

Effect of Supplementation of Cactus and Selected Browses Mix on Feed Utilization of Somali Goats

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Abstract

The problem of feed shortage is more aggravated in arid and semi-arid areas where erratic nature of the rainfall hampers crop production. During the dry season, there is under nutrition and malnutrition of livestock. In an effort to alleviate the problem looking for non-conventional feeds deserves due attention. In this regard cactus pear is known to have great potential. In this study, the effect of supplementation of spineless cactus (*Opuntia ficus indica*) and selected browse species mixture on feed intake, digestibility and body weight (BW) change of Somali goats was determined. The feeding and digestibility trial was conducted on a private farm, located in Chiro town, West Hararghe, Ethiopia. Twenty intact male Somali goats with mean initial BW of 20.00±1.43 kg (mean±SD) were used. The experiment consisted of feeding trial of 90 days followed by digestibility trial of 7 days. The feeding and digestibility trials were conducted using a randomized complete block design with five replication of four animals in each block. The dietary treatments used were hay ad libitum (T₁), hay + 300 g cactus and *Acacia saligna* (T₂), hay +300 g cactus and *Acacia robusta* (T₃) and hay + 300 g cactus and *Sesbania sesban* (T₄) on dry matter (DM) basis at 1:1 ratio. Hay intake was higher (P<0.001) in supplemented goats than the control. Supplementation favored (P<0.001) the CP intake of T₂, T₃, T₄ more than the control. Nutrient digestibility for DM, OM and CP were higher (P<0.001) for supplemented than the control goats. Nutrient detergent fiber and acid detergent fiber digestibility (P<0.5) and (P<0.01), respectively were higher among the supplemented goats. Similarly, there was higher (P<0.001) daily BW gain in the supplemented than in the non-supplemented goats. In addition, feed conversion efficiency and feed conversion ratio (P<0.001) were improved among the supplemented goats compared to the control ones. From the results of the study, it is concluded that mixtures of chopped and dried cactus and the browse species reversed body weight loss of goats in the dry

season. Among the mixtures of cactus and the browse species, the cactus and sesbania mix could be recommended for a better body weight gain.

Keywords: Feed intake; spineless cactus; digestibility; body weight change; browse

1. Introduction

The basic reason for the poor performance of livestock in developing countries is the seasonal inadequacy of feed, both in quantity and quality. These deficiencies have rarely been corrected by conservation and/or supplementation, often for lack of infrastructure, technical know-how, poor management, etc. In addition, many feed resources that could have a major impact on livestock production continue to be unused, undeveloped or poorly utilized. A critical factor in this regard has been the lack of proper understanding of the nutritional principles underlying their utilization [1]. The Short-eared Somali goat type occupies the northern and eastern parts of Ogaden (Jijiga, Degehabur and Warder) where they are kept by the Issaq and Mijertein Somali clans, and Dire Dawa, Issa and Gurgura (the former Awraja name for Miesso and neighboring small towns)[2]. These areas are mostly low lands in nature where the problem of feed is more severe especially during the dry season.

Cactus has the ability to remain succulent in drought and produce forage, fruit and other useful products and prevent long-term degradation of ecologically weak environment. Cactus is estimated to produce at least 10 t/ha DM in unirrigated situations, which is equal to many important annual agronomic crops [3]. Chemical analysis results showed that prickly pear (*Opuntia ficus indica*) had low dry matter (DM) and crude protein (CP) content [4]. Protein deficiency can be also solved through appropriate supplementation and/or feed source combination [5]. The cactus cladodes (pads) had high ash content and reported to be high in mineral content of calcium, potassium and magnesium and it is low in phosphorous with a high calcium phosphorus (Ca:P) ratio [6]. Therefore, the nutritional value of cactus must be improved to get a better performance of ruminant animals and the most efficient utilization of prickly pear cactus.

Similar to cactus, browse species are also adapted to arid and semiarid areas, where they play a significant role in providing fodder for ruminants. Most browse species have the advantage of maintaining their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate both in quality and quantity [7]. In addition to high CP content, browse species also provide vitamins and mineral elements, which are lacking in mature natural grassland pastures, especially during the dry season [8]. [9] Reported that the CP content of twelve indigenous browse species in Abergelle, Tigray ranged between 12.5-22.8 %. [10] Also reported that the foliage from fodder trees, legumes and shrubs has high protein content, ranging from 14 to 25%. The advantage of using these trees as a source of feed for ruminants is that supplementation with their foliages up to about 35% of the diet does not seem to have any effect on the intake of fibrous feed materials. [11] Studied the nutritive values of diets based on spineless cactus (*Opuntia ficus-indica var inermis*) and *Atriplex* (*Atriplex nummularia*) and concluded that cactus is a good source of energy and *Atriplex* a good source of nitrogen. Energy and nitrogen requirement may be matched by using diets based on these two feeds. [12] Reported that cactus was readily consumed and the animals preferred it to tef straw. Consumption of cactus dry matter intake (DMI) increased with increasing level of cactus inclusion. Water intake decreased with increasing percentage of cactus

inclusion in the diet. Treatment effect on live weight change shows that there was a significant difference ($P < 0.05$) between the treatment groups in daily live weight gain with the highest gain in sheep fed on 52.88 g/day and the least weight gain (23.55 g/day) in control sheep.

Thus, these two feed resources (dried cactus in mixture with browse species) which contrast in their nutritional composition with cactus being high in readily soluble carbohydrates and browses being high in crude protein may complement each other in bridging the dry season feed scarcity observed in moisture stressed agro-ecological settings. Therefore, this study was carried out to determine the effect of inclusion of dried cactus and selected browse species mixtures on feed intake, digestibility and body weight (BW) change of Somali goats.

2. Materials and methods

2.1. Experimental site

The study was conducted on a private farm located in Chiro (the then Asebe Teferi) town, West Haraghe zone of Oromia Regional State, Ethiopia. Chiro town is located at $9^{\circ} 07' N$ latitude and $40^{\circ} 50' E$ longitude and at an altitude of 1780-1820 m.a.s.l., with daily mean minimum and maximum temperature of $17.5^{\circ}C$ and $27^{\circ}C$, respectively. The annual rainfall for Chiro ranges between 900-1000 mm [13].

2.2. Animals and management

A total of 20 yearling intact male short-eared Somali goats with mean initial body weight (BW) of 20.0 ± 1.43 kg (mean \pm SD) was used for the experiment. The animals were housed in a well-ventilated, concrete floored individual pens with a dimension of 1.5 m length and 0.8 m width equipped with feeding troughs and watering bucket. They were used for a period that lasted 112 days (15 days for adaptation, 90 days to the feed trial followed by 7 days of digestibility trial) The basal feed was offered allowing 20% refusal and the amount of hay offered adjusted once in a week when the refusal hay was less than 20%. Representative samples of feed offered per batch and refused per animal were collected once in a week, bulked by feed type and stored in a plastic bag for the entire experiment period in a room with adequate ventilation. The feed samples were thoroughly mixed, sub-sampled and taken to the laboratory for chemical analysis.

2.3. Preparation of feeds

Young and intermediate aged cladodes of spineless cactus (*Opuntia ficus indica*) from the top branches were collected and used in the experiment. The cladodes from each branch were taken and chopped to an approximate size of $1-2 \text{ cm}^3$ using knife. The chopped cactus pear pad was exposed to air-drying on plastic sheet and spread out to dry for 8-10 days under shade. The leaves from young branches of browses were collected and dried under a shade for 4-5 days till the browse easily crushed when pressed in a hand and was packed in a sack for later use. The cladodes, the leaves and twigs of the browse and the local grass were all collected at the end of the main rainy season. The hay offered was purchased from farmers and it is a composite of locally available grass made into hay Besides, machine baled grass hay of *Pennisetum* and *Andropogon* species was also purchased from Sululta town mixed with local grass and stored for later use. The dried hay was chopped approximately to

a size of 5 to 8 cm to minimize selection and wastage. The dried cactus and browse mixtures were mixed in a 1:1 ratio. Feed intake was measured daily by subtracting the feed left over in the feeding trough from the quantity of feed offered to each animal.

2.4. Experimental design, treatments and feeding management

The experiment was conducted using a randomized complete block design. Animals were blocked into five blocks of four animals based on initial BW and randomly assigned to one of the four treatment diets within a block allowing five animals per treatment diet. The dietary treatments used were comprised of native grass hay *ad libitum* (T₁), hay supplemented with 300 g cactus and *Acacia saligna* (T₂), hay supplemented with 300 g cactus and *Acacia robusta* (T₃) and hay supplemented with 300 g cactus and *Sesbania sesban* (T₄) on dry matter (DM) basis. The supplements were mixed at 1:1 ratio. Water and common salt were available free of choice. The supplement feeds were offered at 08:00 and at 16:00 hours by dividing the daily offer into two equal portions. .

2.5. Measurement and observations

2.5.1. Feeding trial

Data on daily feed intake by subtracting the feed left over in the feeding trough from the quantity of feed offered to each animal. Initial BW of each animal was determined by taking mean of two consecutive weights after overnight withholding of feed. The BW of the animals was measured at ten days interval after overnight withholding of feed using suspended balance of 100g precision.

2.5.2. Digestion trial

The digestibility trial was conducted after 90 days of feeding trial. All animals were adapted to fecal collection bags for three days, which was followed by total collection of feces for seven consecutive days. During the latter days, feces was collected and weighed every morning from each animal before feed was offered. Twenty percent of the feces collected daily was taken and bulked for each animal and kept frozen at -20⁰C in deep freeze. At the end of the collection period, the feces collected were thoroughly mixed for each animal and 20% was sub-sampled and transported to Haramaya University Animal Nutrition Laboratory using ice box. The fecal samples were dried at 60⁰C to constant weight in a hot air drying oven and the partial DM was recorded. The dried fecal samples were ground to pass through 1mm sieve for chemical analysis.

The laboratory DM content of the feces was determined by drying the partially dried samples at 105⁰C overnight in forced draft oven. Feces DM were then determined by multiplying partial DM of the feces with DM of the feces. Amount of feed offered and refusals were measured daily. Weight of each animal was recorded on the first and last day of the feces collection period.

2.6. Chemical analysis of feeds and feces

Feed and feces samples were analyzed for Dry matter (DM), Organic matter (OM), Crude protein (CP), and ash according to [14]. Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were analyzed according to [15]. Crude Protein content of feed and feces was calculated as nitrogen content *6.25.

2.7. Statistical analysis

Data obtained from the experiments were analyzed by using analysis of variance using the General Linear Model (GLM) procedures of [16]. Differences among treatment means were tested using Least Significance Difference (LSD). The model for the experiment was:

$$y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

where y_{ij} = the observation in the j^{th} block and i^{th} treatment; μ = overall mean; α_i = i^{th} treatment effect; β_j = the j^{th} block (initial BW) effect; and e_{ij} = the random error associated with y_{ij} .

3. Results

3.1. Chemical composition of feeds

The dried, chopped and grounded spineless cactus had CP content of 61.3 g/kg DM (Table 1) which is lower than that of the hay (67.5 g/kg DM). However, the CP content of each of the treatment feeds is cactus +*A. saligna* 82.3, cactus +*A. robusta* 127.9, cactus +*S. sesban* 185.7 g/kg DM is much higher than that of hay and spineless cactus. High content of OM, NDF and ADF were determined in the hay compared to the treatment feeds.

3.2. Feed and nutrient intake

The daily feed and nutrient intake of the experimental goats are presented in Table 2 and it was calculated from the total dry matter intake. Among supplemented animals, those supplemented with dried cactus and *Acacia saligna* foliage (T_2) had the lowest ($P < 0.001$) hay intake. Compared to other treatments, hay DM intake was higher ($P < 0.001$) in T_1 . The total DM intake in the current study was higher ($P < 0.001$) for the supplemented goats than the controls. It was increased ($P < 0.001$) in the order of T_4 and $T_3 > T_2 > T_1$. The OM intake was higher ($P < 0.01$) in the order T_4 and $T_3 > T_2 > T_1$.

The total DM intake increased ($P < 0.001$) in the order of T_4 and $T_3 > T_2 > T_1$. The low total DM intake of goats fed cactus and *Acacia saligna* (T_2) as compared to T_3 and T_4 was probably due to the higher NDF (47.7%) and ADF (32.3%) content and the presence of secondary plant compounds such as tannins. This study showed that goats fed on sole hay had lower total DM intake than the supplemented groups because of the lower nutrient content of hay especially CP which reduces the digestion activity of microorganisms in the rumen.

Table 1: Chemical composition of treatment feeds

Feed Type	DM g/kg	OM	CP	NDF g/kg DM	ADF	ADL	Ash
Hay	897.4	879.3	67.5	735.1	475.6	82.7	120.7
<i>A. saligna</i>	903.1	842.6	120.9	514.4	389.6	114.2	157.4
<i>A. robusta</i>	919.3	868.2	173.4	410	282.2	78	131.8
<i>S. sesban</i>	913	889.7	257.7	207	159.4	46.9	110.3
Spineless Cactus	913.1	719.9	61.3	387.6	199.9	48.8	280.1
Cactus+ <i>A. saligna</i>	904.1	783.2	82.3	476.9	322.6	95.7	216.8
Cactus+ <i>A. robusta</i>	911.5	809.9	127.9	415.5	273.3	62.5	190.1
Cactus+ <i>S. sesban</i>	904.2	801.3	185.7	372.4	206.8	48.1	198.7

ADF: acid detergent fiber; ADL: acid detergent lignin; CP: crude protein; DM: dry matter; NDF: neutral detergent fiber; OM: organic matter; T₁ (control) : grass hay alone; T₂: 150 g/head/d Cactus+ 150 g/head/d *A. saligna*; T₃ : 150 g/head/d Cactus g/head/d +150 g/head/d *A. robusta*;T₄ : 150 g/head/d Cactus+150 g/head/d *S. sesban*.

Table 2: Daily DM and nutrient intakes of Somali goats fed grass hay supplemented with mixture of with chopped and dried cactus and foliage of browse trees (g/kg DM /head/d).

Parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Hay DM intake	560.7 ^a	376.3 ^c	447.1 ^b	475.0 ^b	16.8	***
Supplement DMI	0.0	300	300	300		
Total DM Intake	560.7 ^c	676.3 ^b	747.1 ^a	775.0 ^a	16.8	***
DM (%BW)	2.6 ^c	3.3 ^b	3.6 ^{ab}	3.8 ^a	0.1	***
OM intake	495.38 ^c	558.1 ^b	638.9 ^a	662.2 ^a	13.2	***
CP intake	41.6 ^d	49.5 ^c	70.4 ^b	88.4 ^a	1	***
NDF intake	413.7 ^c	415.8 ^b	460.0 ^a	469.0 ^a	10.9	**
ADF intake	266.5 ^c	273.3 ^{bc}	294.4 ^{ab}	303.9 ^a	7.1	**
ADL intake	47.8 ^b	58.4 ^a	54.9 ^a	55.7 ^a	1.2	***

^{a-c} means in the same row with different superscripts differ significantly; *** (P<0.001); ** (P<0.01); ADF: acid detergent fiber; ADL: acid detergent lignin; BW: Body weight; CP: crude protein; DM: dry matter; OM: organic matter; NDF: neutral detergent fibre; SL: Significance level; SEM: standard error of mean; TDM: total dry matter ;T₁ (control): grass hay alone; T₂: 150g/head/d Cactus+ 150 g/head/d *Ac. saligna*; T₃: 150g/head/d Cactus g/head/d +150g/head/d *Ac. robusta*;T₄: 150g/head/d Cactus+150 g/head/d *S. sesban*.

Neutral detergent fiber intake was higher ($P<0.01$) for supplemented groups than the non-supplemented ones. Goats in T₃ and T₄ had higher ADF intake ($P<0.01$) than T₁ and T₄ had also higher ($P<0.01$) ADF intake than T₂. The ADL intake was higher ($P<0.001$) for the supplemented goats than T₁.

3.3. Apparent nutrient digestibility

Digestibility coefficients of DM, OM, CP, NDF and ADF of the experimental feeds are presented in Table 3. The apparent DM digestibility coefficient of T₁ is significantly lower ($P<0.001$) than that of the supplemented groups. Goats in T₃ and T₄ had higher DM digestibility than those in T₂. Goats in T₄ (cactus plus *Sesbania sesban* mix) showed higher DM digestibility coefficient (0.78) than the other treatments.

Digestibility of CP was higher ($P<0.001$) for T₃ and T₄ goats as compared to T₂ and non-supplemented goats. The CP digestibility coefficient was between 0.56-0.78, with the lower value attributed to non-supplemented goats.

Table 3: Nutrient digestibility in Somali goats fed grass hay and supplemented with with chopped and dried cactus and dried foliage of browse trees

Treatments	Digestibility Coefficient				
	DM	OM	CP	NDF	ADF
T1	0.64 ^c	0.64 ^b	0.56 ^c	0.64 ^b	0.62 ^{bc}
T2	0.69 ^b	0.68 ^b	0.57 ^c	0.63 ^b	0.60 ^c
T3	0.75 ^a	0.74 ^a	0.69 ^b	0.69 ^{ab}	0.66 ^{ab}
T4	0.78 ^a	0.76 ^a	0.78 ^a	0.71 ^a	0.70 ^a
SL	***	***	***	*	**
SEM	0.014	0.014	0.09	0.07	0.06

^{a-c} Means in the same column with different superscripts are significantly different *** = ($P<0.001$); ** = ($P<0.01$); * = ($p<0.05$); SEM: standard error of mean; SL: Significance level; DM: Dry Matter; OM: Organic matter, CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

This experiment showed difference ($P<0.001$) in digestibility of DM, OM and CP between non-supplemented and supplemented treatments. However, relatively better nutrient digestibility was recorded in T₄ supplemented animals compared to T₂. Digestibility coefficients for OM, CP and NDF of T₁ and T₂ were statistically similar. The body weight (BW) parameter, feed conversion ratio (FCR) and feed conversion efficiency (FCE) of Somali goats fed experimental feeds are presented in Table 17. The loss in BW of goats in T₁ (-14.67 g/d) in the current study might be attributed to the lower total DM and CP intake and relatively lower apparent digestibility of DM and nutrients.

3.4. Body weight change

Supplemented goats had higher ($P<0.001$) final BW and mean daily BW gain as compared to the control. Among the supplemented animals, goats in T₄ had higher ($P<0.001$) mean daily BW gain than goats in T₂ and T₃. Supplemented and non-supplemented goats differed highly (Table 4) in feed conversion efficiency.

Table 4: Body weight parameters, feed conversion efficiency and feed conversion ratio of Somali goats fed grass hay supplemented with chopped and dried cactus mixed with dried foliages of browse trees

Parameter	Treatments				SEM	SL
	T1	T2	T3	T4		
Initial BW (kg)	20.0	20.0	20.2	19.86	0.16	ns
Final BW (kg)	18.68 ^C	21.5 ^b	22.3 ^{ab}	22.85 ^a	0.29	***
Daily BW gain (g/d)	-14.67 ^c	16.67 ^b	23.33 ^b	33.22 ^a	2.34	***
FCE (g BWG/ g DMI)	-0.026 ^c	0.028 ^b	0.032 ^{ab}	0.044 ^a	0.004	***
FCR (g DMI/g BWG)	-49.82 ^b	43.54 ^a	39.58 ^a	25.55 ^a	6.18	***

^{a-c} means within a row not bearing similar superscripts are significantly different ($p<0.05$); *** : ($P<0.001$); ns: not significant; ADG : average daily body weight gain; BW : body weight; FCE: feed conversion efficiency; FCR : feed conversion ratio; SEM : standard error of means; SL : significant level; T₁ (control) = grass hay alone; T₂ =150g/head/d cactus+ 150 g/head/d *Ac. saligna*; T₃=150g/head/d cactus g/head/d +150g/head/d *Ac. robusta*;T₄ = 150g/head/d cactus+150 g/head/d *S. sesban*.

Generally, goats supplemented with mixtures of cactus and different multipurpose trees had higher ($P<0.001$) feed conversion efficiency compared to those in the control treatment. Among the supplemented goats, T₄ showed higher ($P<0.001$) FCE than T₂. Supplemented goats showed positive trend BW change because of the provision of mixture of cactus and browse foliages which are rich in energy and CP content, respectively.

4. Discussion

4.1. Chemical composition

The CP content of hay in the present study is higher than the CP content reported by [17] and comparable to the report by [18] and [19], respectively and in between the CP range for hay during the dry and wet seasons in

different woredas. However, the CP content of the hay in this study is below the maintenance requirement of animals that range between 70-75 g/kg DM reported by [20].

The DM, OM and CP contents of *Acacia saligna* obtained in this study are lower than the values reported for dried foliage of *Acacia saligna* [17]. However, the NDF and ADF values in the present study are higher than the report by [17]. [21] Reported lower DM and CP contents in dried *Acacia saligna* foliage compared to the results of this study, however, the NDF and ADF values reported by the author are higher than the present study. The variation in the results of the laboratory findings might be attributed to the difference in fertility status of the soil, the season of harvest, the age of the plant, the way of storing the dried hay and other environmental factors. [20] Suggested that the total biomass production and the nutrient yields could be affected by several factors mainly age of shrubs, harvesting date and procedure, rainfall precipitation, and soil type.

The DM, CP and ash contents of *Acacia robusta* obtained in this study are higher than that reported by [22]. However, the NDF and ADF contents of this study are lower than the same report. [22] Reported nutritive value of *Acacia robusta* collected in rangelands of Botswana in the months of March to September to be 481, 461, 584, 62 and 122 g/kg DM for DM, ADF, NDF, ash and CP, respectively.

The DM, OM and CP contents of *Acacia robusta* obtained in the present study are moderately higher than that obtained for *Acacia saligna*. However, its OM and CP contents are lower than that of *Sesbania sesban*, which has 889.7 and 257.7 g/kg DM, respectively. The NDF and ADF contents of *Acacia robusta* is lower than the values for *Acacia saligna* but these were higher than the NDF and ADF content of *Sesbania sesban*. The CP content of *Sesbania sesban* obtained in this study is higher than the CP content of all other supplement feeds used in the study, as well as greater than the CP content for *Sesbania sesban* 1198 and *Sesbania sesban* 15019 reported by [23]. However, the NDF and ADF content of *Sesbania sesban* obtained in this study was comparable to that for *Sesbania sesban* 1198 and 15019 accessions reported by the same authors.

The CP content of the spineless cactus in the present study is slightly lower than the report by [4]. The result of this study is in between the results of [6] and [24]. However, [25] reported a CP content of 107.6 g/kg DM, which can be considered as a moderate protein source.

The spineless cactus cladode (pads) has high ash content (280.5 g/kg DM) which is also higher than (231.4 g/kg DM) reported by [4]. There was significant age effect on Ca, Mg, and Na contents and a highly significant effect in P content. Age did not affect K content. Compared to mature 12 year old cladodes, 2-year-old cladodes had substantially higher N, K and Mn, but lower Na, Ca and Fe [26]. The NDF (387.6 g/kg DM) and ADL (48.9 g/kg DM) contents of cactus pad obtained in this study are higher than 289 and 40 g/kg DM; however, the ADF content (199.9 g/kg DM) is lower than 219 g/kg DM reported by [4]. [12] Reported higher contents of CP, NDF and ADF which were 83, 392 and 263 g/kg DM, respectively, than that observed in this study. Cladode age is an important factor that determines its nutritional value. Young cladodes of *Opuntia ficus-indica* grown for commercial fruit production in Spain had 10.6-15% CP, while mature cladodes had CP content that varied from 4.4 to 11.3% [27]. According to [28], the nutritive value of *Opuntia* depends on plant type (species and variety), cladodes age, season and agro-climatic conditions (soil type, growing conditions, etc.). The chemical analysis

result in the present study revealed that local grass hay could not fulfill the maintenance CP requirement of ruminant animals and need to be supplemented with those feeds which are less costly and available in the agro-pastoral and pastoral areas of Miesso woreda.

4.2. Feed and nutrient intake

Compared to other treatments, hay DM intake was higher ($P < 0.001$) in T_1 , which was in agreement with the findings reported by [18] in Somali goats fed hay and supplemented with graded levels of concentrates and that reported by [19] in Abergelle goats fed hay supplemented with selected indigenous multipurpose trees. Supplementation affected basal feed and total DM intake in this study. The difference among the supplemented groups might be due to the amount of dietary CP and the level of anti-nutritional factors present in the respective feeds.

[29] Suggested that basal feed intake usually increases with supplementation. These authors showed that goats and sheep given leucaena as a supplement to spear grass (*Heteropogon contortus*) demonstrated similar response to supplementation. These authors observed an increase in hay intake and an overall improvement in diet digestibility with supplementation. The low total DM intake of goats fed cactus and *Acacia saligna* (T_2) as compared to T_3 and T_4 was probably due to the higher NDF (47.7%) and ADF (32.3%) content and the presence of secondary plant compounds such as tannins. Most browse species contain phenolic compounds that reduce digestibility of CP and contribute to unpalatability and reduced intake [30]. Condensed tannins in *Acacia* depress rumen digestion of carbohydrates, voluntary intake [31] and CP digestibility [32]. [17] reported that the mean daily DMI of the different forms of *Acacia saligna* ranged from 151 to 156 g/day, which is comparable to the present study (150 g/kg DM), and that the grass hay intake of the sheep was significantly reduced due to *Acacia* supplementation compared to the controls fed on grass hay only. This was also true for goats which were supplemented with *Acacia saligna* in the present study.

This study showed that goats fed on sole hay had lower total DM intake than the supplemented groups because of the lower nutrient content of hay especially CP which reduces the digestion activity of microorganisms in the rumen. Nutrient deficiencies that reduce the activities of rumen microorganisms are likely to reduce feed intake. The most common is protein or nitrogen deficiency, which may be corrected by supplementation with rumen-degradable protein or with a simple source of nitrogen such as urea [33]. Supplementation with either *Leucaena* or *Sesbania* species resulted in positive BW gain, DM intake, feed digestibility, N balance and improved rumen function in different species of animals [34]. [33] Indicated that although rate of digestion and intake are related to the concentration of cell walls in the ruminant feeds, the physical form of the cell walls also affects intake. The mechanical grinding of roughages partially destroys the structural organization of the cell wall, thereby accelerating their breakdown in the rumen and increasing feed intake. In the current study, DM intake as percent of BW in all of the treatment groups ranged from 2.6-3.8% which is closely within the range of reported values of 1.7-4.8 % for various breeds of goats in the tropics [35].

The CP intake was higher ($P < 0.001$) in supplemented compared to non-supplemented goats. Goats supplemented with cactus and *Sesbania sesban* had higher ($P < 0.001$) CP intake compared to those

supplemented with cactus and *Acacia saligna* and cactus and *Acacia robusta* and the latter had also higher ($P < 0.001$) CP intake compared to *Acacia saligna* supplemented ones. Such differences could be attributed to the differences in the CP content of the browse species.

4.3. Apparent nutrient digestibility

Goats in T₄ showed higher DM digestibility coefficient (0.78) than the other treatments. [36] Stated that, generally, DM digestibility of *Sesbania* species is superior to that of most other tree and shrub legumes. In northeast Thailand, *in vitro* DM digestibility of *Sesbania grandiflora*, *Sesbania sesban* and *Sesbania sesban* var. *nubica* was 66, 75 and 66%, respectively; all higher than that of 15 other tree legumes that were tested [36].

Digestibility of CP was higher ($P < 0.001$) for T₃ and T₄ goats as compared to T₂ and non-supplemented goats. The CP digestibility coefficient was between 0.56-0.78, with the lower value attributed to non-supplemented goats. The CP digestibility in the present study is slightly higher than the range of CP digestibility (0.46-0.65) reported by [23]. However, this value is somehow comparable to the value reported by [19] which was between 0.52-0.70. [21] Found CP digestibility coefficient of 0.40 for dried and 0.44 for fresh form, respectively, of *Acacia saligna* fed to desert mature male goats. The same author concluded that neither fresh nor air-dried *Acacia saligna* could be used as a sole diet for sheep and goats, because of low CP digestibility and slightly low intake. But in the present study, CP digestibility coefficient is found to be higher than that reported by [21]. This difference in value might be due to variation in the type, fertility status of the soil in which the plant grows and the composition of the treatment feeds.

The low CP digestibility of animals fed cactus and *Acacia saligna* among supplemented animals in the present study might be due to the level of tannins which could inhibit nutrient digestibility. The condensed tannins in *Acacia* depress rumen digestion of carbohydrates, voluntary intake [30] and CP digestibility [31]. In this study, OM digestibility is lower (0.68) and the CP digestibility (0.57) is higher than the value obtained by [10] where *Acacia cynophylla* (one of the four varieties of *Acacia saligna*) was used to supplement cactus based diets fed for Babarine sheep, indicated that sheep fed 246 g DM/ day cactus and 211 g DM/day *Acacia*, the percent diet digestibility for OM and CP was 73.9 and 34.8, respectively.

The increased digestibility coefficient of CP observed from T₂ to T₄ of supplemented goats is due to increased supply of dietary CP in treatment feeds compared to the control. The lower digestibility of the nutrient observed in the control than the supplemented goats might be due to lower CP content of the hay compared to the others. The digestibility coefficient for NDF and ADF in the present experiment were lower compared to the digestibility of DM and OM in all treatment groups. [32] Reported that NDF and ADF contents of feeds reflect the voluntary intake and digestibility of animals, respectively. There is a negative relationship between the NDF content of feeds and the rate at which they are digested. In agreement with the above statement, in the present experiment, the content of NDF and ADF decreased in the order of T₂, T₃ and T₄ (Table 13), while the digestibility of treatment feeds increased in the same trend (Table 15).

4.4. Body weight change

The loss in BW of goats in T₁ might be attributed to the lower total DM and CP intake and relatively lower apparent digestibility of DM and nutrients. [37] Reported loss in BW of 30.18 g/day for Somali goats fed grass hay without supplementation. [33] Indicated that rumination and fermentation are slow processes, and fibrous feeds may have to spend a long time in the digestive tract for their digestible components to be extracted posing difficulty to ruminants in processing bulky feeds despite their adaptation to utilize such feeds. In effect, ruminants could hardly meet their nutrient requirements from such type of feeds.

Generally supplemented goats had higher final BW and mean daily BW gain as compared to the control and goats in T₄ had higher (P<0.001) mean daily BW gain than goats in T₂ and T₃. This could be due to higher DM and CP intake and digestibility of nutrients in these treatment feeds. Supplementation of multipurpose trees to small ruminants improved growth performance in several studies [38, 23, 19].

The average BW gain for T₄ observed in this trial is slightly comparable to the result of [23] who reported daily BW gain of 33.4 and 35.7 g/day for male Menz sheep fed teff straw and supplemented with sole multipurpose trees. [39] Reported that sheep fed dried *Sesbania sesban* as a supplement to teff straw gained BW at a relatively high rate (48 g/day) over 90 days. [17] Reported daily BW gain of 21.9 g/day for Farta sheep fed grass hay supplemented with dried foliages of *Acacia saligna* which is higher than the BW gain (16.67 g/day) observed in this trial. This may be due to difference in the chemical composition of nutrients which was higher, especially for NDF and ADF and lower for CP of *Acacia saligna* in the present study.

5. Conclusions

In general, supplementation improved feed intake, nutrient digestibility and BW gain and better result was obtained in T₄. Overall, supplementation with cactus and browse species mix enabled BW gain and prevented BW loss. Therefore, the different cactus browse mix could be used as strategic feed supplements during the dry season. Among the supplements, cactus and *Sesbania sesban* mix could be recommended for a better performance of goats.

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