Heliyon 8 (2022) e10181

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Acacia nilotica leaf meal - potential supplement to 25% dorper crosses of local sheep fed a basal diet of natural pasture hay

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ARTICLE INFO

Keywords:
Acacia nilotica leaf Meal
Dorper cross sheep
Carcass weight
Weight gain
Noug seed cake

ABSTRACT

This research was conducted to evaluate the replacement potential of *Acacia* nilotica dried leaf meal for Noug Seed Cake (NSC) to supplement low quality grass hay in the diet of crossbred sheep (25% Dorper). In doing so, four treatments were set up in such a way that 0%, 33%, 67%, and 100% NSC is replaced with dried leaf of *Acacia* nilotica from a conventional supplement while the treatments were kept isonitrogenous. The experiment was set up in a Randomized Complete Block Design, with initials weight used as the blocking factor. Twenty animals were allocated to the four treatments. The experiment consisted of hundred days of feeding trial followed by evaluation of carcass components at the end. In addition, the experimental feed ingredient was studied *in vitro* for gas production, methane (CH_4) production, fractional rate of degradation (Kd), and *in vitro* dry matter digestibility (IVDMD). In view of chemical composition, grass hay contained lower crude protein (CP = 3.2% DM) and high cell wall contents that makes it lower quality feed. On the other hand, *Acacia nilotica* leaf meal was moderate in quality (CP = 14.3% DM) that can support moderate level of ruminant production. In an *in vitro* study, *Acacia* nilotica was found to have lower ($P < 0.01$) levels of CH_4, total gas, kd, and IVDMD compared to the other feed ingredients. This indicates that tannin have an effect on *Acacia* nilotica feed. Partial and complete replacement of NSC with *Acacia* nilotica leaf meal significantly increased total dry matter intake (TDMI) ($P < 0.001$). Average daily gain (ADG) and dressing percentage was also higher for leaf meal supplemented groups. Hot carcass weight was in the range of 14.8–17.8 kg, which is higher than the national average carcass weight for Ethiopian sheep, and it was also found to be higher when NSC was partially (33%) as well as completely replaced by the leaf meal. In general, NSC can be replaced either partially or completely with *Acacia nilotica* leaf meal in the diet of 25% Dorper crosses while weight gain as well as carcass yield is promoted. The maximum inclusion level of *Acacia* nilotica was 61.3% or 319.2 g per day for 25% Dorper cross sheep fed natural pasture hay as a basal diet.

1. Introduction

Currently, there are emerging causes to focus on roughages based livestock feeding than the conventional intensified farming system where utilization of industrial byproducts, cereal grains, additives, fertilizer, pesticide and antibiotics is a tradition. The public concern related with the treat imposed by the intensive system on the soil, water and biodiversity is among the driving forces (Sundrum, 2001; Peter et al., 2019). Besides, the growing interest of the developed world on employing food crops as an input for biofuel production has also called a growing focus on the efficient utilization of roughages including natural pasture hay and multipurpose trees.

In the global southern, crop residues and natural pastures are the main feed resources for the livestock population. However, these feeds are known for their low nutritional quality particularly of lower crude protein (CP). Hence, effective utilization of these roughages is the immediate option available for many of the smallholder farmers in the tropics.

Furthermore, cross breeding local sheep breeds with improved ones which are known for their high demand of nutritional requirements, is

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https://doi.org/10.1016/j.heliyon.2022.e10181
Received 9 July 2021; Received in revised form 26 May 2022; Accepted 28 July 2022

considered as a breed improvement approach in many countries in the tropics. Dorper sheep is among the breeds imported for local sheep improvement programs. Following the importation of Dorper as improver breed, various investigations have been held to evaluate the crosses of Dorper with local sheep having different blood level and in various production systems and contexts (e.g. Zonabend et al., 2016; Tsegay et al., 2013; Souza et al., 2013). In Ethiopia, crosses with Dorper blood level of 25% were reported to perform better than the locals and higher blood level crosses (Tilahun et al., 2014). However, most of the investigations were done with improved feeding system where industrial by products supplementation was a part. Information on how such 'improved' sheep perform on roughage based feeding system where there is limited byproduct supplementation is scarce. Indeed roughages including natural pasture (hay) and crop residues are poor in quality. However, the poor quality roughages can be supplemented with improved leguminous forages to improve their utilization by animals and this gives an advantage for productive utilization of the abundant renewable resources. Due to their high productivity, palatability, ability to withstand grazing and well adaptability to the local environment, leguminous tree forages can significantly increase livestock production (Alemayehu Mengistu, 2002; Mangesho et al., 2017). In addition to increasing pasture growth and animal welfare, legume trees alter microclimatic conditions such as temperature, water vapor content, and wind speed. As a result, they can play both ecological and economic roles in livestock systems (Karki and Goodman, 2009; De Angelis Anna et al., 2021). The current research focused on leaf meals from *Acacia* nilotica, which is found and cultivated in nearly all tropical and subtropical regions and subcontinents (Ecocrop, 2012; Orwa et al., 2009; Fagg and Mugedo, 2005). *Acacia Nilotica leaf* meals were reported to have crude protein content ranging between 13.7 and 17.6 g/kg DM (Heuzé et al., 2016) and previous researches indicted the potential of its leaf meal as important supplements for local animals (Rubanza et al., 2007; Mokoboki et al., 2011). However, there is limited information about how these feeds can support improved breeds feed requirement when used in place of the conventional industrial byproduct protein supplements. Particularly, the aim of the current study was to evaluate whether *Acacia nilotica* leaf meal might substitute the commercial by-product noug seed cake in the diet of Dorper and local crossbred sheep (F2).

2. Materials and methods

2.1. Description of the experimental site

Specifically, the study site is *Showa robit*, which is located at 1006' 650"- 090 57'957" N, 0390 54'37"-039056'579" S, in North Showa Zone of Amhara Regional State, Ethiopia. The agro ecology of the study site is lowland (sub-moist warm) with altitude ranging between 1120 and 1350 m a.s.l. The vegetation cover of the area is woodland dominated by trees such as *Acacia*, *Erythrina, Cordia* and, *Ficus* species (Zerihun et al., 2015).

2.2. Animal care

The experiment was approved by Debre Berhan University's Ethics Committee, which followed the criteria of the European Union directive number 2010/63/EU on animal care and use for experimental and scientific reasons. Vice president of research and community service, research director, and college heads are among the members of the committee.

2.3. Experimental diets and treatments

The feed ingredients used as supplements are listed in (Table 1). The test feed in this experiment was *Accacia nilotica* leaves replacing conventional protein supplement noug seed cake. *Acacia nilotica* leaves were harvested from Debre Berhan University research site, which is located in Showarobit. Collection of the experimental test feed *Acacia nilotica* leaf was carried out by pruning the branch of an acacia tree and then the leaves on the branches were allowed to air dry and then removed by gently beating the branches with sticks. The bulk of the dried foliage was stored in jute bag for the subsequent feeding experiments. The other feed ingredients used for the experiment were wheat bran, noug seed cake, and salt.

The treatments were arranged in such a way that noug seed cake was replaced by dried (*Acacia nilotica* leaves) at the rate of 0%, 33%, 67%, and 100%. The treatments were set-up to ensure equal amounts of crude protein (CP), 76.7 g/day, in each supplement. At the beginning of the experiment, the isonitrogen level was determined. At 08:00 and 16:00, supplements of conventional concentrate and dried *Acacia nilotica* leaves were given individually in two equal portions. As a basal diet, all treatment groups were fed natural pasture hay ad libitum throughout the experiment.

2.4. Experimental animals and management

Twenty Dorper cross sheep having blood level of 25%, six to eight month of age with mean initial live body weight of 25.3 ± 0.5 kg (mean ± SD) were purchased from farmers organized by Debre Berhan research center to undergo village based breeding program using 50% blood level Dorper sheep as a sire. The offspring from the breeding program having 25% blood level of Dorper sheep was proved adapted to local conditions (Tilahun et al., 2014). All sheep purchased were given vaccinations for pasteurellosis, sheep pox and anthrax, during the fifteen-day quarantine period. In addition, both internal and external parasites were treated with ivermectin.

2.5. Experimental design

The experiment was carried out using a randomized complete block design (RCBD). The animals were divided into five blocks of four animals each based on their initial live body weight at the end of the quarantine period. In each of the blocks, experimental animals were randomly assigned to the four treatment diets. An analysis of the carcasses was followed by a 100-day feeding trial.

2.6. Feed intake measurement

Each experimental animal's feed intake was measured daily throughout the experimental period by recording the feed offered to them and the corresponding refusals. On a dry matter (DM) basis, the intake was determined as the difference between the amounts of feed offered and feed refused. For the determination of dry matter and chemical composition of feed, representative samples feed offered per batch were collected every three days.

2.7. Measurement of live weight

Each animal's initial weight was determined after overnight fasting using two successive weights at the start of the actual feeding procedure. Each animal's weight was measured every 10 days during the experiment. The animals were weighed in the morning before they were offered feed and water, and the amount of live weight gain was calculated by

Table 1. Description and proportion of the feed ingredients used as a supplement in the different treatment diets.

Treatments	Wheat bran (g)	Noug seed cake (g)	Dried *Acacia nilotica* leaves (g)	Total CP(g)
0%	200	150	0	76.7
33%	200	100	108.4	76.7
67%	200	50	216.8	76.7
100%	200	0	325.2	76.7

subtracting their initial weight from their final weight and dividing it by the number of days they were fed.

2.8. Carcass measurement

Feeding trials ended with an evaluation of carcass parameters. The carcasses of three randomly selected blocks of sheep were assessed from each treatment group. Body weights were taken shortly before slaughter on day 101, and carcass and non-carcass component weights were taken immediately after slaughter. After subtracting the gut content of each animal from its slaughter weight, empty body weights of each animal were estimated. Calculating the dressing % involved dividing the hot carcass weight by the slaughter and empty body weights. To determine the weight of the hot carcass, the thoracic, abdominal, and pelvic cavities, as well as the head and foot (which were removed at the cannon bone's proximal end), were excluded.

2.9. Chemical analysis

To determine the chemical composition of the ingredients of the experimental diets, samples were dried in a forced draft oven at 65 °C for 72 h, ground to pass through a 1 mm sieve, and analyzed. The AOAC (1990) procedures were used to determine the compositions of samples for ash, dry matter (DM), organic matter (OM), and crude protein (CP). Fiber analyses were also conducted according to the procedures of Van Soest et al. (1991) using Acid detergent lignin (ADL), neutral detergent fiber (NDF), and acid detergent fiber (ADF). The total tannin content of the leaves of *Accacia nilotica* ranged from 2.04 to 11.8 percent DM (Motubatse et al., 2007; Isam Eldin, 2014; Zabré et al., 2017).

2.9.1. *In vitro incubations*

The *in vitro* study were implemented at Swedish University of Agricultural Sciences, Department of Agricultural Research for Northern Sweden, Umeå, Sweden. Animals for the *in vitro* incubation were handled according to the guidelines established by the Swedish Ethics Committee on Animal Research (Dnr A 32–16), represented by the Court of Appeal for Northern Norrland in Ume, Sweden.

Two hours after morning feeding, rumen fluid was collected from two fistulated Nordic Red lactating dairy cows who were given an ad libitum TMR of grass silage and concentrate (600:400 g/kg on a DM basis).

Rolling barley and rapeseed meal (800:200 g/kg DM) were used to make the concentrate feed. The rumen fluid was kept in two steel thermoses that had been prewarmed and CO_2-flushed to induce anaerobic conditions. The detail procedure for the *in vitro* incubation could be accessed (Fant et al., 2019).

2.9.2. Gas sampling

At 2, 4, 8, 24, 32, 48 and 72 h of incubation, gas samples were drawn from each bottle through the rubber suba seal using a gas-tight syringe (Hamilton, Bonaduz, Switzerland). Detail procedure for the *in vitro* incubation and kinetic parameters of fermentation from methane and total gas production at each time point 0.2 h, separately obtained from (Ramin and Huhtanen, 2012).

2.10. Statistical analysis

The general linear model procedure of SAS was used to analyza the experimental data for feed intake, body weight change, and carcass parameters using the analysis of variance model for completely randomized block design (SAS, 2002). The Tukey honestly significant difference (HSD) test were used to separate treatments means. The experiment's feed intake, body weight change, and carcass parameters were all modeled using the following equations:

$$Y_{ij} = \mu + T_i + B_j + \varepsilon_{ij} \tag{1}$$

Y_{ij} = the response variable (the observation in jth block and ith treatment).
μ = Overall mean
T_i = (Treatment) effect
B_j = (Block) effect
ε_{ij} = Random error

Moreover, the model for predicted *in vitro* CH_4 and gas production was:

$$\text{Yijk} = \mu + + \text{ Ti } + \text{ Rj } + \text{Bk } + \text{ eijk} \tag{2}$$

Where Yijk is dependent variable ijk, μ is overall mean, Ti is feed i, Rj is run j, Bk is bottle k, and eijk is the random residual error.

3. Results and discussion

3.1. Chemical composition of the experimental feeds

Laboratory results for the chemical composition of the treatment feeds are given in (Table 2). The basal diet, hay, contained high structural carbohydrates, NDF, ADF, and Lignin. However, the CP content was insufficient even for the normal functioning of rumen microbes, and is lower than the critical level of 6–8 % that suppresses appetite and forage intake Forbes (1995).

The CP content of *Acacia nilotica* was 14.3% which was slightly higher than the values reported by Motubatse et al. (2007) and Kiran and Bargali, (2009) and slightly lower than the amount reported by Rubanza et al. (2007).

However, the current *Acacia nilotica* leaves CP content was in the range of 13.7–17.6% CP on DM basis, which was reported in the tropics (Heuzé et al., 2016; Mousa, 2011). *Acacia nilotica* leaf meal can be categorized as a medium protein supplement feedstuff according to Lonsdale, (1989) categorization of feed quality, which ranks feeds according to their CP content of >20%, 20%–12%, and 12%, respectively. As true for most roughage feeds, the cell wall content of *Acacia nilotica* leaf meal and its ADF proportion is high. However, Singh and Oosting's

Table 2. Experimental feed ingredients' chemical composition.

Ingredients for experimental feed	The chemical composition of the sample (%DM)					
	DM (%)	ASH	CP	NDF	ADF	ADL
Grass hay	87.0	11.2	3.2	60.0	51.7	19.0
Acacia nilotica	89	8.0	14.3	38.9	28.9	11.1
Wheat bran	90	3.4	15.1	13.3	8.9	3.3
Noug seed cake	90	6.7	31.0	26.7	17.8	10.0

DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin.

Table 3. The effect of experimental feed on predicted total gas and methane production *in vitro.*

Parameters	Noug seed cake	Wheat bran	*Acacia nilotica*	SEM	*P*
CH_4(ml/g DM)	31.3[b]	37.7[a]	9.2[c]	0.45	0.004
Kd	0.05[a]	0.05[a]	0.03[b]	0.0001	0.002
IVDMD	0.81[a]	0.81[a]	0.69[b]	0.008	0.005
Gas (ml/g DM)	168.0[b]	223.8[a]	137.9[c]	3.0	0.004

SEM = standard error of mean, CH_4 = predicted *in vitro* methane production, Kd = Fractional rate of degradation (1/h), IVDMD = *in vitro* dry matter digestibility, GP = predicted *in vitro* total gas production, *P* = probability; *abc* = Means in the same row without common letter are statistically different at $p < 0.01$.

(1992) classification of roughages includes leaf meal with NDF content less than 45% as a good quality feed.

3.2. In vitro *incubations*

Predicted *in vitro* CH_4 and total gas production presented (Table 3). *Acacia nilotica* had lower ($P < 0.01$) values for all parameters (CH_4, total gas, kd, and IVDMD) than the other feed group. Surprisingly, *Acacia nilotica* produces 71% and 75% less *in vitro* CH_4 and 18% and 38% less gas than noug seed cake and wheat bran, respectively. Rira et al. (2019) also found 64% lower CH_4 production from *Accacia nilotica* leaves than the control feed (feed without tannin). The result for CH_4 production from *Acacia nilotica leaves* in line with Pal et al. (2015) 9.37 ml/g DM. According to Carulla et al. (2005), sheep fed a mixture of *Lolium perenne* and *Trifolium pratense* or *M. sativa* had their CH4 emission lowered by 130 kJ/MJ with the addition of 29 g of *Acacia mearnsii* condensed tannin/kg DM. Different authors have reported that tropical trees containing tannin have the ability to decrease metanogenesis. According to Bhatta et al. (2012), *Sesbania grandiflora*, *Jatropha curcus*, and *Autocarpus integrifolia* have the ability to inhibit methanogenesis. Tannin may suppress methanogenesis directly or indirectly by inhibiting protozoal proliferation (Patra and Saxena, 2010).

The fractional rate of degradation (kd) *Acacia nilotica* was 38% lower than wheat bran and noug seed cake. García-Rodríguez et al. (2019) evaluated 26 agro industrial byproduct *in vitro* and found kd ranges 0.036–0.09 in line with our result. Jonker et al. (2011) stated that a rapid initial rate of protein degradation in the rumen can lead to low protein utilisation efficiency. It is important to know how degradation kinetics affects the amount of nutrients absorbed by the animal (Dhanoa et al., 1995). In modern mechanistic feed evaluation systems, the fractional rate of degradation of fermentable nutrients in the rumen is a crucial parameter (Hvelplund et al., 2009). *Acacia nilotica* showed ($p < 0.01$) lower IVDMD than wheat bran and noug seed cake. Negative correlation with IVDMD and tannin containing feed were observed by (Seresinhe and Iben, 2003; Kamalak, 2005). According to Reed et al. (1990), tannins are found in the NDF and ADF fractions, are strongly linked to the cell wall and cell protein, and appear to be implicated in limiting digestibility. Tannin is known to hamper digestibility and availability of nutrients (Alam et al., 2007; Rubanza et al., 2007). Although tannin containing feed have a lower digestibility and palatability than non-tannin feed, it has a significant advantage in nitrogen utilization efficiency. Addition of dietary condensed tannin feed, reduce the rate and extent of ruminal protein degradation and shifts the site of N metabolism, absorption and increase bypass protein (Waghorn et al., 1994; Coblentz and Grabber, 2013). Calsamiglia et al. (2010) noted that the nitrogen use efficiency of typical dietary protein sources for ruminant diets, such as *Medicago sativa* and soybean meal, is around 25% due to their high degradability in the rumen. It has been demonstrated that replacing alfalfa with tannin-containing fodder such as birds foot trefoil improves dietary nitrogen utilization (Deaville et al., 2010). Condensed tannins have the advantage of protecting dietary protein from degradation in the rumen by forming stable protein-tannin complexes (Patra and Saxena, 2011). Condensed tannins are frequently the topic of tannin-animal interactions (Naumann et al., 2017).

3.3. *Feed and nutrient intake*

Dietary components and nutrient intakes of experimental feeds are shown in (Table 4).

Total dry matter intake was influenced by replacing noug seed cake with *Acacia nilotica* in various proportions, with the trend rising as *Acacia nilotica* leaf meal content increased. This finding was in contrary to Chike, (2014) who reported the daily feed intake declined as the level of *Acacia nilotica* inclusion increased from 25% to 100% on the diet of Red Sokoto

Table 4. Effect of replacement of noug seed cake with *Acacia nilotica* leaf meal on daily dry matter and nutrient intake of experimental animals.

Parameters	Treatments				SEM	*P*
	0%	33%	67%	100%		
DMI (g/h/d)						
Total DM intake	878.3[c]	937.4[b]	949.1[b]	978.8[a]	1.84	<.001
Concentrate supplement	350.0[a]	300.0[b]	250.0[c]	200.0[d]	0.005	<.001
Acacia nilotica intake	0.0[d]	108.4[c]	216.8[b]	319.2[a]	0.328	<.001
Grass hay	528.3[a]	528.9[a]	482.4[b]	459.6[c]	1.78	<.001
DM intake (% BW)	2.58[a]	2.55[b]	2.61[a]	2.66[ab]	0.00006	<.001
Acacia inclusion (% supp)	0.00[d]	26.5[c]	46.4[b]	61.3[a]	0.0004	<.001
Nutrient Intake (g/d)						
CPI	93.6[a]	93.6[a]	92.1[b]	90.43[c]	0.08	<.001
NDFI	383.7[c]	412.9[b]	413.4[b]	426.3[a]	1.10	<.001
ADFI	317.5[c]	340.2[b]	338.3[b]	347.2[a]	0.94	<.001
ADLI	121.8[b]	128.9[a]	127.1[a]	129.2[a]	0.34	<.001

SEM = standard error of mean; ns = not significant; *P* = probability; DM = dry matter; CPI = crude protein intake; ADFI = acid detergent fiber intake; NDFI = neutral detergent fiber intake; ADLI = acid detergent lignin intake; BW = body weight; supp= (Concentrate supplement + *Acacia nilotica* intake); *abcd* = Means in the same row without common letter are different at $P < .001$.

Table 5. Effect of replacement of Noug seed cake with *Acacia nilotica* leaf meal on body weight change and feed conversion efficiency of experimental animals.

Parameters	Treatments				SEM	*P*
	0%	33%	67%	100%		
Initial body weight (kg)	25.6	25.2	25.0	25.3	0.12	0.25
Final body weight (kg)	34.0[b]	36.8[a]	36.4[a]	36.8[a]	0.33	0.025
Average daily gain (g/d)	83.6[b]	116.0[a]	114.3[a]	115.0[a]	2.66	<.001
Feed conversion efficiency (FCE)	0.10[d]	0.123[a]	0.11[c]	0.12[b]	0.0007	<.001

SEM = standard error of mean, FCE = ADG/TDMI; [abcd] =Means in the same row without common letter are statistically different at $p < 0.05$

Table 6. Effect of replacement of Noug seed cake with *Acacia nilotica* leaf meal on carcass parameters of experimental animals.

Parameters	Treatments				SEM	*P*
	0%	33%	67%	100%		
Slaughter BW (kg)	34.02[b]	36.80[a]	36.41[a]	36.82[a]	0.33	0.025
Empty BW (kg)	30.4	32.83	29.33	30.77	0.86	0.57
Hot carcass weight (kg)	14.83[b]	17.73[a]	16.93 [ab]	17.80[a]	0.30	0.033
Dressing percentage (%)						
Slaughter BW base	42.14	45.81	44.12	45.45	0.005	0.091
Empty BW base	49.82[b]	53.96[ab]	52.65[ab]	57.73[a]	0.007	0.023

SEM = standard error of mean, *P* = probability, BW = body weight; [abcd] =Means in the same row without common letter are statistically different at $p < 0.05$.

goats. However, Rubanza et al. (2007) reported similar incremental effect on the daily DMI. Reed et al. (1990) also noted sheep fed *A. seyal* leaves slowly increased their intake over the period of the growth trial.

On the contrary, the intake of basal diet decreased with increasing content of *Acacia nilotica*, which decreased by 13% in the group (100%) compared to the control group. This could be due to the higher filling value or bulkiness of the leaves of *Acacia nilotica* compared to the concentrate supplement. Sheep fed *Acacia* were also found to have the lowest basal feed intake (Reed et al., 1990).

In the current study CP, intake decreased significantly ($P < 0.001$) the higher the proportion of *Acacia nilotica*. This could be a consequence of the different digestibility and CP availability of noug seed cake and *Acacia nilotica* leaf meal. This difference could be related to the tannin content of *Acacia nilotica* leaves (Hemalatha et al., 2007). In view of this, the results of the current study are consistent with those of Makaranga (2002), who reported lower CP intake in sheep fed tannin-containing forage.

3.4. Body weight change

In terms of body weight, all treatment diets resulted in positive daily live weight gains (Table 5). The composite (33% and 67%) and the group receiving only dried leaves of *Acacia nilotica* (100%) also had the highest weight gain compared with the control group (0%) ($P < 0.05$). This could be due to the higher DMI, the beneficial role of tannin in *Acacia nilotica* leaf meal such as nitrogen use efficiency and bypass protein. This result is consistent with the findings of Reed et al. (1990) that high levels of phenolic compounds in *Accacia seyal* leaves result in lower fiber digestibility in sheep. However, the lower digestibility of fiber did not affect growth rate after sheep became accustomed to eating higher amounts of leaves. This confirmed the potential of *Acacia nilotica* leaf meal as a protein supplement instead of the conventional noug seed cake for 25% Dorper crossbred sheep under Ethiopian conditions. The ADG of Dorper crossbred sheep at 6–8 months of age in this experiment was higher than that of most yearling Ethiopian local sheep, as noted by different authors (Bekele et al., 2016; Simachew, 2009; Moges et al., 2008; Fentie and Solomon, 2008). The ADG determined in the current experiment, on the other hand, was slightly lower than the values reported in Ethiopia for the same blood level crosses of Dorper with Central Highland sheep breed (25% Dorper) (Tilahun et al., 2014). The current growth data showed that they are far above the values reported for Dorper crosses with Harerge Highland and Blackhead Somali sheep breeds (Tsegay et al., 2013). These differences in ADG between Dorper crosses and local sheep breeds could be due in part to the different genotype of the local sheep breeds and in part to the different treatment diets in the different trials.

3.5. Carcass parameters

The value of pre slaughter weight, empty body weight, hot carcass weight, and dressing percentage of experimental Dorper cross sheep are given in (Table 6). Hot carcass weight was higher in treatments with partial (33%) and total replacement (100%) of noug seed cake, as was ADG in the same treatment group. Dressing percentage based on slaughter BW was also tended to be higher in treatments where the noug seed cake was either partially or completely replaced by *Acacia nilotica* leaf meal (33%, 67%, and 100%). The percentage of dressing, based on empty body weight, was higher in the treatment in which the noug seed cake was completely replaced by the leaf meal (100%). This could be due to the synergistic effect of the leaf meal with the concentrate, the availability of tannin in providing bypass protein, the higher TDMI and ADG. Moderate tannin levels in forage legumes have a number of advantages in ruminant diet. According to Antonello Cannas (2018), moderate tannin provide higher growth rates and milk yield, increased efficiency in nitrogen recycling to the rumen, lower urinary nitrogen excretion with less nitrogen wastage, greater rumen outflow often larger than nitrogen intake, and increased microbial protein flow (up to 28% in sheep).

The hot carcass weight of Dorper cross sheep in this experiment (14.8–17.8 kg) was appreciably higher than most local Ethiopian sheep. The average carcass weight in Ethiopia per slaughtered animal is 10 kg (Tibbo, 2006; FAO, 2009). The dressing percentage observed in the current study is higher than the report for the Dorper cross with local Ethiopian sheep breeds (Tilahun et al., 2014; Tsgaye et al., 2013), which could be due to the difference in genotype of the local sheep as well as the feed type used.

4. Conclusions

Substitution of noug seed cake with *Acacia* leaf at different level has demonstrated positive response in terms of intake, body weight gain and carcass characteristic. Therefore, in areas where acacias are a potential forage resource, they may be one of the best options to replace protein sources in the concentrate mix at optimal levels that do not compromise digestibility. Furthermore, despite the fact that the maximum amount of *Acacia nilotica* leaf meal given to the sheep in treatment 100% was 325.2 g, the sheep only consumed 319.2 g, or 61.3 percent of the supplement. More research is also needed to understand the nitrogen use efficiency and degradability of *Acacia nilotica* leaf meal.

Declarations

Author contribution statement

Wondimagegne Bekele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Getachew Kassa: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Teklewold Taddes: Performed the experiments.

Muluken Girma, Alemayehu Mengistu: Contributed reagents, materials, analysis tools or data.

Getnet Assefa: Analyzed and interpreted the data.

Funding statement

This work was supported by Debre Berhan University.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

We appreciate Debre Berhan Agricultural Research Center's assistance in obtaining experimental sheep from farmers, Swedish University of Agricultural Sciences, Department of Agricultural Research for Northern Sweden for the *in vitro* study and Debre Berhan University for financial support.

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