzania. Small Ruminants Research and Development in Africa. In Proceedings of the 1st biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya., 445–452. https://hdl.handle.net/10568/70826

[36] Das SM, Rege JEO, S. M. (1994). Phenotypic and genetic parameters of growth traits of Malya goats at Malya, Tanzania. In : Proceedings of the 3rd biennial conference of the African small ruminant research network, UICC, Kampala, Uganda. https://hdl.handle.net/10568/70865

[37] Elmuola I. H. A, Babiker S. A, I. S. E. (1999). Meat production from female goat kids. Journal of Agricultural Science, 9(133), 223–226. https://doi.org/10.1017/S0021859699006644

[38] El Khidir, I. A., Babiker, S. A., & Shafie, S. A. (1998). Comparative feedlot performance and carcass characteristics of Sudanese desert sheep and goats. Small Ruminant Research, 30(2), 147–151. https://doi.org/10.1016/S0921-4488(98)00097-2

[39] Shahjalal M, Bishwas AM, T. A. & H. M. (2000). Growth and carcass characteristics of goats given diets varying protein concentration and feeding level. Asian- Australian Journal of Animal Science, 13(5), 613–618. https://www.animbiosci.org/upload/pdf/13-81.pdf

[40] 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

[41] Alkass, J. E., Oray, K. A. D., & Abdulla, M. K. (2014). Studies on Growth, Carcass Traits and Body Composition of Goats Raised either in Intensive or Pasture Conditions (1-Growth Performance and Carcass Traits). Journal of Biology, Agriculture and Healthcare, 4(10), 45–53. www.iiste.org

[42] Gama, J. F. P., Pereira Filho, J. M., Nascimento, G. V. do, Cezar, M. F., Gonzaga Neto, S., Pessoa, R. M. dos S., Ferreira, J. M. de S., & Cordão, M. A. (2022). Carcass traits of goats finished with different levels of concentrate supplementation and kept on caatinga enriched with Urochloa trichopus. Ciência Animal Brasileira, 23. https://doi.org/10.1590/1809-6891v23e-71730e

[43] Liméa, L., Boval, M., Mandonnet, N., Garcia, G., Archimède, H., & Alexandre, G. (2009). Growth performance, carcass quality, and noncarcass components of indigenous Caribbean goats under varying nutritional densities. Journal of Animal Science, 87(11), 3770–3781. https://doi.org/10.2527/jas.2009-1834

[44] Rashid, M. A., Khan, M. J., Khandoker, M. A. M. Y., & Monir, M. M. (2016). Feeding different forms of ration including compound pellet and performance of growing black bengal goat. Journal of Agriculture and Veterinary Science (IOSR-JAVS), 9(4), 18–23. https://doi.org/10.9790/2380-0905010108

[45] Sebsibe, A., Casey, N. H., Van Niekerk, W. A., Tegegne, A., & Coertze, R. J. (2007). Growth performance and carcass characteristics of three Ethiopian goat breeds fed grainless diets varying in concentrate to roughage ratios. South African Journal of Animal Science, 37(4), 221–232. https://doi.org/10.4314/sajas.v37i4.4094

[46] Tesema, Z., Tilahun, M., Yizengaw, L., Zegeye, A., Bisrat, A.,

& Abebe, A. (2018). Growth, carcass and non-carcass characteristics of central highland and boer x central highland goats under different levels of supplementation. Livestock Research for Rural Development, 30(11).
https://www.researchgate.net/publication/339512358

[47] Martins, S. R., Chizzotti, M. L., Yamamoto, S. M., Rodrigues, R. T. de S., Busato, K. C., & Silva, T. S. (2014). Carcass and non-carcass component yields of crossbred Boer and Brazilian semiarid indigenous goats subjected to different feeding levels. Tropical Animal Health and Production, 46(4), 647–653. https://doi.org/10.1007/s11250-014-0545-1

[48] Atiba, E. M., Sayre, B. L., Temu, V. W., & Sayre, B. (2016). Effects of Dietary Protein Supplementation on the Performance and Non-Carcass Components of Goats Artificially Infected with Haemonchus contortus. Science Letters, 4(2), 124–130.
https://www.researchgate.net/publication/309285418

[49] Silva, I. G., Giometti, I. C., Castilho, C., Soriano, G. A. M., Santos, A. O., Guimarães, L. J., Sena, G. C., Rêgo, F. C. A., & Zundt, M. (2023). Different nutritional systems influence the tenderness and lipid oxidation of ewe lamb meat without altering gene expression. Anais Da Academia Brasileira de Ciencias, 95, 1–13.
https://doi.org/10.1590/0001-3765202320220562

[50] Pophiwa, P., Webb, E. C., & Frylinck, L. (2017). Carcass and meat quality of Boer and indigenous goats of South Africa under delayed chilling conditions. South African Journal of Animal Science, 47(6), 794–803.
https://doi.org/10.4314/sajas.v47i6.7

[51] Simela, L., Webb, E. C., & Frylinck, L. (2004a). Effect of sex, age, and pre-slaughter conditioning on pH, temperature, tenderness and colour of indigenous South African goats. South African Journal of Animal Science, 34(SUPPL. 1), 208–211. https://www.researchgate.net/publication/242183427

[52] 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). Chemical composition and meat quality attributes of indigenous sheep and goats from traditional production system in Tanzania. Asian-Australasian Journal of Animal Sciences, 26(2), 295–302.
https://doi.org/10.5713/ajas.2012.12432

[53] Lee, J. H., Kannan, G., Eega, K. R., Kouakou, B., & Getz, W. R. (2008). Nutritional and quality characteristics of meat from goats and lambs finished under identical dietary regime. Small Ruminant Research, 74(1–3), 255–259.
https://doi.org/10.1016/j.smallrumres.2007.05.004

[54] Madruga, M. S., Torres, T. S., Carvalho, F. F., Queiroga, R. C., Narain, N., Garrutti, D., Souza Neto, M. A., Mattos, C. W., & Costa, R. G. (2008). Meat quality of Moxotó and Canindé goats as affected by two levels of feeding. Meat Science, 80(4), 1019–1023. https://doi.org/10.1016/j.meatsci.2008.04.020

[55] Pratiwi, N. M. W., Murray, P. J., & Taylor, D. G. (2007). Feral goats in Australia: A study on the quality and nutritive value of their meat. Meat Science, 75(1), 168–177.
https://doi.org/10.1016/j.meatsci.2006.06.026

[56] Shao, Y., Xu, J., Wang, M., Ren, Y., Wei, M., Tian, B., Luo, J., Loor, J. J., & Shi, H. (2024). Preliminary Results on the Effects of Soybean Isoflavones on Growth Performance and Ruminal Microbiota in Fattening Goats. Animals, 14(8).
https://doi.org/10.3390/ani14081188

[57] Abdullah, A. Y., & Musallam, H. S. (2007). Effect of different levels of energy on carcass composition and meat quality of male black goats kids. Livestock Science, 107(1), 70–80.
https://doi.org/10.1016/j.livsci.2006.09.028

[58] Johnson, D. D., McGowan, C. H., Nurse, G., & Anous, M. R. (1995). Breed type and sex effects on carcass traits, composition and tenderness of young goats. Small Ruminant Research, 17(1), 57–63. https://doi.org/10.1016/0921-4488(95)00661-4

[59] Goetsch, A. L., Merkel, R. C., & Gipson, T. A. (2011). Factors affecting goat meat production and quality. Small Ruminant Research, 101(1–3), 173–181.
https://doi.org/10.1016/j.smallrumres.2011.09.037

[60] Simela, L., Webb, E. C., & Frylinck, L. (2004b). Post-mortem metabolic status, pH and temperature of chevon from indigenous South African goats slaughtered under commercial conditions. South African Journal of Animal Science, 34(SUPPL. 1), 204–207.
https://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0375-15892004000500061

[61] Ripoll, G. (2023). Carcass and Meat Quality in Ruminants. In Carcass and Meat Quality in Ruminants.
https://doi.org/10.3390/books978-3-0365-5981-0

[62] Díaz, M. T., Velasco, S., Cañeque, V., Lauzurica, S., Ruiz De Huidobro, F., Pérez, C., González, J., & Manzanares, C. (2002). Use of concentrate or pasture for fattening lambs and its effect on carcass and meat quality. Small Ruminant Research, 43(3), 257–268. https://doi.org/10.1016/S0921-4488(02)00016-0

[63] Assan, N., & Never, A. (2015). Some major factors affecting carcass composition in goats. Scientific Journal of Animal Science, 4(7), 81–88. https://doi.org/10.14196/sjas.v4i7.1923

[64] Santos, V. A. C., Silva, S. R., & Azevedo, J. M. T. (2008). Carcass composition and meat quality of equally mature kids and lambs. Journal of Animal Science, 86(8), 1943–1950.
https://doi.org/10.2527/jas.2007-0780