academicJournals

Vol. 9(4), pp. 79-87, April 2018
DOI: 10.5897/IJLP2016.0335
Article Number: CCA50FE56467
ISSN 2141-2448
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http://www.academicjournals.org/IJLP

International Journal of Livestock Production

Full Length Research Paper

Digestibility and growth performance of Dorper×Afar F1 sheep fed Rhodes grass (Chloris gayana) hay supplemented with alfalfa (Medicago sativa), Lablab (Lablab purpures), Leucaena leucocephala and concentrate mixture

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Received 29 August, 2016; Accepted 13 March, 2017

A study was conducted to determine effect of supplementation with isonitrogenous level of concentrate mixture (CM; 33% noug seed cake (NSC) and 67% wheat bran (WB)), alfalfa, lablab, and *Leucaena leucocephala* (LL) on feed intake, digestibility, daily body weight gain (ADG) and net return of sheep kept on Rhodes grass hay (RGH) basal diet. Twenty four yearling male Dorper×Afar F1 crossbred sheep were used in completely randomized block design blocked by initial body weight into 6 blocks of 4 animals and allocated to one of the treatments. Treatments were RGH fed ad libitum to all treatments plus 300 g/day CM (T1), 286 g/day alfalfa hay (T2), 326 g/day lablab hay (T3) and 299 g/day LL hay (T4). The study contained 90 days feeding and 7 days digestibility trials. The CP, NDF and ADF contents of RGH was 11, 77 and 51%, respectively. The CP contents of NSC, WB, alfalfa, lablab and LL were 32, 17, 23, 20 and 22%, respectively. Among the supplements alfalfa and lablab had relatively higher NDF and ADF levels. Total DM intake differed among treatments and was greater (P<0.05) for T2 and T4 than T3, and values for T4 was greater than T1 (P<0.001) (715, 727, 682 and 809 g/day for T1, T2, T3 and T4, respectively). The CP intake was 103, 110, 92, 130 (SEM = 5.83) and was in the order of T4 > T1 = T2 > T3 (P<0.05). Apparent DM digestibility ranged from 62-66% and was lower (P<0.05) for T2 than T1 and T4, while values for T3 was similar (P>0.05) with all other treatments. The apparent digestibility of CP was greater for T1 than T2 and T3, but values for T4 was similar with the other treatments (82.3, 78.7, 78.3 and 80.4 (SEM = 0.02) for T1, T2, T3 and T4, respectively). ADG was 65, 45, 40 and 69 g/day (SEM = 8.36) for T1, T2, T3 and T4, respectively and the values were greater (P<0.05) for T1 and T4 as compared to the other two treatments, while other mean values were similar (P>0.05). The net return in the currents study was 836, 797, 888 and 982 ETB. Thus, based on biological performance and net return, T4 and T1 outweighs other treatments. However, all supplements used in this study induced favorable ADG and thus can be employed in feeding systems depending on their availability and relative cost.

Key words: Isonitrogenous, crossbred, digestibility, ADG, RGH, DM, SEM.

INTRODUCTION

Livestock play an important role in the country's economy and the livelihood of the majority of the Ethiopian people, where the sale of the livestock and their products are vital sources of cash income for small-holder farmers.

Despite the relatively huge livestock population with high potential for meat and milk production, nutritional constraints have been identified to be the binding problems of livestock production in Ethiopia (Alemayehu, 2002).

In Ethiopia, the sources of feeds are residues of different crops such as Wheat, Barely, Maize, Teff, Lentil and Chickpea which are fibrous, with a high content of lignin and low nutritive value (McDonald et al*.,* 2002). Their high fiber content restricts their use as feed for ruminants. In addition to this, most dry forages and roughages found in Ethiopia have a crude protein (CP) content of less than 7% and these do not satisfy the requirements of rumen microorganisms (Van Soest, 1994). When fed alone, such feeds are unable to provide even the maintenance requirement of livestock (ILRI, 1999). Therefore, inadequate nutrition is among the major constraints to limit sustainable livestock production in Ethiopia and the rest of Sub-Saharan Africa (Alemayehu, 1997).

Dietary nutrients, especially energy and protein are the major factors affecting productivity of sheep. The lowest energy density at which the sheep does not lose weight is between 8 and 10 metabolisable energy (MJ/kg DM) and the minimum protein level required for maintenance is about 80 g/kgDM (Minson, 1990; Gatenby, 2002). However, the most productive animals such as rapidly growing lambs and lactating ewes need about 110 g/kgDM (Minson, 1990; Gatenby, 2002). These energy and protein levels are considerably higher than the average values found in natural pastures and crop residues (CTA, 1991). Mtenga and Nyaky (1985) reported that animal performance can be improved by supplementation of protein sources.

There are several complementary and alternative strategies that can be pursued in tropical regions with the objective of making low quality feeds more useful for production of meat and milk. Concentrate feed supplementation is one strategy, which can increase digestibility, nutrient supply and intake (Preston and Leng, 1987). Moreover, maximization of livestock productivity in the tropical regions largely depends on the efficiency of utilization of local protein sources (Seyoum et al*.,* 1996), such as leguminous forage (Poppi and McLennan, 1995).

In recent years, the use of forage legumes in livestock production systems for ruminants in the tropics has increased. Forage legumes offer several advantages to tropical farming systems. First, leguminous cover reduces soil erosion and runoff, conserve soil, improve organic matter content and compete with weeds (Humphreys, 1995; Schaaffhausen, 1963). Second, the legume – rhizomal symbiosis converts atmospheric nitrogen (N) to forms of N which plants can take up and cycle within the plant-animal-soil system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N whose production is environmentally "clean". This symbiosis does not involve the consumption of fossil fuel, as occurs in the production of fertilizer N which contributes to global warming (Humphreys, 1995; Said and Tolera, 1993). As a consequence of different biochemical pathways of carbon fixation during photosynthesis, N fixing legumes have higher concentrations of cellular protein than tropical grasses (Bjorkman et al*.,* 1976). As such, tropical forage legumes are rich in protein, which is usually the most limiting nutrient in tropical animal diets.

Forage legumes can be grazed, harvested and fed fresh or stored as hay or silage (Harricharan et al*.,* 1988). A sustainable way of improving the feeding value of poor quality crop residues and pastures, especially for resource poor smallholders, is through supplementation with forage legumes and tree foliage (Patra, 2009a; Khan and Habib, 2012). Though there are several forage plants that have the capacity to produce high yields of dry matter, they contribute little to the much needed improvement of livestock production, because data on their nutritive values are scarce (Barro and Ribeiro, 1983). With this in mind, the objective of this experiment was to assess the impact of isonitrogenous level of alfalfa, lablab, *Leucaena leucocephala* and concentrate mixture on sheep kept on Rhodes grass hay basal diet on digestibility, feed intake, weight change and net return.

MATERIALS AND METHODS

Experimental site, materials and design

The trial was conducted at Werer Agricultural Research Center which is located at 9°16'N and 40°9'E, and 280 km away from the capital Addis Ababa in Amibara wereda of Afar Regional State at an altitude of 740 m above sea level. The soil type is alluvial and vertisol with pH ranging from 7- 8. Based on the meteorological data of the center, the area receives an average annual rainfall of 578 mm, of much of it occurs during July and August. The long term mean annual minimum and maximum temperatures are 19.5 and 34.4ºC, respectively; while the evapo-transpiration approximates to 2,700 mm, Institute of Agricultural Research (EIAR, 2004).

Experimental animals and management

Twenty-four Dorper×Afar F1 sheep of 7-9 months old were selected based on their body weight from the flock and used in 90 days of feeding trial and 7 days digestibility trial. Their age was determined by using the center record data. There was no quarantine period because they were taken from the center. However, animals were

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adapted for fifteen days in order to observe their health condition in the new diet and get adapted to the experimental condition.

During this period all animals were vaccinated against common diseases such as pasteurellosis and anthrax, and sprayed **(**Diazinon) to treat against external parasites. They were drenched with broad spectrum anthelmintic to treat internal parasites. The treatment feed were introduced gradually over the two weeks adaptation period and then full fed during the trial period.

The basal diet for this study was Rhodes grass (*Chloris gayana)* and supplemental forage legumes used in this study were alfalfa *(Medicago sativa*), lablab *(Dolicos lablab*) and *L. leucocephala* foliage adequate for animals over the feeding period was collected from tree plantation on the farm. The basal diets and the supplemental forage legumes were established using irrigation at Werer Agricultural Research Center. The basal diet and forage legumes were at around 50% flowering and harvested around 45 days growth period and field-cured under shade and stored as hay under a roofed shelter to protect from rain and intense sun light. During the feeding period, the basal diet and forage legumes were chopped to about 3-5 cm in length to minimize selection and facilitate uniform intake by the animal. A concentrate mixture of noug seed cake (NSC) and wheat bran (WB) at the ratio of 33% NSC and 67% WB was formulated to be used as a supplement for one of treatments. NSC and WB were purchased from Addis Ababa town from mechanical oil extracting plants and flour processing plant, respectively.

The basal diet (Rhodes grass hay) was fed *ad libitum* at 15% level of refusal adjusted daily due to highly digestibility and high cp content. The amount of concentrate mixture supplement in the first treatment (T1) was set at 300 g/head/day following previous recommendation that such level of supplement would induce good performance of growing sheep (Fentie, 2007; Wondesen, 2010). The amount of the other supplements was calculated based on the CP content of the supplements that were obtained from laboratory analysis to make them on isonitrogenous basis to that of the concentrate mixture. Therefore, samples of the four supplements were analyzed for DM and CP content to establish the amount of supplements to be fed before the commencement of the study. Accordingly, the supplemental levels were 286 g/head/day for alfalfa hay (T2), 326 g/head/day for lablab hay (T3) and 299 g/head/day for *L. leucocephala* hay T4 (Table 2). The supplement feeds were offered sole at 0800 and 1600 hour in two equal portions daily and there were no refusals for treatment diets. Animals were adapted for 15 days to the respective diets before the commencement of the data collection. Samples of offers from all diets and refusals from hay were collected, weighed, and bulked over 7 and 90 days for digestion and feeding trials, respectively for chemical analysis.

At the end of the feeding trial, all sheep in each treatment were used to conduct the digestion trial for 7 days. Animals were fitted with faecal collection bags for five days of acclimatization period to faecal collection bags prior to total collection of faeces for 7 days. During the faecal collection period, daily intake of hay and supplements were recorded. Samples of feeds offered and refused were collected and weighed every morning. Total faeces voided and collected in the harness were weighed daily and samples of 20% from each animal were taken and pooled in plastic bags and stored at -20°C in deep freezer. At the last day of the digestion trial, faecal samples were thoroughly mixed and sub sampled for each animal. The sub-sampled faeces were stored in ice-box containers and taken to Holetta Research Center Nutrition Laboratory and dried at 60°C for 72 h for chemical analysis. The apparent digestibility coefficient (DC) of DM, OM, ADF, neutral detergent fiber (NDF) and CP were determined using the following formula:

$$\text{Apparent Digestibility (\%)} = \frac{\text{(Nutrient intake - Fecal nutrient)}}{\text{Nutrient intake}} \times 100$$

Chemical analysis

Samples of feed offered, refusals and faeces were dried in an oven at 60°C for 72 h the samples were ground using laboratory mill to pass through 1 mm screen size. Dry matter was determined after oven drying of sub samples of partially dried samples at 105°C. The ash and nitrogen (N) were analyzed according to the procedures of AOAC (1990). Crude protein was calculated as N × 6.25. Neutral detergent fiber, ADF, and acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson *(*1985*).*

Partial budget analysis

The partial budget analysis involved the calculation of the variable cost of sheep, feeds and benefits gained from the result (Upton, 1979). The prices of sheep were assessed in Werer Sheep market before the actual experiment. The price of experimental sheep was in the range of 954.00 -959.6 ETB and the average purchase price per sheep was 957.88 ETB which has been used in partial budget analysis. At the end of the experiment, experienced sheep dealers estimated the selling price of each experimental sheep. The selling price of the forage legumes (alfalfa, lablab and *L. leucocephala*) was estimated to be a maximum of Birr 2.50 per kg. This was done with the assumption that alfalfa and *L. leucocephala* are perennial forages and once established can serve for up to 10 years which reduces their overall production cost, while lablab is an annual but its biomass production is very high. This was done because there was no standard cost for forage legumes in the area. The price of the concentrate mix (Birr 5.00 per kg) was calculated based on the market price of Birr 4.50 and Birr 6.00 per kg for wheat bran and NSC, respectively. The price of Rhodes grass hay was used in this study was estimated to be Birr 2.00 per kg.

The total return (TR) was determined by the difference between selling and purchasing price of sheep in each treatment after and before the experiment. The net income (NI) was calculated by subtracting total variable cost (TVC) from the total return (TR):

$$NI = TR - TVC$$

The change in net income (△NI) was calculated as the difference between the change in total return (△TR) and the change in total variable cost (△TVC):

$$\triangle NI = \triangle TR - \triangle TVC$$

The marginal rate of return (MRR) measures the increase in net income (△NI) associated with each additional unit of expenditure (△TVC):

$$MRR = (\triangle NI)/(\triangle TVC)$$

Statistical analysis

Variables considered in the feeding trial (feed intake, live weight change and feed efficiency) and in the digestion trial (DM and nutrient digestibility) were subjected to the analysis of variance (ANOVA) procedure using the General Linear Model procedure of SAS (SAS, 2000). Mean separation was done using least significance difference (LSD).

The model for the experiment was:

$$Y_{ij} = \mu + T_i + B_j + E_{ij}$$

Y_{ij} = the response variable
μ = the overall mean

Table 1. Chemical composition of experimental feeds and refusals.

Treatments feed	Chemical composition (% for DM and %DM for others)					
	DM	OM	CP	NDF	ADF	ADL
Rhodes grass hay	96.0	86.4	11.0	77.2	51.3	10.6
NSC	92.6	91.2	31.6	41.3	35.7	6.7
WB	90.2	95.1	17.4	50	13.7	4.2
Alfalfa	96.2	88.3	23.0	46	40	7.5
Lablab	95.8	89.1	20.2	50.1	44.3	9.7
Leucaena	93	86.2	22.2	34	27	10.6
Hay refusals						
T1	95.2	88.5	7.2	81.3	59.5	15.2
T2	95.9	88	7.4	80.8	59.8	14.9
T3	94.9	87.8	6.8	81.8	59.9	15.8
T4	95.5	88.2	7.6	81.68	58.4	15.3

ADF=Acid detergent fiber; ADL= acid detergent lignin; CP=crude protein; DM= dry matter; WB= wheat bran; NDF=neutral detergent fiber; NSC=Noug seed cake; CM= concentrate mix (33% noug seed cake; 67% wheat bran); T1=Hay *ad libitum*+300 g concentrate mix; T2=Hay *ad libitum*+286 g Alfalfa hay; T3=Hay *ad libitum* +326 g Lablab hay; T4=Hay *ad libitum* +299 g *Leucaena leucocephala* hay.

Table 2. Daily dry matter and nutrient intake of Dorper×Afar F1 sheep fed hay and supplemented with concentrate mix and different forage legumes.

Intake (g/day)	Treatment				SEM
	T1	T2	T3	T4	
Hay DM	414.87^{cb}	440.97^{ab}	355.62^{c}	510.36^{a}	62.92
Supplement DM	300.00	286.00	326.00	299.00	-
Total DM	714.87^{cb}	726.97^{ab}	681.62^{c}	809.36^{a}	51.50
OM	672.41^{a}	606.03^{b}	568.26^{b}	681.33^{a}	47.97
CP	103.23^{b}	109.51^{b}	91.96^{c}	129.72^{a}	5.83
NDF	487.46^{a}	449.63^{a}	308.17^{b}	356.47^{b}	39.95
ADF	287.18	317.92	303.77	320.24	50.91

$^{a-c}$means with a row not bearing a common superscript are significantly different; DM=dry matter; ADF=acid detergent fiber; CP=crude protein; NDF=neutral detergent fiber; OM= organic fiber; ME=metabolizable energy; SL=significance level; SEM=standard error of mean; CM= concentrate mix (33% noug seed cake; 67% wheat bran); T1=Hay *ad libitum*+300 g CM; T2=Hay *ad libitum*+286 g alfalfa hay; T3=Hay *ad libitum* +326 g lablab hay; T4=Hay *ad libitum* +299 g *Leucaena leucocephala* hay.

$T_{i.}$ = the treatment effect
B_j = the block effect
E_{ij} = the random error

RESULTS AND DISCCUSION

Chemical composition of feeds

The chemical composition of the feeds used in the present study is given in Table 1. The CP content of Rhodes grass hay used in the present study was 11% and was quite high. The CP content of hay in this experiment is an indication that the hay was of good quality and is above the 7% CP required for microbial protein synthesis in the rumen that can support at least the maintenance requirement of ruminants (Van Sosest, 1994; Minson, 1990). The CP content of the hay used in this study was similar to the CP content of good quality grass hay (11%) reported by McDonald (2002), and was within the range of 7.5 - 15.45% reported for natural pasture hay (Yihalem, 2004; Solomon et al., 2008a, b). At leaf stage (around a growth period of 30-40 days) Rhodes grass contained 12% CP the level which is often quoted to meet the minimum requirement for lactating cows (Howard, 1962; Stobbs, 1971; Said, 1974). However, at and after the growth stage of 75 days, the CP content drops below 7% the minimum level required for positive nitrogen balance (Milford and Haydock,

1965). Rhodes grass hay used in the current study was harvested around 45 days growth period.

The NDF, ADF and ADL content of Rhodes grass hay recorded in the present experiment were higher than the values reported by Getahun (2001) and Wekesa et al. (2006) but lower than the amount reported by Gebru et al. (2010). The chemical composition of the hay could be characterized by its medium CP and high NDF and ADF contents. The high NDF content of the hay used in this study may limit ruminal fill and hence intake (Cheeke, 1999). The chemical compositions of hay refusals were similar among all treatments. The CP content of the hay refusals was reduced and that of NDF and ADF was increased as compared to the hay offered, indicating selectivity by animals for nutritious parts of the hay, although there was an attempt to decrease selectivity by chopping in this study.

The CP content of lablab used in the present study was similar to those reported previously (Andrea and Pablo 1999; Murphy, 1998). Aganga and Kgwatalala (2005) and Taye (2004) reported a medium CP content of lablab of 16.4 and 17.4%, respectively. However, Murphy et al. (1999) and Odunis (2003), reported higher lablab CP values ranging from 21.4-30.3 and 23%, respectively. In the current study the CP content of *L. leucocephala* was within the range of 21.6−27.8% reported by Solomon et al. *(*2004) and similar to those reported by Dicko and Sikena (1992) values ranging from 22-28%, but OM and NDF contents were lower and greater in the current study compared to the report of Solomon et al. (2004). The CP value of Alfalfa *(M. sativa*) in the present study was similar with the 18-25% reported by Katic et al. (2006) and greater than the value reported by Dawit (2007).

The CP content of noug seed cake (NSC) in this study was comparable to the 30-32% noted by different studies (Almaz, 2008; Taye, 2011). However, lower values than that noted in this study (Jemberu et al., 2010; Gezu, 2011) and greater values than the current result (Tesfaye, 2008) were reported previously. Range of values of 15-23% CP for wheat bran (WB) has been reported before (Fentie, 2007; Abebe et al., 2010) and the result of this study was within this range. The difference in CP content of NSC and WB of different studies might be due to differences in the raw material (Solomon, 1992) and the method of extraction or milling employed. Even sample of the same variety of wheat from the same region may vary up to10% and sometimes more in content of protein due to processing and /or milling methods (Morrison, 1984).

The CP value of Alfalfa *(M. sativa*) in the present study was similar with the 18-25% reported by Kaito et al. (2006) and greater than the value reported by Dawit (2007). The CP content of lablab used in the present study was similar to those reported previously (Abule et al., 1995; Ahmad et al., 2000; Andrea and Pablo 1999; Murphy, 1998). Aganga and Kgwatalala (2005) and Taye (2004) reported a medium CP content of lablab of 16.4 and 17.4%, respectively. However, Murphy et al. (1999) and Odunsi (2003), reported higher lablab CP values ranging from 21.4-30.3 and 23%, respectively. In the current study, the CP content of *L. leucocephala* was within the range of 21.6−27.8% reported by Solomon et al. *(*2004) and similar to those reported by Dicko and Sikena (1992) values ranging from 22-28%, but OM and NDF were lower and greater in the current study compared to the report of Solomon et al. (2004). Based on the energy and CP content, feeds can be classified into low, medium and high protein and energy source feeds. According to Lonsdale (1989) feeds that have <120, 120-200 and >200 g CP/kg DM are classified as low, medium and high protein sources, respectively and also feeds that have <9, 9-12 and >12 MJ ME/kg DM are classified as low, medium and high energy sources, respectively. Based on this classification, concentrate mix, alfalfa, lablab and *L. leucocephala* used in the present study are classified as high protein source feeds.

Dry matter and nutrient intake

Significant differences (P<0.001) were observed among treatments in daily hay DM and total DM intakes. Hay and total DM intakes were greater (P<0.05) for T2 and T4 than T3, and values for T4 was greater than T1 (P<0.001). The reason for the difference in hay DM intake among treatments despite similar level of CP supplementation in the current study is not apparent. However, the slightly higher levels of NDF and ADF of lablab as compared to the other supplements might have slightly limited intake of hay in T3. The total DM intake as percent of body weight in the current study was 3.0, 3.1, 2.9 and 3.3 for T1, T2, T3 and T4, respectively, which was within the range of 2-6% recommended by the ARC (1980) and 2-4% of body weight suggested by Susan (2003).

Dry matter and nutrient digestibility

Apparent DM and nutrient digestibility of experimental feeds are shown in Table 3. The apparent digestibility of DM was lower (P<0.05) for T2 as compared to T1 and T4, while values for T3 was similar (P>0.05) with all other treatments. Digestibility of OM was highest for T1 but similar among the other 3 treatments. The CP digestibility was greater for T1 than T2 and T3, but values for T4 was similar with the other treatments. Generally values for CP digestibility among the different treatments were very close. The digestibility of NDF was the highest for T1 and that of ADF was the lowest for T4 as compared to the other treatments. The reduced digestibility of fiber in T4 could be due to the presence of tannins in leaves that may interfere with the fiber degrading microbes in the rumen (Patra, 2009b).

Table 3. Apparent dry matter and nutrient digestibility of Dorper ×Afar F1 cross sheep fed hay and supplemented with concentrate mix and different forage legumes

Digestibility (%)	Treatment				SEM
	T1	T2	T3	T4	
DM	65.37[a]	62.47[b]	64.63[ab]	65.81[a]	0.019
OM	69.31[a]	63.16[b]	65.46[b]	63.08[b]	0.025
CP	82.28[a]	78.69[b]	78.33[b]	80.41[ab]	0.022
NDF	68.02[a]	62.01[bc]	63.9[b]	58.54[c]	0.029
ADF	61.02[a]	61.8[a]	62.44[a]	49.65[b]	0.035

[a-c]means with a row not bearing a common superscript are significantly different; ADF=acid detergent fiber; CP=crude protein ; DM =dry matter NDF=neutral detergent fiber; OM=organic matter; SL=significant level; SEM=standard error of mean; CM= concentrate mix (33% noug seed cake; 67% wheat bran); T1=Hay *ad libitum*+300 g CM; T2=Hay *ad libitum*+286 g alfalfa hay; T3=Hay *ad libitum* +326 g lablab hay; T4=Hay *ad libitum* +299 g *Leucaena leucocephala* hay.

Table 4. Body weight parameters and feed conversion efficiency of Dorper ×Afar F1 cross sheep fed hay and supplemented with concentrate mix and different forage legumes.

Parameter	Treatments				SEM
	T1	T2	T3	T4	
IBW(kg)	21.21	21.31	21.68	21.30	0.72
FBW(kg)	27.08[a]	25.33[b]	25.28[b]	27.53[a]	0.88
BWC (kg)	5.86[a]	4.01[b]	3.6[b]	6.23[a]	0.74
ADG (g/d)	65.1[a]	44.63[b]	40[b]	69.17[a]	8.36
FCE	0.08[a]	0.06[b]	0.06[b]	0.08[a]	0.001

[a-b]means within a row not bearing common superscript are significantly different; ADG=average daily body weight gain; BWC=body weight change; FBW=final body weight; FCE=feed conversion efficiency (g ADG/g DM intake); IBW=initial body weight; SEM=standard error of mean; CM= concentrate mix (33% noug seed cake; 67% wheat bran); T1=Hay *ad libitum*+300 g CM; T2=Hay *ad libitum*+286 g alfalfa hay; T3=Hay *ad libitum* +326 g lablab hay; T4=Hay *ad libitum* +299 g *Leucaena leucocephala* hay.

Live weight gain and feed conversion efficiency

Final body weight of sheep was greater (P<0.05) for T1 and T4 as compared to the other two treatments which is indicated in Table 4, while values for T1 and T4 as well as for T2 and T3 were similar (P>0.05) (Table 5). Body weight change, average daily weight gain (ADG) and feed conversion efficiency were significantly affected by treatments (P <0.0001) and took a similar trend like that of final body weight. This appears to be consistent with differences in digestibility of DM and CP that might have resulted to differences in nutrients available for absorption and metabolism. The relatively higher content of NDF and ADF in alfalfa and lablab could have also been responsible for the lower ADG observed in T2 andT3 as compared to the other two treatments.

Supplementation of multipurpose trees to small ruminants improved growth performance in a number of independent studies (Reed et al., 1990; Melaku et al., 2004) and also In a study that involved feeding of *Calliandra calothyrsus* and *L. leucocephala* to goats, supplemented group gained 11-15% more body weight than the control group. Sheep fed leaves of *S. sesban* as a protein supplement also had higher body weight gain compared to un-supplemented group (Reed et al., 1990). Multipurpose trees were also complained of anti nutritional factors (Reed et al., 1990; Melaku et al., 2004), which could significantly limit their utilization. These results are also close to the findings of Yami et al. (2000) who reported that the inclusion of varying levels *L. leucocephala* leaves in the diets had significantly (P < 0.05) affected body weight gain.

A review made by Andrea and Pablo (1999) values of Lablab purpureus, indicated that CP content of lablab leaves, which ranged from 14.3-38.5% was higher than the CP content of its stems, which ranged from 7.0-20.1%. The author also reported that lablab leaves contained 37.3, 23.4 and 4.4% NDF, ADF and ADL, respectively, which were lower than 61.9, 49.4 and 9.1% NDF, ADF and ADL, respectively contained in the stems. Nsahlai and Umunna (1996) reported that the nitrogen in lablab is rapidly degradable in the rumen which is useful to meet the requirements of rumen microorganisms for efficient degradation of low quality roughages. Similarly,

Table 5. Partial budget analysis of Dorper × Afar F1 cross sheep fed hay and supplemented with concentrate mix and different forage legumes.

Parameters	Treatments			
	T1	T2	T3	T4
Purchase price per sheep (ETB)	954	959	960	959
Hay consumed (kg /sheep)	37.33	39.68	32.00	45.93
Concentrate consumed (kg /sheep)	27.00	–	–	–
Alfalfa consumed (kg/sheep)	–	25.74	–	–
Lablab consumed (kg/sheep)	–	–	29.34	–
Leucanea consumed (kg/sheep)	–	–	–	26.91
Feed costs				
Cost of hay (ETB/sheep)	74.70	79.38	64.08	91.80
Cost of concentrate (ETB /sheep)	135.00	–	–	–
Cost of alfalfa (ETB/sheep)	–	64.35	–	–
Cost of lablab (ETB/sheep)	–	–	73.35	–
Cost of *leucanea* (ETB/sheep)	–	–	–	67.28
TVC (ETB/sheep)	209.70	143.73	137.43	159.08
Selling price (ETB/sheep)	2000	1900	1985	2100
Total return (TR) (ETB/sheep)	1046	941	1025	1141
Net return (ETB/sheep)	836.30	797.27	887.57	981.93
Change in total return (ETB/sheep)	–	-105	-21	95
Change in net return (ΔNR) (ETB/sheep)	–	-39.03	51.27	145.63
Change of total variable cost (ΔTVC)	–	-65.97	-72.27	-50.63
MRR (ΔNR)/ (ΔTVC)	–	59	-71	-288

ETB= Ethiopian birr; ΔNI= change in net income; ΔTVC= change in total variable cost; MRR= marginal rate of return; NR= net return; NSC= noug seed cake; WB= wheat bran; TR= total return; T1=Hay ad libitum+300 g concentrate mix; T2=Hay ad libitum+286 g Alfalfa hay; T3=Hay ad libitum +326 g Lablab hay; T4=Hay ad libitum +299 g *Leucaena leucocephala* hay; concentrate mix=67% wheat bran +33% noug seed cake.

Adu et al. (1990) reported that lablab supplementation to sorghum stover significantly improved CP digestibility and generally improved rumen fermentation of the test diets and improved live weight gains of sheep.

Partial budget analysis

The result of this study indicated that the highest total return (1141 ETB /sheep) was obtained from sheep supplemented with 299 g/d/head *L. leucocephala* (T4); followed by T1, T3 and T2 in a decreasing order. Net return was in the order of T4 > T3 > T1 > T2 and ranged 797 – 982 ETB. The difference in the net return among treatments was mainly due to the difference in feed cost and selling price of the animals. The higher profit obtained in T4 is due to the highest total return of *L. leucocephala*, better feed conversion efficiency and body weight gain of the sheep in this treatment, which resulted in higher selling price. On the other hand, the net income of sheep in T2 was lower due to the low selling price of animals in this group. Thus, based on biological performance and net return, T4 outweighs other treatments. However, all supplements used in this study induced favorable ADG and thus can be employed in feeding systems depending on their availability and relative cost.

Conclusions

According to the chemical analysis result of the treatment diets, CP, NDF and ADF contents of Rhodes grass hay was 11, 77 and 51%, respectively. The CP contents of NSC, WB, alfalfa, lablab and *leucaena* were 32, 17, 23, 20 and 22%, respectively. Among the supplements alfalfa and lablab had relatively higher NDF and ADF levels. Hay DM intake was 415, 441, 356 and 510 g/day (SEM = 62.9) for T1, T2, T3 and T4, respectively and values were greater (P<0.05) for T2 and T4 than T3, and values for T4 was greater than T1 (P<0.001). Total DM intake differed among treatments and followed a similar trend like that of hay DM intake (715, 727, 682 and 809 g/day for T1, T2, T3 and T4, respectively). The CP intake was 103, 110, 92, 130 (SEM = 5.83) and was in the order of T4 > T1 = T2 > T3 (P<0.05). Apparent DM digestibility ranged 62-

66% and was lower (P<0.05) for T2 as compared to T1 and T4, while values for T3 was similar (P>0.05) with all other treatments. The apparent digestibility of CP was greater for T1 than T2 and T3, but values for T4 was similar with the other treatments (82.3, 78.7, 78.3 and 80.4 (SEM = 0.02) for T1, T2, T3 and T4, respectively). Generally values for CP digestibility among the different treatments were very close.

Partial budget analysis result showed that net return in the currents study to be 836, 797, 888 and 982 ETB, indicating that net return was in the order of T4 > T3 > T1 > T2. The difference in the net return among treatments was due to the difference in feed cost and selling price of the animals. Thus, based on biological performance and net return, T4 and T1 outweighs other treatments. However, all supplements used in this study induced favorable ADG and thus can be employed in feeding systems depending on their availability and relative cost.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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