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Growth Performance and Carcass Characteristics of Tigray Highland Lambs Fed Grass Hay and Supplemented with Different Levels of Lablab (*Lablab Purpureus*) Hay in Northern Ethiopia

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Abstract

The study was conducted for ninety days of feeding trial using forty-eight male lambs aged 8-9 months with average body weight of 18.33 ± 0.04 kg with the objectives to evaluate the effect of supplementation of different levels of Lablab purpureus *hay on body weight gain and carcass characteristics of Tigray Highland Lambs. The experiment was arranged in four blocks with twelve replicates and four treatments in a randomized complete block design. The treatments were ad libitum feeding of grass hay with no supplement of lablab (T1, control), grass hay supplemented with 1.0 % of BW of lablab (T2), grass hay supplemented with 1.5 % of BW of lablab (T3) and grass hay supplemented with 2.0 % of BW of lablab (T4)* Lablab purpureus *hay on dry matter basis. Supplementation increased (P<0.01) total DM intake (*gday^{-1}*) with values for T1 (781.6), T2 (843.6), T3 (916.9) and T4 (919.7). Daily weight gain, final BW,* slaughter weight*, empty BW, hot carcass weight, dressing percent and* rib-eye muscle area *were higher (P<0.01) in the supplemented treatments. Sheep on the T3 supplementation had significantly (P<0.05) heavier* total edible offal*, whereas those on grass hay alone (T1) exhibited heavier (P<0.05)* total nonedible offal*. It was concluded that supplementation of Tigray Highland Lambs with different levels of* Lablab purpureus *hay promoted BW gain, favors carcass characteristics, dressing percentage and increased the proportion of edible offal. The use of* lablab *hay in the diets of Tigray Highland Lambs would benefit smallholder farmers to utilize this legume crop and reduce the cost of purchasing expensive commercial and agro-industrial by-products of Crude Protein sources.*

Keywords: Carcass characteristics; Tigray highland sheep; Grass hay; Lablab purpureus hay; Weight gain;

Introduction

Sheep and goats are widely reared in crop–livestock farming systems and are distributed across different agro ecological zones of Ethiopia. Although diverse sheep and goat resources are found in the country, their productivity is low partially because of inadequate year-round nutrition, in terms of both quantity and quality. The major feed resources in the country are natural pasture and crop residues (CSA, 2021). They are generally low in nitrogen, energy, vitamins, and minerals; consequently, affecting microbial growth and fermentation in the rumen, resulting in low feed intake and digestibility that lead to decline in growth rates of animals and delay the attainment of slaughter weights and adversely affect meat/mutton yield and quality (Muchenje et al., 2008 cited by Mekonnen et al., 2016).

A sustainable way of improving the feeding value of poor-quality crop residues and pastures, especially for resource poor smallholders, is through inclusion of forage legumes in the ration of animals. According to Gezahagn et al., (2014), most herbaceous legumes have crude protein content which is usually required to support lactation and growth (greater than 15%), suggesting the adequacy of herbaceous legumes to supplement basal diets of predominantly low-quality pastures and crop residues. Forage legumes can be grazed, harvested, and fed fresh or stored as hay or silage (Harricharan et al., 1988). According to Andrea and Pablo (1999), *Lablab purpureus* combines a great number of qualities that can be used successfully under various conditions. Its first advantage is its adaptability, not only is it drought resistant, but it is also able to grow in a diverse range of environmental conditions worldwide. Staying green during the dry season, it has been known to provide up to six tonnes of dry matter/ha. Being palatable to livestock, it is an adequate source of much needed protein and can be utilized in several different ways. It can be grazed in a pasture setting or as a companion crop to maize or cut as hay. *Lablab purpureus* can be used advantageously as a cover crop for mulching. Its dense green cover during the dry season protects the soil against the action of the sun's rays and decreases erosion by wind or rain. As green manure, it provides organic matter, minerals and fixes nitrogen into the soil thereby improving crop yields in an economic and environmentally friendly manner.

Supplementing animals with commercial protein supplements, agro-industrial by-products such as different oil seed cakes from edible oil, brans and milling industries are practiced in the country. However, they are inaccessible and if any too expensive for the smallholder farmers of the rural and peri-urban areas of the country. Production and feeding of herbaceous legumes through intercropping with food crops were encouraged by extension agents to improve the nutrient supply to livestock (Solomon, 2001). The present study was, therefore, conducted with the objective of investigating the effect of supplementing a basal diet of grass hay with protein rich herbaceous legume specie (*Lablab purpureus*) on growth performances and carcass characteristics of Tigray Highland Lambs.

Materials and Methods

Description of the study area

The study was conducted at Abergelle International Livestock Development PLC center, located 25 kms north of Alamata District, Ethiopia (altitude 1529 m above sea level, latitude 12°32'58''N, longitude 39°38'34''E), 625 km north of Addis Ababa and about 155 km south of the Tigray Regional capital city, Mekelle. Average maximum and minimum temperature were 23.9 °C and 14.1°C, respectively. Average annual rainfall ranges from 600 to 800 mm which is highly variable from year to year and erratic in nature.

Feeds preparation and feeding

The experimental feeds were composed of natural grass dominated by *Cynodon dactylon* hay as a basal diet and herbaceous legume forage *Lablab purpureus* hay as a supplement. The grass hay was harvested manually at the end of the rain season (1st week of September) at a stage of maturity with high leaf to stem ratio. To prevent bleaching that may happen during drying, the harvested grass was turned up frequently and dried for two days. Then grass hay was transported to the experimental site, chopped manually into small pieces of about 5-7 cm, further air dried under shade and stored separately till the feeding trial started.

Lablab purpureus seeds were collected from forage seed multiplication reserves in the Bureau of Agriculture of Southern Zone of Tigray. Seeds were sown at the recommended rate of 18-20 kg/ha for pure stand (Alemayehu, 1997) at the fattening center's forage production field. Hand weeding was continued until the forage reach for harvest in September 2019 Rain fed *Lablab purpureus* growth was monitored until the 20–30% blooming stage (Berhane and Eik, 2006) and hand-cut during the first week of September 2019. Manual chopping was done to 5-7 cm length and the chopped material was air dried under shade then stored in a dry place until use for feeding. The supplement hay is expected to contain CP to meet the minimum recommendation for intensive feeding (i.e., 14% CP), according to NRC (2007). Individual feed troughs were used to offer the feeds. Grass hay was provided to all animals *ad libitum* at a rate of 20% refusal as a basal diet. The daily legume hay supplement was offered once a day at 1600 pm. Feed offered and refused was weighed and recorded daily. Common salt blocks and water were available to the animals all the time throughout the experimental period.

Animals and their management

Forty-eight male lambs aged 8-9 months with initial body weight (BW) of 18.33 ± 0.04 kg (mean ± S.D.) were purchased from surrounding village farmers by asking the owners about their lambs' age and checking the dentition of each lamb. The sheep were held in quarantine for 21 days and observed for any health problem. During this time, a plastic ear tag identification number was applied for each sheep, vaccinated against bovine pasteruolosis, anthrax and sheep pox. Animals were also treated against internal and external parasites using anti-helminths (Albendazole) and acaricides (Steladon) as per the recommended dosage. The animals were placed in individual pens equipped with a drinking bucket and a feeding trough in a well-ventilated concrete floor experimental barn.

Experimental design and treatments

A randomized complete block design consisting of four treatments and four blocks was used for the study. Sheep were blocked according to their initial body weight (BW) and randomly allocated to different levels of *Lablab purpureus* hay supplement, namely 0% BW (Control, Treatment 1), 1.0% BW (Treatment 2), 1.5% BW (Treatment 3) and 2.0% BW (Treatment 4). These levels were chosen to accommodate the inclusion rates of forage legumes suggested by Devendra (1988) and adjusted based on weighing of animals every 10 days intervals. All animals were fed in individual pens and *Lablab purpureus* hay was provided every evening at 16:00 hr separately for each pen. Common salt blocks and water were available at free access to the animals throughout the experimental period.

Data collection and analysis

Feeding trial

After an acclimatization period of 14 days to the experimental diets and pens, the feeding trial was conducted for 90 days. The daily feed offered, and refusals were weighed and recorded for each sheep. Daily dry matter and nutrient intake were calculated as the difference between the feed offered and refused. Samples of feed offered were collected per batch while samples of refusal were taken from each sheep daily and pooled per animal over the experimental period and stored in plastic bags. Sub-samples of feed offered, and refusals were taken after thorough mixing for determination of nutrient composition, and the sub-samples taken were dried at 60°C for 72 hours in a forced draft oven to make it ready for grinding and chemical analysis.

Body weight change and feed conversion efficiency

Body weight of the animals was taken at the beginning of the feeding trial and every 10 days interval during the 90 days of feeding. All animals were weighed in the morning hours before feed provision using weighing balance with a sensitivity of 100 grams. Average daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency was determined by dividing the daily average body weight gain (ADG) by daily total DM intake of the animal.

$$\text{Average daily body weight gain} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Number of feeding days}}$$

$$\text{Feed conversion efficiency} = \frac{\text{Average daily body weight gain in gram}}{\text{Daily dry matter intake in gram}}$$

Digestibility trial

Following the feeding trial, digestibility trial was conducted and four sheep from each treatment were harnessed with a fecal collection bag to collect feces for determination of digestibility. The sheep were accustomed to the fecal collection bags for three days. This was followed by collection of feces for seven consecutive days. During this period, feed offered and refused were recorded and samples of feed offered were pooled per treatment, while samples of feed refused were pooled per animal. Fresh feces were collected into a fecal collection bag fitted to the animal. The total fecal output was collected by emptying the bag twice per day at 6:00 AM and 6:00 PM per animal were weighed and recorded for each sheep throughout the digestibility trial. The feces were weighed fresh, thoroughly mixed and 20% of the total feces samples (224 samples) were sub sampled for each sheep and stored in a deep freezer at -18°C. The samples were pooled per animal across the collection period and 20% of the composite sample was taken, weighed and partially dried at 60°C for 72 hours. The partially dried fecal samples were milled by Wiley mill to pass through a 1mm sieve and stored in airtight polyethylene bags pending chemical analysis. Apparent digestibility of DM and other nutrients were determined as a percentage of the nutrient intake not recovered in the feces using the formula (McDonald et al., 2010).

$$\text{Percent of apparent digestibility} = \frac{(\text{Nutrient intake} - \text{Nutrient in feces})}{\text{Nutrient intake}} \times 100$$

Bodyweight change measurement

The bodyweight was measured using a suspended or hanging scale, which had 50 kg weighing capacity, with 100 g of calibration or sensitivity. Lambs were weighed at the beginning of the experiment and subsequently every 10-days interval in the morning hours after overnight fasting of feed and water to avoid residual feed effect from previous day. Daily body weight gain was calculated as the difference between final and initial live weight divided by the number of feeding days. Similarly, feed conversion efficiency (FCE) was computed as a proportion of daily body weight gain to daily feed intake.

Chemical Analysis

Samples of feed offered refusals and feces were ground to pass through a 1 mm sieve mesh. Analysis for DM, ash and N contents was done according to AOAC (2005) procedures. Total nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as N*6.25. Neutral detergent fiber

(NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van Soest and Robertson (1985). The energy value of the treatment feeds was estimated according to McDonald et al. (2010) as metabolizable energy (ME, MJ/Kg DM) = 0.016 x DOMD, where DOMD (g) indicates digestible organic matter per kilogram of dry matter.

Carcass and non-carcass parameters

At the end of the feeding and digestibility trials, all lambs were transported to Abergelle International Export Abattoir for slaughter. The lambs arrived at the slaughterhouse two days before slaughter to allow for muscle glycogen to be replenished by the body as much as possible. Sheep were fasted overnight, then weighed and slaughtered for carcass evaluation. The weights of the edible and non-edible components of the carcass were measured and recorded for each sheep. The empty BW was calculated by subtracting the weight of the alimentary tract contents from the slaughter weight. The cross-section of the rib-eye muscle was traced on transparency paper between the 11^{th} and 12^{th} ribs (Galal et al., 1979) of the left half side of the carcass after freezing, and the area was measured using a planimeter. The rib-eye area was taken as the mean of the two sides of the ribs. In the present study, heart, liver, kidney, empty gut, kidney knob and channel fat, omental fat and tongue were considered as edible offal. Blood, gut content, spleen and pancreas, testicles and penis, skin, feet, gall bladder and urinary bladder were categorized as non-edible offal.

Dressing percentages on slaughter weight basis $= \frac{\text{Hot carcass weight}}{\text{slaughter weight}} * 100$

Dressing percentages on empty body weight basis $= \frac{\text{Hot carcass weight}}{\text{empty body weight}} * 100$

2.5.7 Statistical Analysis

The statistical model used for analysis of data on feed intake, BW change and apparent digestibility coefficient was:

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

where Y_{ij} is the individual weight, μ the overall mean, T_i the effect of the i^{th} level of *Lablab purpureus* hay supplement (i = 1–4), B_j the effect of j^{th} block (j = 1–4) and e_{ij} is the residual.

Data on carcass parameters was analyzed using the statistical model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} is the response variable, μ is the overall mean, T_i the effect of the i^{th} level of *Lablab purpureus* hay supplement (i = 1–4), and eij is the random error

The data collected were subjected to one-way analysis of variance (ANOVA) using STATA (2022) Version 16. When significant, pairwise comparison among the treatment groups was employed by the Bonferroni method.

Results and discussion

Chemical composition of experimental and refused feeds

Chemical composition of the experimental diets used in the experiment is indicated in Table 1.

Table 1. Chemical composition of experimental and refused feeds on DM basis.

Experimental feeds	DM%	Nutrient composition (DM%)						
		CP	OM	Ash	NDF	ADF	ADL	DOMD
Grass hay	91.20	10.15	88.53	11.47	68.56	44.25	5.78	51.36
Lablab purpureus hay	89.21	19.94	91.36	08.64	45.86	37.65	7.24	70.12
Hay refusal								
T1	91.79	7.84	92.87	7.13	70.21	52.42	8.36	39.76
T2	90.03	09.23	89.54	10.46	48.56	39.12	8.95	29.41
T3	89.97	11.12	89.32	10.68	47.63	38.89	8.47	28.93
T4	89.95	11.53	89.12	10.88	46.23	38.42	8.25	28.36

DM=dry matter, CP=crude protein, OM=organic matter NDF=neutral detergent fiber, ADF=acid detergent fiber, ADL=acid detergent lignin, DOMD=digestible organic matter in dry matter

The grass hay DM content in the current study was 91.2% which was higher than the values 90.5% and 90.9% reported by Mamo et al. (2021) and Challa (2020), respectively and disagrees with the higher values (ranging from 92.3 to 93.7%) reported by authors (Mekonnen, 2017 and Abuye et al., 2018). On the other hand, OM content of the grass hay was higher than the 87.8% reported by Challa (2020) and lower than the 91.6% reported by Abuye et al., (2018) and the 90.5% reported by Diriba et al., (2013). The NDF, ADF and ADL values 68.56%, 44.25% and 5.78%, respectively, reported in the current study were higher than the values 52.82%, 37.59%, 6.71% reported by Abuye et al., (2018) and lower than the values 72.4%, 44.5%, 8.3% reported by Challa (2020). This could be attributed to the stage of maturity of the natural grass during cutting for hay where grass hay cut at 20 – 30% flowering stage is expected to have less DM% and higher OM% with lower ADF and ADL content than over-matured grass hay. Even though the CP content of the basal feed, grass hay was lower than the other treatment diets as expected, its CP content was higher than the lower limit of 7% CP required for optimum rumen function (Van Soest, 1994). As a result, the natural pasture diet (T1) can be considered as adequate for maintenance requirement of animals in terms of its CP content. As reported by Topps (1995), when the CP content of roughages is below 7%, there will be impaired rumen function resulting in poor digestion of feeds, low DM intake and poor animal performance. The 10.15% CP content of grass hay used in this study was higher from the range 7.07% - 8.49% reported by Tusa et al., (2021), Challa (2020) and Mamo et al., (2021). This could be attributed to the stage of maturity of the natural grass during cutting and the drying technique followed to keep the green color expected to have high CP%.

The DM, NDF, ADF and ADL contents of *Lablab purpureus* hay (91.20, 70.56, 47.25 and 05.98%, respectively), reported by Diriba et al., (2013) were higher than values obtained for the same nutrients in the current study. Values obtained in the current study were also lower than values reported by Mekonnen (2017) for the same nutrients. In terms of chemical constituents, herbaceous legumes are primarily characterized by high N content. Crude protein content of herbaceous legumes under local conditions varied from 15% in trifolium to 26% in vicia with a mean of about 19% (Seyoum, 1995). The CP content of *Lablab purpureus* hay used in this study was comparable to the value19.23% reported by Hunegnaw and Berhan (2016), 19.93% reported by Abuye et al., (2018) and lower than the 21.0% and 25.1% reported by Challa (2020) and Diriba et al. (2013), respectively. The NDF, ADF and ADL contents of the refusals were higher than the corresponding contents of feeds offered, whereas the CP contents of the refusals were lower than the corresponding contents of feeds offered. This could be explained as animals selectively eat the nutritious parts of the feed preferring leaves and twigs than the stem parts. The high ADL content in the refusals could be attributed to refusals mainly constituted the stem part of the feed, which indicates that the lignin must have been mainly contained in the stem than the leaves and twigs.

The higher DOMD obtained from the two feed staffs may be attributed to their lower NDF and ADF concentrations. The relatively higher percentage of CP and intermediate fiber fraction content of the grass hay may have occurred from the optimal stage of harvesting and proper drying timing. As plants mature, the cell wall constituent increases and therefore, the structural carbohydrates such as cellulose and lignin increase, and the percentage of the CP normally decreases (McDonald, 2002). Longer periods of exposure of the harvested grass to sunshine causes bleaching which causes the green color of the grass to disappear and consequently the CP content of the hay decreases.

Dry Matter and Nutrient Intake

Average daily dry matter and nutrient intake of Tigray Highland Lambs fed grass hay alone or supplemented with graded levels of *Lablab purpureus* hay is given in Table 2.

Table 2: Average daily dry matter and nutrient intake of Tigray Highland Lambs fed grass hay alone or supplemented with graded levels of *Lablab purpureus* hay

Parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Dry matter intake (g day^{-1})						
Grass hay DM	781.6^{a}	667.2^{b}	648.7^{c}	637.4^{c}	3.00	*
Supplement DM	0	176.4^{c}	268.2^{b}	282.3^{a}	2.94	*
Total DM	781.6^{c}	843.6^{b}	916.9^{ab}	919.7^{a}	2.88	**
Total DM (g/kg BW)	43.4^{c}	46.9^{b}	50.9^{ab}	51.1^{a}	0.16	**
Total nutrient intake						
CP (g day^{-1})	58.5^{c}	63.5^{b}	69.5^{ab}	70.2^{a}	0.24	*
OM (g day^{-1})	384.7^{d}	416.7^{c}	458.0^{b}	464.4^{a}	1.66	*
NDF (g day^{-1})	250.1^{d}	280.4^{c}	319.1^{b}	334.1^{a}	1.75	*
ADF (g day^{-1})	151.0^{d}	181.0^{c}	217.7^{b}	239.1^{a}	1.84	*
Digestible (D) nutrient intake (g day^{-1})						
DDM	430.9^{d}	499.9^{c}	541.4^{b}	551.1^{a}	2.50	*
DCP	37.3^{c}	41.2^{b}	44.5^{ab}	43.8^{a}	0.14	*
DOM	226.4^{d}	259.8^{c}	282.4^{b}	290.1^{a}	1.33	*
DNDF	120.4^{d}	154.2^{c}	171.8^{b}	187.7^{a}	1.40	*
DADF	77.3^{d}	93.0^{c}	109.3^{b}	124.9^{a}	0.99	*

^{a,b,c,d} Means within a row with different superscripts differ significantly (P < 0.05); * = (P < 0.05); (P < 0.01); ** = (P < 0.01); SEM=standard error of means; SL=significance level; ns=non-significant; DM=dry matter; BW=body weight; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin; ME=metabolizable energy; GH=grass hay; LP=Lablab purporeus; T1=control (grass hay) T2=T1+ 1.0%BW LP hay; T3=T1+ 1.5%BW LP hay; T4=T1+ 2.0%BW LP hay;

Significant (P< 0.05) differences were observed among treatments in the mean daily DM and nutrient intakes. The mean total DM and total DM (g/kg BW) intake of the control group (T1) was significantly (P>05) lower than the treatment groups supplemented with different levels of the *Lablab purpureus* hay. Dietary protein supplementation is known to improve intake by increasing the supply of nitrogen to the rumen microbes. This has a positive effect on increasing rumen microbial population and efficiency, thus enabling them to increase the rate of breakdown of the digesta. When the rate of breakdown of digesta increases, feed intake is accordingly increased (Van Soest, 1994). In the current study a significant (P>0.05) difference in CP intake between T1 and the supplemented group T2, T3, and T4 was observed. Total NDF and ADF intake was lower (P>0.05) for T1 than the supplemented groups. This might be associated with the availability of CP in the diets that lambs offered feed having low CP content (T1) consumed relatively low DM due to the longer retained digesta in the rumen causing longer period of gut fill as explained by (Van Soest, 1994).

In a study on Arsi-Bale sheep fed Desho grass hay and supplemented with 150, 300 and 450 grams of *Vicia villosa* legume, daily DM intake and daily body weight gain of experimental sheep showed significant ($P < 0.05$) improvement with increased level of inclusion into the basal ration (Mergia et al., 2021). Supplementation also showed a positive effect on growth performance and carcass characteristics which agreed with the current study.

Body weight change and feed conversion efficiency

Growth performance parameters of lambs fed on grass hay supplemented with graded levels of *Lablab purporeus* hay are presented in Table 3.

Table 3. Growth performance parameters of lambs fed on grass hay supplemented with graded levels of *Lablab purporeus* hay.

Growth performance parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Initial body weight (kg)	18.3	18.3	18.4	18.4	0.00	ns
Final body weight (kg)	22.8^{d}	23.4^{c}	24.8^{b}	25.3^{a}	0.05	*
Body weight change (kg)	4.4^{d}	5.1^{c}	6.5^{b}	6.9^{a}	0.05	**
Average daily weight gain (g/day)	49.3^{d}	56.8^{c}	71.9^{b}	77.0^{a}	0.58	**
Feed conversion efficiency (g gain/g fed)	0.063^{b}	0.067^{b}	0.078^{a}	0.084^{a}	0.00	*

^{a,b,c,d} *Means within a row with different superscripts differ significantly (P < 0.05); * = (P < 0.05); (P < 0.01); ** = (P < 0.01); SEM=standard error of means; SL=significance level; ns=non-significant; T1=control (grass hay) T2=T1+ 1.0%BW LP hay; T3=T1+ 1.5%BW LP hay; T4=T1+ 2.0%BW LP hay.*

The average daily gain and feed efficiency were linearly increased ($P < 0.01$) with increasing levels of *Lablab purpureus* hay supplementation. The final body weight of lambs in the control group T1 with value 22.4 kg was lower than the supplemented group T4 which recorded the highest value (25.3 kg) followed by T3 and T2 with values 24.8 and 23.4 kg, respectively. The ADG of lambs increased with the increase in crude protein contained in the experimental forage legumes hay. In the current study, grass hay supplemented with increased levels of legume hay inclusion showed increased daily DM intake and daily body weight gain of lambs. The higher final body weight and ADG of lambs supplemented with *Lablab purporeus* hay in T4 could be attributed to the higher CP content that may favor better intake and digestibility of the basal feed. This agreed with the work of Jalel (2020) who reported natural pasture hay supplemented with wild silver leaf desmodium at levels of 200, 300, 400 g/head/day on dry matter basis improved body weight of sheep and correspondingly increased the net income from the sale of sheep at the end of the feeding trial and concluded supplementation of wild silver leaf desmodium to natural grass hay at 400 g appears to be the best level for Horro sheep in growth and daily body gain.

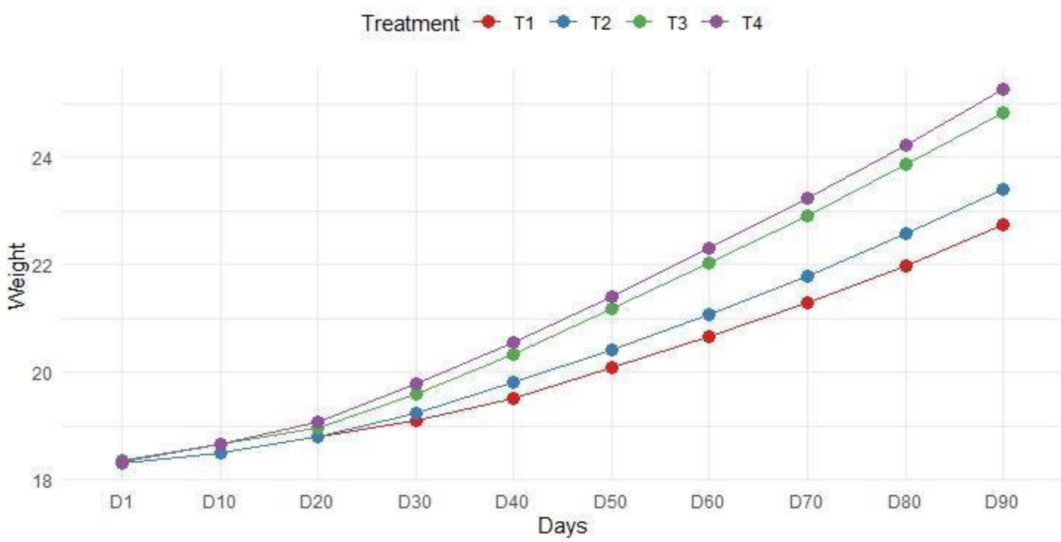

Figure 1. Growth curve of lambs fed on grass hay supplemented with graded levels of *Lablab purporeus* hay

Carcass parameters

Carcass characteristics of the Tigray Highland Lambs fed grass hay supplemented with graded levels of *Lablab purporeus* hay were assessed and results for slaughter weight, empty body weight, hot carcass weight, dressing percentage, forequarter, hind quarter, rib-eye muscle area and edible and non-edible offal components are indicated in Table 4.

Table 4. Carcass characteristics of lambs fed on grass hay supplemented with graded levels of *Lablab purporeus* hay

BW parameters	Treatments					
	T1	T2	T3	T4	SEM	SL
Slaughter weight (kg)	22.8^{d}	23.4^{c}	24.8^{b}	25.3^{a}	0.05	**
Empty body weight (kg)	18.5^{cd}	19.0^{ac}	20.6^{a}	20.4^{ab}	0.04	*
Hot carcass weight (kg)	7.8^{bc}	7.9^{b}	9.5^{ab}	10.0^{a}	0.05	**
Dressing percentage						
Slaughter weight base	34.2^{cd}	33.8^{cd}	38.3^{ab}	39.5^{a}	0.11	**
Empty body weight base	42.2^{c}	41.6^{cd}	46.1^{b}	49.0^{a}	0.14	**
Forequarter (kg)	3.9^{d}	4.4^{c}	5.0^{ab}	5.3^{a}	0.03	*
Hind quarter (kg)	3.5^{d}	4.0^{c}	4.7^{a}	4.6^{ab}	0.02	*
Rib-eye muscle area (cm^2)	6.4^{cd}	7.0^{bc}	7.6^{ab}	9.0^{a}	0.05	**
Total edible offal (kg)	4.2^{dc}	4.5^{bc}	5.0^{a}	4.8^{ab}	0.01	*
Total nonedible offal (kg)	9.1^{a}	8.4^{b}	8.2^{bc}	7.9^{dc}	0.03	*

^{a,b,c,d} *Means within a row with different superscripts differ significantly (P < 0.05); * = (P < 0.05); (P < 0.01); ** = (P < 0.01) SEM=standard error of means; SL=significance level; BW: body weight; SW: slaughter weight; T1=control (grass hay) T2=T1+ 1.0%BW LP hay; T3=T1+ 1.5%BW LP hay; T4=T1+ 2.0%BW LP hay; TEO: total edible offal; TNEO: total non-edible offal.*

The offal components were categorized into edible (head with tongue, heart, kidney, liver with bile, empty gut, tail and fat from kidney, omentum and heart) and non-edible (skin and legs, penis, testis, lung with trachea, esophagus, spleen, bladder and gut contents) based on the eating habit of the people living around the area where the experiment was conducted.

There were significant (P<0.01) differences in slaughter weight between the control group (T1) and the supplemented groups (T2, T3 and T4). Significant (P<05) differences in empty body weight between T3 and T1 was observed with minor differences between the supplemented groups. Hot carcass weight was significantly (p<0.01) higher for T4 than T1 with an increasing value from T1 to T2 and T3. Significantly (p<0.01) higher rib eye muscle area differences were observed between T4, and T1 where T3 and T2 showed a slight increase than T1. Rib-eye muscle area is mostly used as a tool to indicate the proportion of carcass muscling (Wolf et al., 1980). Greater rib-eye muscle area is associated with a higher production of lean in the carcass and higher lean-to bone ratio. In the present study, lambs assigned to the T4 diet showed significantly (P<0.01) higher rib-eye muscle area than the T1 and T2. The current study agrees with (Abuye et al., 2018; Mekonnen et al., 2017) who reported that nitrogen rich leguminous forage had significantly improved slaughter weight, empty body weight, hot carcass weight, and rib-eye muscle area in sheep feeding trials. This study also agreed with the work by Berhan and Asnakew (2015) who reported that the carcass yield of goats as measured by the average values of slaughter weight, empty body weight, hot carcass weight, dressing percentage and rib eye area was superior for concentrate supplemented groups.

Significantly increased total edible offal with increasing level of supplementation for Horro sheep fed natural grass hay and supplemented with Gebisa-17 and Beresa-55 cultivars of *Lablab purpureus* and concentrate mixture was reported by (Abuye et al., 2018). The authors further reported that, total edible offal values ranging from 3.75 to 4.89 Kg which agrees with value obtained in the current study (4.2 to 5.0 Kg). Similarly, comparable total edible offal values ranging from 3.08 to 4.9 Kg for the same breed was reported by (Girma and Mengistu, 2017). A slightly higher than the current study (ranging between 4.2 and 5.0 kg) weight of total edible offal ranged between 4.3 and 5.8 Kg was reported by (Mekonnen et al., 2017) for the Horro sheep breed.

In agreement with the present finding, Hirut (2008) and Michael and Yayneshet (2014) reported negative effect of level of supplementation on the percentage of total non-edible offal in Hararghe and Tigray highland sheep, respectively. The highest value of gut contents weight was recorded for lambs assigned to fed T1 and T2 diet rather than T4. The heaviest gut content of lambs fed T1 and T2 diet might be due to the higher roughage or relatively poor-quality feed used. This was agreed with the views of Van Soest (1994) and Pond et al., (1995) in that non-supplemented animals fill their gut with less digestible roughage, which would retain in the gut for longer time to be degraded by rumen microbes.

Conclusion

The CP content of grass hay was indeed sufficient to meet the maintenance requirement but was relatively low to meet the growth demands of lambs for minimum exportable weight of 25 kg, indicating the need for supplementation of grass hay-based diets with forage legumes such as *Lablab purporeus*. A higher total DM and/or nutrient intake and superior daily body weight gain was recorded in lambs supplemented with *Lablab purporeus* hay. Similarly, slaughter weight, empty body weight, hot carcass weight and dressing percentage on slaughter weight basis and mean rib eye muscle area were all higher in lambs supplemented with *Lablab purporeus* hay. Supplementation resulted in higher body weight gain, carcass yield characteristics, total edible offal components and decreasing trend values for total non-edible offal components in Tigray Highland Lambs fed grass hay. Further studies need be focused on further determination of the level of supplementation of *Lablab purpureus* hay.

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