Ethiop. J. Agric. Sci. 34(3) 20-33 (2024)

Effect of Substituting Concentrate Mix with Alfalfa on Performance of Afar Goat Fed on Panicum Grass Hay as a Basal Diet

Anwar Seid Hassen[1]* Neima Mohammed[1], Endris Feki[1], and Hanfere Mohammed[1]
[1]*Afar Pastoral and Agro Pastoral Research Institute, Department of Livestock Research Directorate, Dubti Pastoral and Agro-Pastoral Research Center, P.O. Box 16, Samara, Ethiopia;*
**Corresponding author, email: anu751751751@gmail.com*

Abstract

The experiment was conducted to evaluate the effect of substituting concentrate mix with Alfalfa hay on growth performance and carcass characteristics of Afar goats and its economic feasibility. Twenty five yearling intact male Afar goats with an initial body weight of 14± 2.25kg (mean± SD) were used for this experiment. The experimental design was a randomized complete block design. The experimental animals were grouped into five blocks of five animals based on their initial body weight and the animal in each block were randomly assigned into one of five treatment diets. The experiment lasted for 115 days, including a feeding trial and a digestibility trial, following adaptation periosd of 15 days and 3 days for experimental diet and fecal sample collection, respectively. The concentrate mix was prepared by mixing wheat bran and Noug seed cake in the ratio of 2:1. All experimental animals were fed panicum grass hay ad libitum as a basal diet, supplemented either with100% concentrate mix (T1), 25 % Alfalfa hay + 75% concentrate mix (T2), 50 % Alfalfa hay + 50% concentrate mix (T3), 75 % Alfalfa hay + 25% concentrate mix (T4) or 100 % Alfalfa hay (T5). The supplement was offered at the rate of 300 g/head/day on DM basis, twice a day at 8:30 AM and 4:00 PM in two equal portions. Basal diet and total dry matter intake were not affected (P>0.05) by experimental diets. However, supplement intake was higher (P < 0.05) in goats supplemented with 75% concentrate mix with 25% Alfalfa (T2). The average daily gain (83.3 g/day) achieved in treatment groups T1 and T2 was significantly higher (P<0.05) compared to the other treatment groups. Except for crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF), the apparent dry matter and nutrient digestibility were not affected (P>0.05) by the substitution of the concentrate mix with alfalfa hay. The substitution of the concentrate mix with alfalfa affected (p<0.05) only the hot carcass weight and the dressing percentage based on slaughter body weight. The highest economic return of 1054 ETB per goat was obtained from the goats supplemented with a diet comprising 25% alfalfa mixed with 75% concentrate mixture (T2) In conclusion, the supplementations of Afar goats either with sole concentrate mix or 25% alfalfa + 75% concentrate mix resulted in greater intake, apparent digestibility, weight gain, hot carcass weight and net benefit compared to other treatments

Keywords: Slaughter body weight, concentrate, hot carcass and dressing percentage

Introduction

Ethiopia is endowed with diverse and large number of livestock resources. These resources make significant contribution to the livelihood of famers and

Pastoralists. Goats are among the most common livestock species in Ethiopia with an estimated population of 52.5 million (CSA, 2021). The goats possess unique abilities to adapt to harsh tropical environments and are closely associated with resource-poor households often found in marginal and harsh environments making significant contribution to livelihood systems and food security in equitable ways (Solomon *et al.*, 2014). Moreover, most of live goats and goat meat exports in Ethiopia are from the lowlands of the pastoral area due to the high goat population. However, the supplies from these areas are seasonally varied and may not meet the local market demands (Solomon *et al*., 2014). In addition, the live animals supplied to the market by pastoralists and farmers have low carcass yield and lower in meat quality demanded by the market (ILRI 2013; Yusuf *et al*., 2019). In addition, the production system is constrained by several factors such as feed shortage, seasonal variability of feed supply, poor quality feed, low genetic potential of the local breeds, and prevalence of diseases and parasites (Tsegaye *et al*., 2013)

In most part of Ethiopia including Afar region, small ruminants are largely raised on fibrous feeds mainly natural pasture and browse species. However, these feed resources are deficient in nitrogen, minerals and vitamins which limit intake and digestibility. Insufficient and poor quality of feed, particularly during the dry season are the most important constraints of livestock production. In Afar region the primary feed sources are rangelands that are composed of indigenous grasses, shrubs and fodder trees species. Most part of the rangelands has been overgrazed, degraded and dominated by unpalatable and poor quality species (Kidane, 2006). Therefore, it is advisable to develop and utilize improved forage to improve livestock productivity. Alfalfa (Medicago sativa L.) is among forage legumes which can be harvested every 35–40 days by storing energy in the crown to support re-growth after cutting (Undersander *et al.*, 2011). Its protein content ranged between 17-19% and can produce up to 24t/ha dry matters annually (Richard 2011). It also improves soil fertility through fixing nitrogen and can withstand long periods of water deficit by halting its vegetative growth and accessing water from greater depths through its deep root system (Annicchiarico and Pecetti, 2010). Alfalfa is also necessary for a goat's rumen to function correctly, as it has a higher content of minerals, vitamins, and even protein than most forages (Mahgoub *et al.*, 2004). Studies have shown that feeding alfalfa to animals leads to improved growth and increased live body weight. Due to these beneficial properties, alfalfa is often referred to as the "Queen of Forages." This is because alfalfa produces a high-quality, protein-rich forage that makes it one of the most widely cultivated forage crops globally (Warmington and Kirton, 1990) and makes alfalfa among widely grown forage crops in the world. Therefore, this study aimed to evaluate the potential of alfalfa to substitute commercial concentrate in goat ration and studying its economical feasibility.

Materials and Methods

Descriptions of the study area

The experiment was conducted at Dubti Pastoral and Agro-pastoral Research Center (DPARC), which is located at 12 km from Samara, the capital city of the Afar National Regional State. The site is located at 11^0 27' N latitude and 41^0 20' E longitude at a distance of 630 km North East of Addis Ababa and at an altitude of 382 meter above sea level. The mean annual rainfall and temperature of the area is 400 mm and 34.1 °C, respectively. Pastoral and agro-pastoral livestock production system is the dominant agricultural activity in the study area (APADB 2006).

Experimental feeds and feeding

Alfalfa (accession number DZ407) and *Panicum antidotale* grass varieties were established at Dubti Pastoral and agro-pastoral research center through irrigation. Alfalfa and *Panicum* grasses were used as an experimental and basal diets, respectively for this study. Alfalfa was harvested manually at flowering stage of growth and *panicum* grass was also harvested at vegetative stage of growth and then dried, baled and stored under hay shade to maintain its quality. The forages were chopped to a length of 2-5cm to reduce feed wastage and avoid selection. Sufficient amount of noug seed cake and wheat bran were purchased from local market at Dubti before the inception of the study. The supplement diets were offered twice a day in the morning and afternoon at 8:30AM and 4:00PM, respectively. Basal diet and experimental diets were fed using separate feed trough. The animals had free access to common salt block and clean drinking water in their respective pen throughout the experimental period.

Experimental animal management

Twenty-five yearling intact Afar goats with an initial body weight of 14±2.25kg (mean ± SD) were purchased from Asayta local market and used for this experiment. The ages of the experimental goat were estimated based on dentations. The goats were housed in individual pens and fed indoor. Animals were quarantined for 3 weeks, and during this period, they were treated against internal and external parasites prior to inception of the experiment.

Feeding and digestibility trial and carcass evaluation

The feeding trial was conducted for 90 days following 15 days of adaptation period for experimental diets. Following feeding trial, the digestibility trial was conducted for 7 days using all animals following 3 days of adaptation period for fecal bag sample collection. Similar animal and treatment arrangements were followed for feeding and digestibility trial. Total collection method was employed

to evaluate apparent dry matter and nutrient digestibility. At the end of feeding and digestibility trial, all experimental animals were slaughtered for carcass evaluation.

Experimental design and treatments

A randomized complete block design (RCBD) was used for the experiment. Animals were blocked into five blocks of five animals based on their initial body weight and animals within a block were randomly assigned to one of the five treatments. The Composition of experimental diets is presented in Table 1. The diatery treatment was formulated based on the available proportion of nitrogen and energy in the diet. The formulation was closely aligned with the standardization of treatments for iso-nitrogenous and iso-caloric levels. Treatments were consisted of feeding panicum grass hay (*Ad libitum*) with the following concentrate mixes:100% concentrate mix (60% wheat bran and 39% Noug seed cake (T1), panicum grass hay (ad libitum) + 25 % Alfalfa + 75% concentrate mix (T2), panicum grass hay (ad libitum) + 50 % Alfalfa + 50% concentrate mix (T3), panicum grass hay (ad libitum) + 75 % Alfalfa + 25% concentrate mix (T4), and panicum grass hay (ad libitum)+ 100 % Alfalfa (T5). The supplement was offered to the animals at the rate of 300g /head/day on DM basis, divided in to two equal portions and given twice a day at 8:30 AM and 4:00 PM. Water and mineral salt block were available free of choice. Basal diet and mixed concentrate refusals were collected, weighed and removed before the morning meal. In this study, graded levels of supplementation were used in order to evaluate the impact of the basal diet (improved panicum grass) and to make the feed technology more economical for smallholder agro-pastoralists and farmers.

Table 1: Experimental diets

Feed ingredients	Treatments				
	T1	T2	T3	T4	T5
Panicum grass	*Adlibtum*	*Adlibtum*	*Adlibtum*	*Adlibtum*	*Adlibtum*
Concentrate mix (g/day)	300	225	150	75	0
Alfalfa (g/day)	0	75	150	225	300
Total	300	300	300	300	300

T1: supplemented with 300g concentrate mix (CM); T2: supplemented with 225g CM + 75g alfalfa (AL); T3: supplemented with 150g CM + 150g AL; T4: supplemented with 75g CM + 225 AL; T5: supplemented with 300g AL

Chemical analysis

Feed refusals and feces samples were dried at 60^0C for 48 hours using drying oven. Following drying, samples were ground to pass 1mm mesh screen size and kept under airtight container pending chemical analysis. Dry matter (DM) and ash were analyzed following the procedure of AOAC (2005). The nitrogen (N) contained in the fecal and feed sample was determined by the Kjeldahl method (AOAC 2005). Crude protein (CP) was calculated as N×6.25. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) were measured according to Van Soest *et al.* (1991) and Van Soest and Robertson (1985), respectively.

Feed intake and digestibility

Feed offered and refusals were measured daily throughout the experimental period to calculate feed intake. Feed samples and refusal were taken daily and pooled per treatment and individual animal, respectively. Feeds and refusal samples were kept in air-tight plastic bags and stored pending chemical analysis. The daily dry matter and nutrients intakes were calculated as a difference between nutrient offered and refusals. The metabolize energy (ME) intake of experimental animals were estimated from its digestible organic matter intake (DOMI) by using the following formula, ME (MJ/kg DM) = DOMI × 0.0157, Where, DOMI = g digestible OM/ kg DM (AFRC, 1993).

At end of the feeding trial, digestibility trial was continued with the treatment arrangement and animals. The apparent digestability trial was conducted following total collection method. The digestability trial was conducted for 7 days following adaptation period of 3 days for fecal bag sample collection. The trial was conducted keeping the animals in an individual pen equipped with feeders and watering trough. After the fecal collection periods were completed, the fecal samples from each animal were thoroughly mixed and combined into composite samples. Then, 20% of the total feces from each composite sample was taken and placed into a paper bag. The paper bags containing the fecal samples were then dried in an oven at 65°C for 72 hours, in preparation for chemical analysis following the methods of AOAC (2005).

$$\%\ Apparent\ nutrient\ digestibility = \left(\frac{Nutrient\ intake - Nutrient\ excreted\ in\ faeces}{Nutrient\ intake}\right) X\ 100$$

Body weight change

Body weight of experimental animals was measured after overnight fasting during the start of the experiment and every 14 day then after. Average daily gain (ADG) gain was calculated as the difference between the final and initial BW divided by the number of feeding days.

Feed conversion efficiency

Feed conversion efficiency was determined as the proportion of daily body weight gain to the total daily dry matter (DM) intake (Gulten *et al.,* 2000). The efficiency of feed utilization and live weight gains were monitored on two weeks interval until the end of experiment and it was calculated as follows:

$$Feed\ conversion\ efficiency\ (FCE) = \left(\frac{Daily\ weight\ gain}{Amount\ of\ feed\ consumed}\right) X\ 100$$

Carcass characteristics

After feeding and digestibility trial, all goats were slaughtered to evaluate the carcass characteristics. Experimental animals were slaughtered after overnight fasting (but water was accessible). Just before slaughtering, body weight was measured and taken as slaughter weight. Weight of edible (Gastrointestinal tract with and without the contents, liver, heart, rumen, reticulum, abomasum, omasum, tail, testicles, kidney, omental, mesenteric and kidney fats, small intestine and tongue) and non-edible (head without tongue, skin, spleen and gall bladder, lungs with trachea and esophagus, blood, large intestine, four feet, fat depots (scrotal, pelvic, kidney, omental and mesenteric fats), penis, and gut content) non-carcass component was measured. The total edible proportion (TEP) was calculated as the slaughter body weight (SBW) minus the contents of gastrointestinal tract, skin, head, feet and lungs and trachea. Total edible products were calculated as the sum of carcass components and total edible offal. The total non-edible proportion (TNEP) was calculated as SBW minus total edible proportion (Bonvillani *et al.* 2010). Empty body weight (EBW) will also be computed as SBW at slaughter minus digestive tract contents. Empty body weight and hot carcass weight of each animal were measured accordingly. Dressing percentage was calculated as proportion of hot carcass weight to slaughter and empty body weights.

$$Dressing\ percentage\ based\ on\ SW\ = \left(\frac{Hot\ carcass\ weight\ (Kg)}{Slaughter\ weight\ (Kg)}\right) X\ 100$$

Partial budget analysis

A partial budget analysis was conducted to determine the cost-benefit ratio, and thus the profitability of substituting the concentrate feed mix with alfalfa hay. The variable costs included the expenses for supplementary feed, basal feed, and medication, which were tracked for each experimental goat treatment. The partial budget analysis was calculated based on these variable costs and the resulting benefits. At the end of the experiment, the selling price of experimental goat was estimated by three experienced local goat dealers and the average value was taken. The variable costs were calculated from supplementary feed and basal feed costs which were supplied for each experimental goat treatment costs. Net return (NR) was calculated as; NR = TR – TVC

The change in net return (ΔNR) was calculated as the difference between change in total return (ΔTR) and the change in total variable costs (ΔTVC).

Statistical analysis

Data were analyzed following the general linear model procedure of SAS (SAS 2012). Treatment means were separated by least significant difference (LSD) test. The model used for data analysis was; $Yij = \mu + Ti + Bj + eij$, where Yij = the response variable (the observation in jth block and ith treatment), μ = the overall mean, Ti = the treatment effect, Bj = the block effect and eij = the random error.

Results and Discussion

Chemical composition of the treatment feeds

The chemical composition of the experimental feeds is presented in (Table 2). The crude protein content of the *panicum antidotale* hay was notably higher than the crude protein content of natural grass hay (6.5%). Similar finding was reported by Simiret (2005). However, it was slightly lower than the crude protein content of good quality grass hay (11%) reported by McDonald (2002). Thus, it revealed that, the type of grass used in the current study was categorized as good quality and can support the microbial protein synthesis in the rumen and while also competent to keep the maintenance requirement of the growing animal. The findings of the current study suggested that improved grass hay can have a favorable impact on the nutritional needs of growing goats. Additionally, it promotes digestibility thereby allowing the young animals to better utilize the available nutrients. This, in turn, supports their energy requirements and overall growth and development.

As indicated in Table 3. The CP, DM, NDF, and ADL content levels were higher in the refusals than in the feed that was originally offered. This is due to the selection effect, were animals are more likely to selectively consume the more palatable and digestible parts of the feed, leaving behind the less digestible and less palatable components. The less digestible components often have a higher proportion of structural proteins, DM, NDF, ADL and less available protein, resulting in an increase in the CP, DM, NDF, ADL content of the refusals. The average CP content of the alfalfa variety used in this study was greater than the threshold value of 19% reported by Redfearn and Zhang (2011). The CP content of the alfalfa used was within the acceptable range, exceeding 20% CP. This makes it suitable to be used as a protein supplement, as reported by Murphy and Colucci (1999). The findings of this study are supported by the work of Alvarez-Rodriguez *et al.* (2012), who reported that supplementing feedlot animals with high CP roughage sources, such as the alfalfa used in this study, helps to support rumen motility, increase body size and muscular development, and promote rumination in the animals.

Table 2 Chemical composition of experimental feeds % DM Bases

Dietary feeds	DM (%)	OM (%)	Ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	Energy (MJ/Kg DM)
PG	94.3	89.6	7.7	7.8	77.6	45.7	6.6	11.3
Alfalfa	90.1	85.5	10.1	20.5	52.4	34.8	8.0	10.4
NSC	93.5	90.9	9.4	30.3	41.1	36.2	7.4	11.1
WB	91.2	93.1	6.9	16.9	58.5	17.4	4.8	12.6
Conc.Mix	92.8	91.1	7.2	22.9	48.5	21.6	5.3	10.7

DM: dry matter; OM: organic matter; CP: crude Protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; PG: panicum grass; WB: wheat bran; NSC; nuge seed cake; Conc.Mix: concentrate mixture

Table 3. Chemical composition of treatment feeds and refusal

Treatment feeds offered	DM (%)	OM (%)	Ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)
Conc. Mlx	92.8	91.1	7.2	22.9	48.5	21.6	5.3
Alfalfa	90.1	85.5	10.1	20.5	52.4	34.8	8.0
50% Alfalfa + 50% Conc. Mlx	91.0	87.3	8.1	21.4	50.1	30.2	6.8
25% Alfalfa + 75% Conc. Mlx	91.3	88.9	7.4	21.8	49.0	26.3	6.1
75% Alfalfa + 25% Conc. Mlx	89.9	87.2	7.1	20.7	49.8	27.9	7.3
Treatment feeds refused							
Conc. Mlx	93.2	85.4	13.4	20.0	51.5	27.0	6.7
Alfalfa	93.9	86.9	8.2	16.2	52.8	37.8	11.0
50% Alfalfa + 50% Conc. Mlx	93.0	89.1	7.7	17.6	51.1	36.1	10.9
25% Alfalfa + 75% Conc. Mlx	93.1	89.6	8.3	19.2	51.0	36.3	11.3
75% Alfalfa + 25% Conc. Mlx	92.8	88.7	7.8	16.6	52.1	36.2	11.8

DM: dry matter; OM: organic matter; CP: crude Protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; PG: panicum grass; WB: wheat bran; NSC; nuge seed cake; Conc.Mlx: concentrate mixture

Feed and nutrient intake

Feed and nutrient intake of the goats fed on panicum grass as a basal diet and supplemented with different proportions of concentrate mix and alfalfa are presented in Table 4. The substitution of the concentrate mix with alfalfa affected (P<0.05) the intake of supplement, CP, NDF, ADF, and ADL. However, the intake of basal grass, total dry matter, dry matter on a body weight basis, ME, and OM did not differ (P>0.05) among the treatment groups. The effect of blocking by initial body weight in this study was not significant across the treatment groups. Supplement intake was greater for treatment groups T1 and T2 compared to T3, T4, and T5. There was no difference in supplement intake between T1 and T2, or among T3, T4, and T5. As the level of alfalfa increased in the experimental diet, the supplement intake decreased. This indicates there was greater selection of alfalfa, with the more palatable parts of the alfalfa being consumed.

Though it was not statistically significant, total dry matter intake decreased as the level of alfalfa increased in the diet. Similarly, the CP intake reduced following the decrease in supplement intake. However, in contrast to the present study, Wang *et al.* (2008) reported that alfalfa supplement DMI increased as the degree of alfalfa hay supplementation increased. NDF intake was reduced as the level of alfalfa increased in the supplement, whereas the ADF and ADL increased as the level of alfalfa increased in the diet. This is because wheat bran has a higher NDF and lower ADF and ADL concentration compared to alfalfa (Table 2)

Table 4. Daily feed and nutrient intake of Afar goats fed on panicum grass hay and supplemented with different proportions of alfalfa and concentrates mix.

Treatment feeds	T1	T2	T3	T4	T5	SEM	SL
PGH DM intake (g/day)	392.5	391.1	391.5	393.8	393.4	10.2	NS
Supp.DM intake (g/day)	298.9^{a}	293.3^{a}	289.2^{b}	284. 9^{b}	282.3^{b}	6.4	*
Total DM intake (g/day)	691.4	684.4	680.7	677.9	675.7	11.2	NS
DM intake (% BW)	4.1	4.0	4.0	4.1	4.1	1.3	NS
ME intake (MJ/d)	4.9	5.0	4.9	5.0	5.0	1.4	NS
Nutrient intake							
OM intake	625.3	632.8	629.9	628.1	636.5	10.2	NS
CP intake	128.2^{a}	117.6^{b}	112.3^{c}	110.9^{c}	110.1^{c}	4.1	*
NDF intake	402^{a}	392^{b}	370^{bc}	360^{c}	355^{d}	2.3	***
ADF intake	213^{d}	276^{b}	253^{c}	225^{d}	301^{a}	2.1	***
ADL intake	127^{b}	136^{b}	130^{b}	128^{b}	141^{a}	1.9	**

$^{a, b, c, d}$ means with different superscripts in a row are significantly different.*: (p<0.05); **: (p<0.01);***: (p<0.001); ME= metabolizable energy; OM:=organic matter; CP= crude protein ; NDF= neutral detergent fiber; ADF=acid detergent fiber; ADL= acid detergent lignin; DM= dry matter; NS=non-significant; SEM=standard error of mean; SL= significant level; PGH=panicum grass hay. Treatments are described in Table 1.

Dry matter and nutrients digestibility

The apparent DM and nutrient digestibility of experimental feeds are presented in Table 5. Except for CP, NDF and ADF, apparent dry matter and nutrient digestibility was not affected (P<0.05) by substitution of concentrate mix with alfalfa hay. The digestibility of CP, NDF, and ADF was greater for alfalfa compared to the concentrate mix. This finding is strongly supported by the reports of Coleman *et al.* (2003), Park *et al.* (1989), and Reid *et al.* (1990), who stated that alfalfa not only has a higher CP concentration but generally has lower levels of ADF, and a greater organic matter intake and digestibility by animals. Additionally, the apparent NDF and ADF digestibility for T1 was lower than T2, T3, T4, and T5. The current study revealed that supplementing the concentrate mix with alfalfa increase CP and fiber digestibility compared to the concentrate alone.

According to findings reported by Reid *et al.* (1990), feeding a diet consisting of alfalfa hay and a concentrate mix can result in greater organic matter intake and higher fiber digestability when consumed by goats compared to sheep. The greater digestibility associated with alfalfa might be related to a slow passage rate in the rumen for forage crops, which allows more time for microorganisms to digest cellulose (Alvarez-Rodriguez *et al.*, 2012).

Table 5. Apparent dry matter and nutrient digestibility (%) in Afar goats fed panicum grass hay as basal diet and supplemented with different proportions of alfalfa and concentrates mix.

Dry matter and nutrient digestibility (%)	T1	T2	T3	T4	T5	SEM	SL
DM digestibility	84	87	85	85	89	1.9	NS
OM digestibility	85	87	86	86	90	1.1	NS
CP digestibility	80^{c}	88^{a}	83^{c}	81^{c}	89^{a}	1.8	*
NDF digestibility	79^{b}	83^{b}	81^{b}	82^{b}	88^{a}	2.1	*
ADF digestibility	74^{b}	76^{b}	75^{b}	75^{b}	82^{a}	1.3	*
ADL digestibility	61	61	64	62	63	1.7	NS

$^{a, b, c}$, means with different superscripts in a row are significantly different.*: ($p<0.05$); **: ($p<0.01$); OM= organic matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ADL=: acid detergent lignin; DM =dry matter; ns=non-significant; SEM= standard error of mean; SL= significant level; treatments are described in Table 1

Body weight gain and feed conversion efficiency

Initial and final BW, TLWG, ADG and FCE of experimental animals are indicated in Table 6. The results showed that substituting the concentrate mix with alfalfa hay affected ($P< 0.05$) BW, TLWG, ADG, and FCE of the experimental animals across the different treatment groups. However, the goats supplemented with solely concentrate mix (T1) and those supplemented with 25% alfalfa and 75% concentrate mix (T2) gained equal body weight, and this body weight gain was greater than the weight gain observed in the other treatment groups. Similarly, the highest FCE was recorded for the T1 and T2 treatment groups.

The daily body weight obtained (83 g/day) per animal in the present study is relatively higher than the finding of Dereje *et al.* (2016), who reported 42.1, 51.4, 41.3 g/day for Bati, Hararge highland and Somali short eared goats, respectively. However, it was lower than the findings reported by Wildeus *et al.* (2007) who found that Spanish goats fed on alfalfa-hay-based diets supplemented with concentrate mix at 0.5% of their body weight gained an ADG of 103 g/day. The discrepancy between the current study's results and those of Wildeus *et al.* (2007) may be attributed to differences in breed, the amount, quality, and proportion of the supplement fed. Additionally, the observed variation can be attributed to the small size nature of the breed, and the experimental animals were affected by seasonal feed shortages prior to their arrival at the research site.

Table 6. Body weight change and feed conversion efficiency of Afar goat fed panicum grass as a basal diet and supplemented with different proportion of alfalfa and concentrate mix

Parameters	T1	T2	T3	T4	T5	SEM	SL
IBW (kg)	16.5	17	16	17,3	17	2.0	Ns
FBW (kg)	24.5	24.5	23	24	23.5	1.4	*
TLWG (kg)	7.5^{a}	7.5^{a}	7^{ab}	6.7^{b}	6.5^{b}	2.9	*
ADG (g/day)	83.3^{a}	83.3^{a}	77.7^{b}	74.4^{bc}	72.2^{c}	3.1	*
FCE (g DBWG/g DDMI)	0.106^{a}	0.151^{a}	0.058^{b}	0.052^{b}	0.055^{b}	2.8	*

$^{a, b, c}$, means within a row not bearing similar superscript are significantly different; *= P<0.05,; ADG=average daily body weight gain; TLWG=total live weight gain; IBW= initial body weight; FBW= final body weight: FCE= Feed conversion efficiency, [DG(g)/DMI(g)], SEM=standard error of mean; SL= significance level; treatments are described in Table 1

Carcass characteristics

The carcass characteristics of goat fed panicum grass hay as a basal diet and supplemented with different proportion of alfalfa and concentrate mix is presented in Table 7. The substitution of the concentrate mix with alfalfa significantly affected ($P < 0.05$) hot carcass weight, empty body weight, and dressing percentage, both on a slaughter and empty body weight basis, following a similar trend to body weight gain. Greater hot carcass weight and dressing percentage were observed for sole concentrate mix supplementation, as well as for supplementation with 25% alfalfa and 75% concentrate mix. In agreement with the present study, Shahjalal *et al.* (1992) reported that, higher CP intake resulted in higher dressing percentage in wether goats fed a higher proportion of concentrate mix.

Supporting this idea, McDonald *et al.* (2011) reported that greater carcass weight and higher dressing percentage are associated with higher intake of CP and increased DM digestibility. In contrast, Atti *et al*. (2004) reported in their research findings that higher CP intake had no effect on carcass weight or carcass characteristics in intact male Tunisian goats. This suggests that the relationship between higher CP intake and improvements in carcass characteristics observed in the present study could be influenced by breed and feed quality, as reported by Mahgoub and Lu (1998).

Table 7. Carcass characteristics Afar goats fed chopped panicum grass and supplemented with different proportion of green chopped and concentrate mix

Parameters	T1	T2	T3	T4	T5	SEM	SL
SBW (kg)	25.9	26	24	25,4	24.8	1.7	NS
EBW (kg)	15.9^{a}	16 ^{a}	15^{ab}	14.2^{b}	14.4^{b}	1.5	*
HCW (kg)	9.5^{a}	9.6^{a}	8.6^{b}	8^{b}	8^{b}	2.3	*
Dressing percentage on							
SBW base	40.1^{a}	40.4^{a}	38.8^{b}	38.2^{b}	38.2^{b}	2.1	*
EBW base	57.9 ^{a}	58 ^{a}	55.8^{b}	55^{b}	55.2^{b}	2.4	*
Rib-eye area (cm^{2})	12	12	11	11	11	0.4	NS

$^{a, b, c}$ means with different superscripts in a row are significantly different*=($p<0.05$); ns=non-significant; SEM= standard error of means; SL= significance level; SBW = slaughter body weight; EBW=empty body weight; HCW= hot carcass weight; treatments are described in Table 1.

Partial budget

The partial budget analysis of Afar goats fed on panicum grass hay as a basal diet and supplemented with different proportions of alfalfa hay and concentrate mix presented in Table 8. The partial budget analysis was performed to evaluate the economic advantages of substituting the concentrate mix with alfalfa hay in the goat ration. The difference in net return among the treatments reflects weight gain and feed intake. Although, all groups resulted in a positive net benefit of more than 890 Birr per goat, those with better nutrient intake had superior average daily gain and final body weight, which resulted in better sale prices and higher net returns. The results of this study indicated that a higher net return (1054

ETB/goat) was obtained from the goats supplemented with a diet consisting of 25% alfalfa mix and 75% concentrate mixture (T2), followed by T1, T4, T5, and T3 in decreasing order. The positive net benefit observed in the present study suggests that alfalfa, either alone or mixed with concentrate, can be used as a supplement for growing goats fed panicum grass as a basal diet.

Table 8 Partial budget analysis of Afar goats supplemented on different proportions alfalfa with concentrates mix.

Parameters	T1	T2	T3	T4	T5
Purchase price of goat (ETB/head)	1950	1950	1950	1950	1950
Panicum grass hay consumed (kg/head)	28.7	27.6	27.7	27.9	28
Alfalfa consumed (kg/head)	-	6.9	10.7	17.1	22.6
Concentrate mix consumed (kg/head)	24	17.1	11.8	5.2	-
Total supplemented mix consumed (kg/head)	24	24.0	22.5	22.3	22.6
Total feed consumed (kg/ head)	52.7	51.6	50.2.	50.2	50.6
Cost of Panicum grass hay (ETB/head)	112	112	112	112	112
Cost of Alfalfa (ETB/head)	-	34	67	103	134
Cost of total concentrate mix (ETB/head)	600	450	300	150	-
Total variable cost (ETB/ head)	712	596	479	265	246
Selling price of goats (ETB/ head)	3640	3600	3320	3190	3100
Total return (ETB/head)	1690	1650	1370	1240	1150
Net return (NR) (ETB/ head)	978	1054	891	975	904

ETB: Ethiopian birr; NR: net return; Treatments are described in Table 1

Conclusion and Recommendation

Supplementation of Afar goats with either a sole concentrate mix or acombination of 25% alfalfa and 75% concentrate mix resulted in greater intake, apparent digestibility, weight gain, hot carcass weight and net benefit compared to other treatments. However, all proportions resulted in positive net benefit of more than 890 Birr per goat. Therefore, either sole concentrate mix or the inclusion of different proportions of alfalfa in the concentrate mix can be used to supplement growing goats, especially, in places where concentrate is unavailable or expensive, alfalfa alone can be used as a supplement for growing goats.

References

Afar Pastoralist Agriculture Development Bureau (APADB) 2006. Regional Atlas of Afar Report

AFRC (Agricultural and Food Research Council). 1993. Energy and protein requirements of ruminants, CAB International, Wallingford

Alvarez-Rodríguez, J.; Monleón, E.; Sanz, A.; Badiola, J. J. and Joy, M. 2012. Rumen fermentation and histology in light lambs as affected by forage supply and lactation length. Research in Veterinary Science 92:247-253

Annicchiarico, P.; Pecetti, L., 2010. Forage and seed yield response of lucerne cultivars to chemically weeded and non-weeded managements and implications for germplasm choice in organic farming. *European Journal of Agron*., 33 (2): 74-80

Association of Official Analytical Chemists (AOAC) 2005. Official Methods of Analysis 18th edition. Maryland, USA.

Atti, N., H. Rouissi, and M. Mahouachi. 2004. The effect of dietary crude protein level on growth, carcass and meat composition of male goat kids in Tunisia. *Small Ruminant. Research*. 54:89-97.

Bonvillani, A., F. Peña, G. de Gea, G. Gómez, A. Petryna and J. Perea. 2010. Carcass characteristics of Criollo Cordobés kid goats under an extensive management system: Effects of gender and live weight at slaughter. *Meat Sci.* 86:651-65

Central Statistics Authority (CSA). 2021. The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Livestock and Livestock Characteristics (Private Peasant Holdings), Addis Ababa. Statistical Bulletin, 589(2).

Coleman, S. W., S. P. Hart, and T. Sahlu. 2003. Relationships among forage chemistry, rumination and retention time with intake and digestibility of hay by goats. *Small Ruminant. Research*. 50:129-140.

Dereje, T., Urge, M., Animut, G. and Mekasha, Y. 2016. Growth and Carcass Characteristics of Three Ethiopian Indigenous Goats Fed Concentrate at Different Supplementation Levels. SpringerPlus, 5, 414. https://doi.org/10.1186/s40064-016-2055-2

Gulten K, Rad F, Kindir M, 2000. Growth performance and feed conversion efficiency of Siberian Stuger juveniles (Acipenserbaeri). Reared in concentrate ways. *Turkish Journal of Veternary and Animal Sience*.24:28.

ILRI (International Livestock Research Institute), 2013. Study of the Ethiopian live cattle and beef value chain. ILRI discussion paper, 23. Addis Ababa, Ethiopia. 48.

Kidane Gebremeskel. 2006. Rangeland Potential, Quality and Restoration Strategies in North-Eastern Ethiopia: A case study conducted in the southern afar region. Dissertation submitted in partial fulfillment of the requirements for the degree Doctor of Philosophy at the University of Stellenbosch.

Mahgoub O, Lu OD 1998. Growth, body composition and carcass tissue distribution in goats of large and small sizes. *Small Ruminant Research* 27:267–278

Mahgoub, O., I. T. Kadim, N. M. AlSaqry, and R. M. Al-Busaidi. 2004. Effects of body weight and sex on carcass tissue distribution in goats. *Meat Sicence* 67:577-585.

McDonald, P., A.R. Edwards, D.F.J. Greenhalgh, A.C. Morgan, 2002. *Animal Nutrition. 6th edition.* Prentice Hall, London. 245-477.

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG. 2011. *Animal Nutrition*. Animal-Nutrition-Peter McDonald/9781408204238

Murphy AM, Colucci PE. 1999. A tropical forage solution to poor quality ruminant diets: A review of Lablab purpureus, *Livestock Research for Rural Development*. 11, 2. 96–113.

Park, Y. W., G. A. Reynolds, and T. L. Stanton. 1989. Comparison of dry matter intake and digestibility of suncured pigeon pea, alfalfa and coastal Bermuda grass by growing dairy goats. *Small Ruminant Research*. 2:11-18.

Redfearn D and Zhang H. 2011. "Forage Quality interpretations, Oklahoma cooperative extension service, PSS 2117". Relative feed value and quality index. In: Proc. Florida Ruminant Nutrition Symposium, University of Florida, Gaines: 16-31.

Reid, R. L., G. A. Jung, J. M. CoxGanser, B. F. Rybeck, and E. C. Townsend. 1990. Comparative utilization of warm- and cool-season forages by cattle, sheep and goats. *Journal of Animal Science* 68:2986-2994.

Richard, C. 2011. Utilizing Lucerne potential for dairy farming. The International Farm Management Congress Methven

SAS (Statistical Analysis System). 2012. SAS/STAT Guide to Personal Computers, SAS software ver. 9.3, by SAS Institute Inc., Cary, NC, USA.

Shahjalal, M., H. Galbraith, and J. H. Topps. 1992. The effect of changes in dietary protein and energy on growth, body composition and mohair fibre characteristics of British Angora goats. *Animal Production*. 54:405-412.

Simret Betsha. 2005. Supplementation of graded levels of peanut cake and wheat bran mixture on nutrient utilization and carcass parameters of Somali Goats. An M.Sc. Thesis Presented to the School of Graduate Studies of Alemaya University.

Solomon A, Mwai O, Grum G, Haile A, Rischkowsky BA, Solomon G, Dessie T. 2014. Review of goat research and development projects in Ethiopia. ILRI Project Report, Nairobi, Kenya: International Livestock Research Institute.

Tsegaye Teklebrihan, Yoseph Mekasha, and Mengistu Urge, 2013. Comparative evaluation of growth and carcass traits of indigenous and crossbred (Dorper × Indigenous) Ethiopian Sheep. *Small Ruminant Research* 114; 247– 252

Undersander, D., Martin, N., Cosgrove, D., Kelling, K., Schmitt M, M., Wedberg, J., Becker, R., Grau, C., & Doll, J. 2011. Alfalfa management guide. American Society of Agronomy, Inc. Crop Science Society of America, Inc. Soil Science Society of America

Van Soest, P.J. and Robertson, J.B., 1985. Analysis of forages and fibrous feeds: A Laboratory Manual for Animal Science, (Cornell University, Ithaca, New York).

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991.Methods for dietary fiber and non-starch polysaccharides in relation to Animal nutrition. *Journal of Dairy Science* 74, 3583-3597.

Wang, Y.; Xu, Z.; Bach, S. J.; McAllister, T. A., 2008. Effects of phlorotannins from *Ascophyllum nodosum* (brown seaweed) on *in vitro* ruminal digestion of mixed forage or barley grain. *Animal Feed Science Technology*, 145 (1/4): 375-395

Warmington, B. G. and A. H. Kirton. 1990. Genetic and non-genetic influences on growth and carcass traits of goats. *Small Ruminant Research* 3:147-165.

Wildeus, S.; Luginbuhl, J.-M.; Turner, K. E.; Nutall, Y. L.; and Collins, J. R., 2007. Growth and Carcass Characteristics in Goat Kids Fed Grass- and Alfalfa-Hay-Based Diets with Limited Concentrate Supplementation. Publications from USDA-ARS / UNL Faculty. 437.

Yusuf A, Abera B, Eticha E. 2019. Evaluation of Carcass Yield Characteristic of Sheep and Goat at ELFORA Export Abattoir, Bishoftu town, Ethiopia Arsi Zone Livestock and Fishery Resource Office, Asella, Ethiopia. *Advanced Biological Research (Rennes).* 13:46–51. 10.5829/idosi.abr.2019.46.51