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Effects of supplementation with pigeon pea (*Cajanus cajan*), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) on feed intake, body weight gain and carcass characteristics in Wollo sheep fed grass hay

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Abstract

The experiment was carried out at Mersa Agricultural Technical Vocational Education and Training (ATVET) College to investigate the effect of supplementation with pigeon pea (*Cajanus cajan),* cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) on feed intake, body weight change and carcass parameters in Wollo lambs fed a basal diet of grass hay. Sixteen male yearling Wollo lambs weighing 18.8±0.35 kg (mean ± SD) were used in randomized complete block design (RCBD) that lasted for 90 days. Treatments consisted of ad libitum feeding of natural pasture grass hay plus 200 g DM wheat bran per day per head for control (T1) and additionally supplementing with 243, 260 or 225 g DM per head per day of pigeon pea, cowpea and lablab for T2, T3 and T4, respectively. Lambs were categorized into four blocks of four lambs based on their initial body weight and the four feed treatments were randomly assigned to each animal in a block, giving four animals per treatment. Forage legume supplementation resulted in increased (P<0.001) total DM, CP and NDF intakes, but depressed (p<0.001) grass hay intake than the control gain of 49.36 g/d was. Higher (P<0.001) average daily weight gain of 49.4 g was recorded in lambs supplemented with 225 g/d per head lablab, while lambs on the control diet gained 3.1 g/d. Feed conversion efficiency (FCE) was higher (P<0.001) in pigeon pea, cowpea and lablab supplemented lambs compared to the control lambs. A higher (P<0.001) hot carcass weight (9.60 kg) was recorded for lablab supplemented lambs than un-supplemented lambs (5.08 kg). Dressing percentage on slaughter weight (SW) basis was higher (P<0.001) in supplemented lambs than the control group (42.1% for lablab and 28.2% for control). A higher (P<0.001) rib eye muscle area was recorded in supplemented lambs compared to the control. When the forage legumes protein supplements were ranked based on CP, average daily gain (ADG) and FCE, it was concluded that supplementation of lablab resulted in better live weight gain, nutrient intake, carcass traits and economic return of Wollo Tumele lambs.

Keywords: Body weight, cowpea, carcass, feed intake, lablab, pigeon pea, supplementation, Wollo Tumele lambs

Introduction

Ethiopia has one of the largest livestock inventories in Africa with a national herd size estimated at 49.2 million cattle, 46.8 million small ruminants, and 9 million pack animals. Livestock currently support and sustain livelihoods for 80% of all rural poor (MoARD, 2007). Although there exist 25.97 million sheep population in Ethiopia, the production and productivity is very low, as expressed by annual population growth rate of 1% and off-take rate of 35% (CSA, 2010). The same source indicated that the average daily growth rate of indigenous meat sheep is 50 g, while the average carcass yield is 10 kg per animal. The low performance of local sheep in terms of body weight gain and carcass yield is mainly due to inadequate nutrition (Betsha, 2005) associated with reliance on sole natural pasture, crop residues and/or stubble grazing, which are inherently low in nutrients available (Solomon *et al*., 2008). Temporally abundance of forage during short rainy season is followed by long dry periods with feed deficit leading to a cycle of live weight gain and loss of animals. Thus, sheep often take longer period to attain market weight, lowering its production efficiency.

Due to seasonal changes, there is serious shortage of feedstuffs that result in the fluctuation of animal production and therefore many farmers in Ethiopia feed their livestock with crop residues, mainly various straws. However, the use of such straw has limitations due to their low nutritive value indicated by their high cellulose, hemi-cellulose and lignin contents, and their low protein content and digestibility. Also, tropical grasses are usually deficient in crude protein (CP). As a result, high levels of production cannot be obtained only from such feeds that hardly meet even the maintenance requirement of animals, particularly during dry season.

On the other hand, the present export market (to the Middle East countries) for Ethiopian live sheep and mutton demands animals weighing between 25 and 30 kg at yearling age. However, under traditional farmer's management system, most local sheep slaughtered at this age weigh between 18 to 20 kg (IAR, 1991), due to mainly low quality and quantity of feeds that are considered to be the major constraints hampering productivity of small ruminants. Thus, lack of consistent supply of sheep at the required body weight and age has remained a major challenge for mutton and live sheep exporters.

Supplementation with palatable feed resources, mainly agro-industrial by-products has been used in many developed countries for improving locally available nutrients of feed resources (Xianjun *et al*., 2012). Supplementing protein source concentrates and/or agro-industrial by-products to low-quality tropical grass hay is known to improve intake and digestibility of roughages (Ajebu, 2010).

However, the use of such protein source supplements is limited under smallholder livestock production systems due to the availability and high cost. Consequently, there is limited prospect for using agro-industrial by-product protein source supplements such as oil seedcakes as a livestock feed by smallholder farmers. In order to mitigate the problems associated with the lack of protein supplements due to reasons of availability and high cost, there is a need to look for alternative protein sources such as supplementation with forage legumes that farmers can produce at their own farms. Among the forage legumes, pigeon pea (*Cajanus cajan*), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) could be easily grown at farmers levels and play an important role in supplementing diets of growing lambs as alternative to oil seedcake supplements.

These forage legumes can improve the growth performance of young ruminant animals on fibrous diets through the provision of more nutrients and optimization of fermentative digestion in the rumen. The growth performance of animals on poor-quality roughage can vary with the protein source. The supplement factors responsible for variations in animal response may include solubility, rate and extent of degradability of protein in the rumen (McDonald *et al.*, 2002). There is a considerable interest in protein sources that are slowly degraded in the rumen. These relatively resistant protein sources (RUP) or intestinal digestion can have special value for young growing ruminants whose protein requirements are relatively high (Tamminga, 1979). On the other hand, dietary protein consumed by ruminants that is degraded in the rumen (RDP) is available for use by the rumen microbes to make microbial protein (McDonald *et al.*, 2002). When formulating diets for ruminants, various criteria can be used to select the protein supplements including palatability, ruminal protein degradability, protein quality, intestinal absorption of amino acids and impact on animal performance (ARC, 1980).

This implies that among other things, it is important to supplement growing ruminants not only with energy sources like wheat bran, but also with protein sources in order to increase the efficiency of growth to the desired market weight so that the economic benefit of sheep production could be enhanced. Therefore, this study was designed to assess the effects of supplementing pigeon pea (*Cajanus cajan*), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) hay on feed intake, body weight gain, carcass characteristics and economic feasibility of Wollo *Tumele* sheep fed grass hay basal diet with wheat bran.

Materials and Methods

Description of the study area

The study was conducted at Mersa Agricultural Technical and Vocational Educational Training

(ATVET) College located at 491 km from Addis in Habru district, North Wollo administrative zone of the Amhara region, Ethiopia. Mersa is situated at an altitude ranging from 1200-2350 m.a.s.l (HWoARD, 2010) at 39^0 38'E longitude and $11^0$35'N latitude in the semi-arid tropical belt of north-eastern Ethiopia (MoA, 1998). Its mean annual maximum and minimum temperatures were 28.5^0C and 15^0C, respectively (HWoARD, 2010), whereas the mean annual rainfall of the district varied from 750 to 1000 mm. It receives a bimodal rainfall, namely the main rainy season and short rainy season. The main rainy season extends from the beginning of July to mid of September while the short rainy season starts by the end of January and lasts up to the end of April (SARC, 2008 unpublished).

Feeds and feeding management

Purchased locally available natural pasture grass hay constituted the basal feed along with wheat bran as energy source. The forage legumes, pigeon pea *(Cajanus cajan)* accession 11560, cowpea *(Vigna unguiculata)* accession 9333 and lablab *(Lablab purpureus)* accession 147 were used as protein source supplements. The supplement forage species were harvested when 50% of the forages were flowered and dried under shade for hay making. The grass hay and forage hays were manually chopped to a size of approximately 3-5 cm to encourage intake. The daily amounts of natural pasture grass hay, forage legumes and wheat bran were offered in separate troughs, wheat bran once a day at 8:00 AM, whereas the hay and forage legumes twice a day at 8:30 AM and 14:00 PM. The lambs had free access to clean, fresh water and common salt at all the time.

Animals and their management

For the current study, the Central Highland sheep which are believed to be crosses of highland Wollo sheep and lowland Afar sheep and commonly called by the community Wollo *Tumele* sheep were used for experiment purpose. Because there is no specialized local sheep in that area the regional government of Amhara demarcated the area from Shewa Robit (Semen Shewa) up to Kobo (North Wollo) areas as Dorper-Boer valley and started project work to satisfy this initiation (Solomon Tiruneh, personal communication). According to Desta (2009), Wollo sheep are characterized by short, fat tail with short twisted/coiled end, occasionally turned up at end; well-developed wooly undercoat; small size; predominantly black, white or brown, either plain or with patches of white, black or brown; long hair with wooly undercoat; horned males. While the Afar sheep have small ears and usually have a dewlap and thick layers of fat on the brisket. The fat tail has a wide base and reaches below the hocks. Hair is short and coarse, the predominant color being solid blond with other colors ranging from shaded white to light brown. There are a few exceptions of animals with spotted color patterns and/or dark brown hair. The average observed wither height for adult rams is 66 centimeters (cm) while that for adult ewes is 61 cm. Afar sheep weigh about 2.5 kg, 13 kg and 25.8 kg at birth, weaning (90 days), and one year of age, respectively. Ewe mature weight is about 31.6 kg. Twin births are not common (Kassahun and Solomon, 2008).

The experiment was conducted using sixteen intact yearling growing indigenous lambs (Wollo *Tumele* sheep) with an average body weight of 18.8±0.35 kg (mean ± SD). The age of the animals was determined by dentition and the information obtained from the owners. The sheep were purchased from the local markets of Mersa and Habru Woredas in North Wollo at Amhara Regional State and quarantined for 3 weeks. They were drenched with a broad spectrum anthelmintic (albendazol) against internal parasites, sprayed with accaricide (diazzinole) against external parasites and vaccinated against anthrax and pasteurelosis.

Following the quarantine period, the initial body weights of all animals were measured. The lambs were kept in well ventilated individual pens equipped with watering and feeding troughs, and identified with neck collars and adapted for 15 days to the respective treatment diets and experimental pens before the start of the actual feeding trial that lasted for 90 days. The experimental animals were carefully observed for the occurrence of any ill health and records were taken for any physiological disorder during the experimental period.

Experimental design and treatments

The experiment was conducted in randomized complete block design (RCBD) with four dietary treatments, each replicated with four lambs. The experiment comprised of feeding of a basal diet (natural pasture grass hay), and/or supplementation of the basal diet with wheat bran alone (control), and additionally supplementing one of the three forage species to the rest of the treatments, each representing a treatment. An equal amount of wheat bran was supplemented across all treatments to provide source of energy. The treatments were feeding of the following treatment diets (DM basis).

Treatment 1 (T1) = Grass hay ad *libitum* + 200 g Wheat bran (Control)
Treatment 2 (T2) = Grass hay *ad libitum* + 200 g Wheat bran + 243 g Pigeon pea
Treatment 3 (T3) = Grass hay *ad libitum* + 200 g Wheat bran + 260 g Cowpea
Treatment 4 (T4) = Grass hay *ad libitum* + 200 g Wheat bran + 225 g Lablab

The treatments consisted of *ad libitum* feeding of grass hay plus 200 g DM wheat bran (control), and the rest of the treatments, T2, T3 and T4 were additionally supplemented with 243 g pigeon pea, 260 g cowpea and 225 g DM lablab per head per day, respectively. The amounts of forage supplements were fixed to supply 43.1 g CP per day required for sheep weighing between 20-25 kg (ARC, 1980). The amount of wheat bran supplemented was based on the recommendation of Mullu *et al*. (2008). The four treatment diets were randomly assigned to each animal in a block giving four lambs per treatment.

Feed chemical analysis

Samples of treatment feeds (basal feed and supplements) were taken for each feed type for chemical analysis before the start of the feeding trial. After the feeding trial was commenced, samples of refusals were collected daily for each animal and pooled for each treatment.The collected samples of the basal feed and supplements and the refusals were thoroughly mixed and enough sub-samples were taken and ground to pass through 1 mm sieve screen. Then, the ground sub samples of feeds and refused were dried in an oven for 48 h at 105^0C to determine the DM, Ash and N contents were determined according to the standard procedure of AOAC (1990). The ash content was determined by burning/igniting feed samples in a muffle furnace at 550^0C for 6 h, and N content of feeds was determined according to Kejldhal procedure and the crude protein (CP) was calculated as N*6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest and Robertson (1985). Hemicellulose (HC) and cellulose (C) contents were calculated as NDF minus ADF and ADF minus ADL, respectively.

Feed intake, body weight gain and feed conversion efficiency (FCE)

The daily amount of feeds offered and the refusal were weighed for each animal and recorded to determine the amount of feed consumed as a difference between the feed offered and refused.

Body weight of the animals was taken at the beginning of the trial and every 10 days during the 90 days of feeding trial period. All animals were weighed in the morning hours after overnight fasting using suspended weighing scale with a sensitivity of 100 g. Daily body weight gain (ABDG) was calculated as the difference between final body weight and initial body weight divided by the number of feeding days. Feed conversion efficiency (FCE) was calculated by dividing average daily gain (ADG) by daily total DM intake.

Carcass analysis

At the end of the feeding trial, all experimental animals were fasted overnight, weighed and slaughtered. On slaughtering, the animals were killed by severing the jugular vein and the carotid artery with a knife. The blood was drained into bucket and its weight was recorded. The skin was carefully flayed to prevent fat and tissue attachments. The skin was weighed with ears after the removal of legs below the fetlock joints. The gastro-intestinal tract with the exception of the oesophagus were removed with its contents and weighed. The gastro-intestinal track was reweighed after emptying its contents. Gastro-intestinal tract and kidney fats were removed and individually weighed. Internal organs, namely, empty gut, heart and kidney were removed and weighed. The hot carcass weight was estimated after subtracting weights of the head, thorax, abdominal and pelvic cavity contents as well as legs below the hock and knee joints (Gilmour *et al.*, 1994).

After evisceration, the carcass were weighed and cut perpendicular to the back bone between the 12^{th} and 13^{th} ribs to measure the cross-sectional area of the rib-eye muscle area. The rib- eye area was traced first on to a transparent paper then by counting the number of squares lying on the traced picture in the square paper and multiplied by the area of the single square paper. The empty body weight was calculated as gut content deducted from slaughter weight. The percentage of total edible offal components (TEOC) was taken as the sum of heart, empty gut, kidney, testis, head and tongue, testicle, tail and fat (omental, kidney knob and channel fat). Percentages of total non- edible offal component (TNEOC) were taken as the sum of blood, skin and feet, penis, and gut content. The dressing percentage was calculated as a proportion of hot carcass weight and empty body weight and/or slaughter body weight (Gilmour *et al.*, 1994).

Partial budget analysis

Partial budget analysis was performed to evaluate the economic advantage of the different treatments by using the procedure of Upton (1979). The partial budget analysis involved the calculation of variable costs and benefits. The selling price of rams in each treatment before and after the experiment was considered as total return (*TR*) in the analysis. For the calculation of the variable costs, the expenditures incurred on various feedstuffs were taken into consideration. The cost of the feeds was computed by multiplying the actual feed intake for the whole feeding period with the prevailing market price. At the time of feed purchasing, the prevailing price of the feeds including the transportation cost incurred to move them to the experimental site were recorded. Partial budget method measures profit or loss, which is the difference between gains and expenses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR): **NR = TR-TVC**

Total variable costs included the costs of all inputs that changed due to the change in production technology. The change in net return (ΔNR) was calculated by the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC), which is to be used as a reference criterion for decision on the adoption of a new technology. **ΔNR = ΔTR-ΔTVC**

The marginal rate of return (MRR) measures the increase in net income (ΔNR) associated with each additional unit of expenditure (ΔTVC). This is expressed in percentage as:

MRR% = (ΔNR/ΔTVC) X 100

Data analysis

All data related to feed intake, body weight change, feed conversion efficiency and carcass parameters were analyzed using the General Linear Model Procedure of SAS (SAS, 2001). Significance differences were declared at P≤0.05. Treatment means were separated using least significance difference test. The model used for the analysis of feed intake, body weight change, feed conversion efficiency and carcass parameters was:

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

Where;

Y_{ij}= Response variable

μ = Overall mean

T_i = the fixed effect of feed

B_j = block effect

e_{ij}= effect of random error

Results

Chemical composition of experimental feeds

The chemical composition of the experimental diets used in the experiment is indicated in Table 1. The DM content of the basal diet, native grass hay, was 90%. Based on the results, the DM, Ash, CP, NDF, ADF and ADL contents of wheat bran offered were 89%, 5.56%, 17.77%, 22.22%, 13.33%, and 6.03%, respectively.

Table 1. Chemical composition of experimental feeds on DM basis

Feeds	Chemical composition					
	DM%	**Ash**	CP	NDF	**ADF**	**ADL**
				%DM		
Hay	90	12.22	7.78	66.66	55.55	22.22
WB	89	5.56	17.77	22.22	13.33	6.03
Pigeon pea	89	8.87	17.5	46.66	33.33	14.55
Cow pea	89	13.33	16.69	23	20	15.55
Lablab	89	11.11	19.23	40	24.44	6.66

ADF=Acid detergent fiber; ADL=Acid detergent lignin; CP=Crude protein; DM=Dry matter; NDF=Neutral detergent fiber and WB=Wheat bran

When the chemical composition of the basal natural grass hay was compared with that of the pigeon pea, cow pea and lablab, the grass hay basal diet had higher proportions of NDF, ADF and ADL while it had lower proportions of CP than pigeon pea, cow pea and lablab.

When the chemical compositions of feed refusals were considered, the NDF, ADF and ADL contents of the refusals of the grass hay and forage legumes (Table 2) were higher than the corresponding contents of feeds offered, whereas the ash and CP contents of the refusals were lower than the corresponding contents of feeds offered. The high ADL content in refusals of lablab is difficult to explain, although the refusals mainly constituted the stem part of lablab, which indicates that the lignin in lablab must have been mainly contained in the stem than the leaves and twigs.

Table 2. Chemical composition of feed refused on DM basis

Feeds	**Chemical composition**					
	DM%	**Ash**	**CP**	**NDF**	**ADF**	**ADL**
		%DM				
Hay	89	7.78	3.01	77.77	60.00	24.44
Pigeon pea	90	5.56	7.68	69.22	73.33	22.22
Cow pea	89	7.78	11.05	73.67	68.88	37.77
Lablab	89	7.72	9.33	80	60	44.44

ADF=Acid detergent fiber; ADL=Acid detergent lignin; CP=Crude protein; and DM= Dry matter

Refusals mainly constituted stem parts of the feed as the result of the stem of the lablab must have been containing higher lignin content than the rest of the feeds.

Feed and nutrient intake

The daily DM and nutrient intakes of Wollo *Tumele* lambs fed natural pasture grass hay and legume supplements are presented in Table 3. There were differences (P<0.001) in total DM, CP and NDF intakes between T1 and the selected forage legume supplemented diets (T2, T3 and T4). The ADF intake of the lambs in T1 and forage legumes supplemented groups was in the order of T1<T4<T3<T2. There were differences (P<0.001) in total ADL intakes between the lambs in T1and lablab supplemented (T4). But there were no differences (P>0.001) in total ADL intakes between cow pea supplemented group (T3) and pigeon pea supplemented group (T2).

Table 3. Daily feed intake and nutrients of Wollo *Tumele* sheep fed grass hay and supplements

DMI, g	**T1**	**T2**	**T3**	**T4**	**SL**	**SEM**
Grass hay	352.33^{a}	264.85^{b}	263.65^{b}	263.96^{b}	***	7.77
Pigeon pea		215.93^{c}				
Cow pea			219.98^{a}			
Lablab				217.74^{b}		
Wheat bran	200^{a}	200^{a}	200^{a}	200^{a}	ns	0
Total	552.33^{b}	680.78^{a}	683.63^{a}	681.70^{a}	***	8.18
Nutrients intake, g						
CP from grass hay	30.62^{a}	22.76^{b}	23.11^{b}	23.14^{b}	***	0.13
CP from pigeon pea		43.24^{b}				
CP from cow pea			42.04^{c}			
CP from Lablab				47.58^{a}		
CP from wheat bran	34.88^{a}	34.88^{a}	34.88^{a}	34.88^{a}	ns	0
Total CP	65.50^{c}	100.88^{b}	100.03^{b}	105.61^{a}	***	1.33
NDF from grass hay	261.48^{a}	196.09^{b}	202.04^{b}	194.70^{b}	***	63.14
NDF from pigeon pea		112.06^{b}				
NDF from cow pea			112.74^{a}			

NDF from Lablab				112.94^{a}		
NDF from wheat bran	44.44^{a}	44.44^{a}	44.44^{a}	44.44^{a}	ns	0
Total NDF	305.92^{b}	352.59^{a}	346.74^{a}	352.08^{a}	***	30.01
ADF from grass hay	217.62^{a}	162.68^{b}	161.56^{b}	162.55^{b}	***	3.68
ADF from pigeon pea		76.57^{a}				
ADF from cow pea			43.37^{c}			
ADF from Lablab				57.85^{b}		
ADF from wheat bran	26.66^{a}	26.66^{a}	26.66^{a}	26.66^{a}	ns	0
Total ADF	244.278^{b}	265.91^{a}	231.59^{c}	247.06^{b}	***	5.52
ADL from grass hay	87.03^{a}	64.82^{b}	65.11^{b}	65.05^{b}	***	0.50
ADL from pigeon pea		36.42^{a}				
ADL from cow pea			35.49^{b}			
ADL from Lablab				14.21^{c}		
ADL from wheat bran	13.32^{a}	13.32^{a}	13.32^{a}	13.32^{a}	ns	0
Total ADL	100.35^{b}	114.55^{a}	113.93^{a}	92.58^{c}	***	0.50

a, b, c, d = means within a row not bearing a common superscript letter significantly differ, (***)=P<0.001;ns = not significant; DMI= dry matter intake; SEM= standard error of mean; CPI= crude protein intake; ADLI= acid detergent lignin intake; NDFI=neutral detergent fiber intake; ADFI=Acid detergent fiber intake; SL= significant level; T1 = hay+200 g wheat bran; T2 = hay +200 g wheat bran +243 g pigeon pea; T3= hay +200 g wheat bran +260 g cow pea; T4 = hay +200 g wheat bran + 225 g lablab.

The crude protein intake (CPI) of lambsin T1 was lower (P<0.001) than CPI of lambs in T2, T3 and T4. Similarly, neutral detergent fiber intake (NDFI) of lambsin T1 was also lower (P<0.001) than the NDFI of lambs supplemented with the selected forage legumes. The daily acid detergent fiber intake (ADFI) of lambsin T1 was lower (P<0.001) than ADFI of lambs in T2, T3 and T4. The daily acid detergent lignin intake (ADLI) also of lambs in T1 was lower (P<0.001) than ADLI of lambs in T2 and T3, but, higher (P<0.001) than lambs in T4. On the other hand, the variations in DMI and NDFI among T2, T3 and T4 were insignificant (P>0.001). However, there were (P<0.001) variations in CPI and ADFI among lambs fed the forage legumes (T2, T3 and T4). The variations in ADLI between T2 and T3 were insignificant (P>0.001). But variations in ADLI among T2, T3 and T4 were (P<0.001). Compared to lambs fed the legume supplemented diets, lambs fed natural grass hay supplemented with wheat bran (T1) had lower (P<0.001) daily DM, CP and NDF intakes.

Lambs supplemented with the forage legumes (pigeon pea, cow pea and lablab) revealed the highest (P<0.001) daily DMI and CPI than lambs fed natural grass hay supplemented with wheat bran. The higher (P<0.001) intakes of DM and CP of lambs fed the legume supplemented diets was indicative of the better nutritive values of the legume supplemented dietsthan the basal diet supplemented with wheat bran alone (T1).

Body weight change and feed conversion efficiency

The mean initial and final body weight, average daily body weight gain (ADG) and feed conversion efficiency (FCE) are presented in Table 4. The final body weight of the lambs in the control group (T1) was lower (P<0.001) than final body weights of lambs fed cow pea, pigeon pea and lablab. Among the supplemented legumes, Lablab resulted in higher (P<0.001) final body weights than T2 and T3. Following the variations in the final weights of lambs fed the experimental diets, there were also variations (P<0.001) in average daily weight gains (ADG) of lambs in the different diets. Accordingly, lambs fed the basal diet supplemented with wheat bran (T1), had lower (P<0.001) ADG than lambs fed diets supplemented with cow pea, pigeon pea and lablab (T3, T2 and T4). Lambs supplemented with pigeon pea and lablab had the highest (P<0.001) ADG and FCE (T4>T2>T3).The ADG of lambs increased with the increase in crude protein contained in the experimental forage legumes.

Table 4. The effect of experimental diets on body weight change

Parameter	T1	T2	T3	T4	S.L	SEM
IBW(kg)	18.95	19.19	19.01	18.71	ns	0.02
FBW(kg)	19.23^{d}	22.34^{b}	20.84^{c}	23.16^{a}	***	0.04
BWC(kg)	0.28^{d}	3.15^{b}	1.83^{c}	4.44^{a}	***	0.02
ADG(g/d)	3.1^{d}	34.97^{b}	20.33^{c}	49.36^{a}	***	3.17
FCE	0.006^{d}	0.053^{b}	0.031^{c}	0.075^{a}	***	7.30

a, b, c, d Means with different superscripts in the same row differ significantly; (***) = P<0.001; ADG=average daily gain; BWC=body weight change; FBW=final body weight; FCE = feed conversion efficiency; IBW=initial body weight; S.L =significance level; T1 = hay+200 g wheat bran; T2 = hay +200 g wheat bran +243g pigeon pea; T3= hay +200g wheat bran +260 g cow pea; T4 = hay +200 g wheat bran + 225 g lablab.

Generally, lambs fed the natural pasture grass hay supplemented with wheat bran (T1) had lower final body weights than lambs fed the legume supplemented diets (T2, T3 and T4). Likewise, lambs in T1 had the lowest (P<0.001) ADG than lambs fed the legume supplemented diets. The higher final body weight and ADG of lambs supplemented with lablab was attributed to the higher CP content of the lablab. The differences in the FBW and ADG among treatments was possibly attributed to the higher CP and low ADL contents, and possibly due to better protein quality in lablab that promoted increased DMI and improved feed utilization efficiency of lambs.

Carcass characteristics

The average slaughter weight (SW) and empty body weight (EBW) were (P<0.001) higher for lambs supplemented with 225 g lablab as compared to lambs supplemented with 260 g cowpea, 243 g pigeon pea and the control treatment (Table 5).

Table 5. Carcass characteristics of Wollo *Tumele* lambs fed grass hay and supplements

Parameter	T1	T2	T3	T4	S.L	SEM
Slaughter weight (kg)	18.00^{d}	21.15^{b}	19.02^{c}	22.82^{a}	***	0.06
Empty body weight (kg)	12.00^{d}	16.07^{b}	13.89^{c}	16.65^{a}	***	0.04
Hot carcass weight (kg)	5.08^{d}	8.74^{b}	7.53^{c}	9.60^{a}	***	0.02
Dressing percentage on						
Slaughter weight basis	28.22^{d}	41.34^{b}	39.59^{c}	42.07^{a}	***	0.87
Empty body weight basis	42.08^{c}	54.39^{b}	54.22^{b}	57.66^{a}	***	1.87
Rib-eye area (cm^2)	3.54^{d}	7.03^{b}	6.63^{c}	8.29^{a}	***	0.03

a, b,c.d= means within a row not bearing a common superscript letter differ significantly; (***) = P<0.001; SEM = standard error of mean; SL= significant level; T1 = hay+200 g wheat bran; T2 = hay +200 g wheat bran +243 g pigeon pea; T3= hay +200 g wheat bran +260 g cow pea; T4 = hay +200 g wheat bran + 225 g lablab.

The DP on slaughter body weight basis in the current study washigher (P<0.001) for the lambs supplemented with pigeon pea and lablab, whereas the DP on the basis of empty body weight was higher (P<0.001) for the lambs supplemented with lablab.

Edible offal components

Edible offal components of Wollo *Tumele* lambs supplemented forage legumes are given in Table 6. Heart, kidney, empty gut, total fat, head and tongue, testis and tail are considered as edible offal. Where as gut content, blood, penis, skin and feet are considered as non-edible offal based on the eating habit of people in the study area. The weight of heart was higher (P<0.001) for the supplemented treatments compared to the control treatment. Kidney was higher (P<0.001) for T4.

Table 6. Edible offal components of Wollo *Tumele* lambs fed grass hay and supplements

Parameter	T1	T2	T3	T4	S.L	SEM
Heart (g)	49.12[d]	65.95[b]	64.24[c]	71.50[a]	***	0.49
Kidney (g)	38.62[d]	54.37[b]	48.02[c]	56.25[a]	***	0.79
Empty gut (g)	1115[d]	1342.50[b]	1215[c]	1415[a]	***	264.58
Total fat (g)	36.18[d]	121.50[b]	82.87[c]	154.75[a]	***	2.35
Head and Tongue (g)	1385[a]	1392.50[a]	1405[a]	1402.50[a]	**ns**	245.83
Testis (g)	185.99[a]	186.25[a]	188.75[a]	187.25[a]	**ns**	1.07
Tail (g)	71.83[d]	722.50[b]	496.57[c]	839.50[a]	***	7.60
TEOC (g)	2794.97[d]	2960.58[b]	3510.46[c]	3271.75[a]	***	506.87

a, b, c, dmeans the same row with different superscripts differ significantly; (***) = P<0.001; ns = not significant; TEOC= total edible offal component; SL= significant level; SEM= Standard error of mean; T1 = hay+200g wheat bran; T2 = hay +200g wheat bran +243 g pigeon pea; T3= hay +200 g wheat bran +260 g cow pea; T4 = hay +200 g wheat bran + 225 g lablab.

Non-edible offal components

Non-edible offal component of Wollo *Tumele* lambs fed on forage legumes are given in Table 7. Penis, skin and feet and TNEOC did not differ (p>0.001) due to forage legumes supplementation. The total non-edible offal (TNEO) was numerically higher for T2 and T4 as compared to T1 and T3.

Table 7. Non-edible offal components of Wollo *Tumele* lambs fed grass hay and supplements

Parameter	T1	T2	T3	T4	S.L	SEM
Gut content(g)	5895[a]	4872[a]	4967[a]	4865[a]	**ns**	233.33
Blood (g)	369.90[c]	761.50[b]	460.92[d]	798.25[a]	***	1.53
Penis (g)	50.06[a]	50.40[a]	50.96[a]	51.00[a]	**ns**	0.15
Skin and feet (g)	1445[a]	1440[a]	1450[a]	1540[a]	**ns**	325
TNEOC (g)	6959.96	7123	6927	7254	**ns**	609.59

a, b, c, d means the same row with different superscripts differ significantly; (***) = P<0.001; ns = not significant; TNEOC= total non-edible offal component; SL= significant level; SEM= Standard error of mean; T1 = hay+200g wheat bran; T2 = hay +200 g wheat bran +243 g pigeon pea; T3= hay +200 g wheat bran +260 g cow pea; T4 = hay +200 g wheat bran +225 g lablab

Partial budget analysis

The cost of feeds used in the experiment was indicated in Table 8, and the result of partial budget analysis was shown in Table 9.

Table 8. Feed cost used in the conduct of the experiment

Feed type	Cost
Natural pasture hay	50 ETB/qt
Wheat bran	380 ETB/qt
Pigeon pea hay	63 ETB/qt
Cow pea hay	65 ETB/qt
Lablab hay	65 ETB/qt

ETB = Ethiopian Birr, QT= quintal

The result of partial budget analysis revealed that the high level of CP% (lablab, 19.23) resulted in higher profit margin than low (cow pea, 16.69), medium (pigeon pea, 17.50) and the control. Lambs fed natural pasture grass hay with wheat bran had the lowest net return and lablab group recorded the highest net return.

Table 9. Partial budget analysis of Wollo *Tumele* sheep fed grass hay and supplements

Parameter	T1	T2	T3	T4
Number of animals	4	4	4	4
Purchase price of sheep (ETB)	650	650	650	650
Total basal diet intake (kg)	126.84	95.35	94.91	95.02
Total pigeon pea intake(kg)	-	77.73	-	-
Total cow pea intake(kg)	-	-	79.19	-
Total lablab intake(kg)	-	-	-	78.39
Total concentrate intake (kg)	72	72	72	72
Cost of basal diet (ETB/head)	15.85	11.92	11.86	11.88
Cost of pigeon pea (ETB/head)	-	12.24	-	-
Cost of cow pea (ETB/head)	-	-	12.87	-
Cost of lablab (ETB/head)	-	-	-	12.74
Cost of concentrate (ETB/head)	68.4	68.4	68.4	68.4
Additional labor cost (ETB/head)	-	55	50	53
Total variable cost	84.25	147.56	143.13	146.02
Selling price of sheep (ETB/head)	675.00	950.00	900.00	1000.00
Total return	25.00	300.00	250.00	350.00
Net return(ETB/head)	-59.25	152.44	106.87	203.98
Change in net return		148.38	107.24	201.46
Change in total variable cost		63.31	58.88	61.77
Marginal rate of return		2.34	1.82	3.26

The results suggested that supplementation of lambs fed hay basal diet with a forage legume; lablab was more profitable than supplemented with pigeon pea and cow pea. The difference in the net return among treatments could be possibly attributed to increased ADG due to the high CP and low ADL contents and possibly better protein quality in lablab that improved feed utilization efficiency of lambs.

Discussion

Chemical composition of experimental feeds

The DM content of the basal diet was comparable to the DM contents of 89% reported by Nigussie (2008) for Napier grass hay and 91.06% reported by Aschalew and Getachew (2013) for natural grass hay. On the other hand, the DM content of the basal diet was lower than 92.3% DM contained in dried grass hay (Biru, 2008). The observed CP content of the natural pasture grass hay was lower than 11.5% CP reported by Tessema (2000). However, the CP content of basal diet in the present study was higher than 6.70% reported by Aschalew and Getachew (2013). Meanwhile, the CP content of the basal diet was comparable to 7.7% and 7.9% CP reported by Taye (2004) and Nigussie (2008), respectively.

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 NDF content of natural pasture grass hay observed in this study, was lower than 73.96% Aschalew and Getachew (2013) but higher than 62.50% (Biru, 2008). The ADF and ADL contents of native grass hay in the present study were also higher than 48.70% ADF and 8.51 % ADL and 43.6 ADF and 18.0% ADL contents reported by Aschalew and Getachew (2013) and Biru (2008) for natural pasture grass hay, respectively.

Based on the results, the DM, Ash, CP, NDF, ADF and ADL contents of wheat ban offered were 89%, 17.77%, 5.56%, 22.22%, 13.33%, and 6.03%, respectively. The DM, CP, ash and ADF were almost similar to the contents of 90.5%, 16.9%, 5.4% and 13.7% reported by Yenesew *et al.* (2013). While the DM, CP and ADF were lower than 93.5% DM, 23.08% CP and 43.83% ADL contents reported by Awet (2007), but higher in 87.38% DM, 3.96% ash, 8.27% ADF and 2.15% ADL contents reported by Fentie (2007). The variation might be due to the effect of processing in milling industries, the variety and the quality of the original grain used in the milling industries.

The DM, CP, ash, NDF, ADF and ADL contents of pigeon pea in this experiment were 89%, 17.5%, 8.87%, 46.66%, 33.33% and 14.55%, respectively. Which were lower than 94.5% DM, 9.45% ash, but higher than 33.8% NDF and 29.4% ADF (Belete *et al*., 2012). The DM, CP, ash, NDF, ADF and ADL contents of cow pea in this experiment was 89%, 16.69%,13.33%, 20%, 20% and15.55%, respectively. According to Ajebu *et al*. (2013), higher (53.7 %) NDF, comparable (33.9%) ADF and lower ash (7.56%) contents obtained in cowpea. Solomon and Kibrom (2014) reported higher 13.6% ADL cow pea accession 12668, 12.1%ADL cow pea white wonder, 14.1% ADL cow pea accession 9333, 13.9% ADL cow pea small seed and 11.6% ADL cow pea black eyed varieties. The chemical composition of lablab in this study was 89% DM, 11.11% ash, 19.23% CP, 40% NDF 24.44% ADF and 6.66% ADL which was lower than 17.4% CP and 7.9% ash, but higher than 47.9% NDF, 38.6% ADF and 7.1% ADL Taye (2004). The reasons for the difference in the chemical composition of experimental forages used in the previous studies might be due to season, soil fertility and post harvesting management.

A review made by Andrea and Pablo (1999) on the nutritive 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.

Feed and nutrient intake

The daily DM intake (DMI) of lambs fed the basal diet (T1) was lower ($P<0.001$) than daily DM intakes of lambs fed pigeon pea, cow pea and lablab diets (T2, T3 and T4). Lambs in the control consumed more DM of grass hay as compared to the legume supplemented treatments, because lambs were seeking to meet their nutrient requirement through the intake of relatively more grass hay than the other treatments, which had an alternative source of feed, concentrate supplements. The daily DM intake of sheep fed grass hay (T1) was lower than 540.5, 447.4 and 610.12 g reported by Fentie (2007), Bimrew (2008) and Abebaw (2007), respectively. The increase in total DM intake in the present study was in agreement with the result reported by Biru (2008). The feeding value of roughages such as natural pasture grass is usually limited because they are low in nitrogen, are high in ligno-cellulosic compounds and, therefore, low in fermentable carbohydrates (Preston and Leng, 1987). The higher nutrient intakes particularly higher CP intakes helped the lambs acquire protein required for growth better than the lambs natural grass hay supplemented with wheat bran indicating the advantages of legume supplementation to improve intake of nutrients specially protein than basal diets. The increase in DMI and CPI as a result of supplementation of legumes to grasses was reported by (Abraha, 2013).

Body weight change and feed conversion efficiency

The final body weight of the lambs in the control group (T1) was lower ($P<0.001$) than final body weights of lambs fed cow pea, pigeon pea and lablab. Among the supplemented legumes, Lablab resulted in higher ($P<0.001$) final body weights than T2 and T3. 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, Adu *et al*. (1990) reported that lablab supplementation to sorghum stover improved CP digestibility and generally improved rumen fermentation of the test diets and improved live weight gains of sheep. The results of this study agreed with the finding of Negussie (2008) in lambs supplemented with napier grass with green leaf desmodium or lablab, Aschalew and Getachew (2013) in lambs supplemented with raw, malted and heat treated grass pea (*Lathyrus sativus*) grain, Getahun (2014) in Ethiopian lowland Afar and Blackhead Ogaden lambs supplemented with concentrates, Abebe *et al.* (2011) on body weight and carcass characteristics in Washera lambs fed urea treated rice straw supplemented with graded levels of concentrate mix, Melese *et al.* (2014) on feed intake and body weight change of Washera lambs fed urea treated finger millet straw, Yeshambel *et al.* (2012) in lambs fed mixtures of lowland bamboo (*Oxytenanthera abyssinica*) leaves and natural pasture grass hay, Abadi *et al*, (2014) in lambs supplemented with faba beans *(Vicia faba L.)* hulls and wheat bran on body weight change and carcass characteristics of Afar lambs fed hay as basal diet.

The ADG of lambs fed natural grass hay supplemented with wheat bran (T1) in the present study was higher than -5 g average daily weight gain of Tigray (Raya District) lambs fed sole natural grass hay (Abraha, 2013). Moreover, it was also higher than - 13.3 g/d ADG for lambs fed sole Rhodes grass hay (Feleke *et al.*, 2009), which was reported to be due to the low intake and low N content of the hay. The low CP and high NDF and ADF content of the hay offered in his study was not possibly enough to satisfy the maintenance requirement of animals and supplementation with protein sources could help in alleviating the possible body weight loss of the lambs.

Carcass characteristics

The hot carcass weight (5.08 kg) recorded for lambs on the control treatment were smaller than the hot carcass weight (9.60 kg) recorded for lambs supplemented with lablab (T4). The average slaughter weight (SW) and empty body weight (EBW) were higher (P<0.001) for lambs supplemented with 225 g lablab as compared to lambs supplemented with 243 g pigeon pea, 260 g cow pea and the control treatment . The dressing percentage (DP) were also higher (P<0.001) for lambs supplemented with 225 g lablab as compared to sheep supplemented with 243 g pigeon pea, 260 g cow pea and lambs in the control treatment. The DP of lambs in T1, T2 and T3 did not vary. Lambs in the control treatment had smaller rib-eye muscle area compared to those supplemented with forage legumes.

In agreement with the present study, Ermias (2008) reported that supplementation with barley bran; linseed meal and their mixtures of Arsi-bale lambs fed a basal diet of faba bean haulms had higher slaughter weight, hot carcass weight, and dressing percentage than the non-supplemented lambs. Moreover, Mulugeta and Gebrehiwot (2013) also reported that sesame cakesupplementation of lambs fed on wheat bran and teff (*eragrostis teff*) straw had increased slaughter weight, hot carcass weight, and dressing percentage than the non-supplemented lambs. Berhan and Asnakew (2015) reported that the carcass yield of goats as measured by the average values of slaughter weight (SW), empty body weight (EBW), hot carcass weight (HCW), dressing percentage (DP) and rib eye area (REA) was superior for concentrate-supplemented groups. Biru (2008) reported that rib-eye muscle area was improved in Adilo lambs supplemented with sweet potato tuber and haricot bean screenings. Hirut *et al.* (2011) also reported thatrib-eye muscle area was increased in Hararghe Highland lambs fed on concentrate supplementation. Assefu (2012) observed that rib-eye muscle area was increased in Washera and Horro lambs fed different roughage to concentrate ratio.

The control group had lower (P<0.001) DP on empty body weight basis than the supplemented treatments, but there was no difference (p>0.001) between the supplemented treatments. The Dressing percentage values on empty body weight basis was higher than on slaughter weight basis,implying the influence of digesta (gut fill) on dressing percentage.In agreement with this study, Hirut *et al*. (2011) reported that heavier empty body weight for the supplemented group than the control.

There was a difference (P<0.001) due to supplementation on empty gut, total fat, tail and TEOC. In line with the present study, Hirut *et al.* (2011) reported relatively lower TEOC which were 2.22 kg for the control and 4.19 kg for supplemented group. Abadi (2014) reported higher TEOC, 3605 g for T1 (control) and 6044 g for 45 g NSC + 200 g WB + 100 g FBH supplemented lambs. Amare (2007) reported comparable TEOC, 2.38 kg for the control and lower TEOC 3.17 kg for the supplemented. Ermias (2008) also reported higher TEOC in Arsi-bale lambs supplemented with barley bran, linseed meal and their mixtures than fed basal diet of faba bean haulms (4.2 kg vs. 2.5 kg)**.**

The amount of blood was higher ($p<0.001$) for T4>T2>T3>T1. There was no a difference ($p>0.001$) in gut content due to forage legumes supplementation. The lack of differences in gut content between control and supplemented lambs in the current study might be due to similarity in the degradability and escape of the forage legumes that neither of the feeds staying longer in GIT. In this study most of the non-edible offal components were not affected ($p>0.001$) by diet.

In line with the present study, Assefu (2012) reported that gut content of lambs fed different roughage to concentrate ratio was similar between all the treatment groups. Biru (2008) reported TNEO was not different ($p>0.001$) in lambs fed on sweet potato tuber and haricot bean screenings in Adilo lambs. Similar results were reported by Mulugeta and Gebrehiwot (2013), who studied on effect of sesame cake supplementation on feed intake, body weight gain, feed conversion efficiency and carcass parameters in the ration of lambs fed on wheat bran and teff (*eragrostis teff*) straw.

Partial budget analysis

The marginal rate of return indicated that each additional unit of 1 ETB per sheep cost increment resulted in 1 ETB and 2.34, 1.82 and 2.26 ETB benefit for T2, T3, and T4, respectively.

The net return from the supplemented experimental treatments was 152.44, 106.87 and 203.98 ETB per head for T2, T3 and T4, respectively. The difference in net return was in a similar trend with their weight gain, i.e., lambs in control group almost remain the same weight and resulted in the lowest net return, while lablab group resulted in higher ADG and recorded the highest net return. Generally, lambs that have a better nutrient intake had superior ADG, as a result of which they fetched higher sale price, and earn higher net return. The difference in the control and treatment was due to the difference in live weight change of the lambs in each treatment, which was a function of differences in feed quality and feed conversion efficiency. The higher net return in T4 was due to the quality of protein and the lower ADL (6.03%) contained in lablab supplementation, which resulted in higher body weight gain (49.4 g/d/lamb) as compared to the other treatments that had body weight gain of 3.1, 35 and 20.3 g/d/lamb for T1, T2 and T3, respectively. This indicated that lambs fed with better quality feed performed well and had higher body weight gain and sold at premium price and earn better net return.

Similar to this result, Mulugeta and Gebrehiwot (2013) studied on effect of sesame cake supplementation on feed intake, body weight gain, feed conversion efficiency and carcass parameters in the ration of sheep fed on wheat bran and teff (*eragrostis teff*) straw had shown good economic return in the supplemented group, Abebe (2006) also observed that supplementation with linseed (*Linumusitatis simum)* cake, wheat bran and their mixtures on feed intake, digestibility, live weight changes, and carcass characteristics in intact male Arsi-bale sheep were economically beneficial, Tesfa *et al.* (2013) studied on effect of supplementing grazing Arsi-bale sheep with molasses-urea feed block on weight gain and economic return under farmers' management condition, Aschalew and Getachew (2013) observed that better economic return sheep fed onraw, malted and heat treated grass pea (*Lathyrus sativus*) grain.

Conclusion

The CP content of natural pasture grass hay was indeed sufficient to meet the maintenance requirement, but was relatively low meet the growth demands of lambs, indicating the need for supplementation of grass hay based diets with forage legumes such as pigeon pea, cowpea and lablab for improved body weight gain. However, a superior daily body weight gain was recorded in lambs supplemented with lablab 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. Supplementation also resulted in higher heart, empty gut, total fat, tail and TEOC, but head with tongue, testis, gut content, penis, skin and feet and TNEOC did not differ due to forage legumes supplementation. It was concluded that supplementation of 225 g lablab with 200 g wheat bran per day and per head results in a higher body weight gain, total DM and/or nutrient intake and carcass yield characteristics of Wollo *Tumele* lambs fed grass hay. Alternatively, supplementation of 243 g pigeon pea or 260 g cowpea each with 200 g wheat bran per day and per head could be recommended for intact Wollo *Tumele* lambs fed grass hay for improved feed and/or nutrient intake and carcass yield characteristics. Further studies need be focused on determination of digestibility and rumen degradability characteristics the forage legumes pigeon pea *(Cajanus cajan)*, cowpea *(Vigna unguiculata)* and lablab *(Lablab purpureus)*.

References

Abadi, N., Mohammed, Y. and Getachew, A. 2014. Substitution effect of faba bean *(Vicia faba L.)* hulls to wheat bran on body weight change and carcass characteristics of Afar sheep fed hay as basal diet. *Agricultural Science, Engineering and Technology Research,* **2**: 1- 11.

Abebaw, N. 2007. Effects of rice bran and/or noug seed (*Guizotia abyssinica*) cake supplementation on feed utilization and live weight change of Farta sheep fed native grass hay. MSc. thesis presented to school of graduate studies of Haramaya University, Ethiopia, 94p.

Abebe, H., Solomon, M., Berhan, T. and Asaminew, T. 2011. Body weight and carcass characteristics of Washera sheep fed urea treated rice straw supplemented with graded levels of concentrate mix. *Livestock Research for Rural Development,* **23**: 12.

Abebe, T. 2006. Supplementation with linseed (*Linumusitatis simum)* cake, wheat bran and their mixtures on feed intake, digestibility, live weight changes, and carcass characteristics in intact male Arsi-Bale sheep. MSc. thesis presented to school of graduate studies of Haramaya University, Ethiopia, 64p.

Abraha, L. 2013. Effects of intercropping maize with cowpea and lablab on sheep growth performance in Raya district of Tigray region, Ethiopia. *Herald Journal of Agriculture and Food Science Research,* **2**: 98 – 108.

Adu, I.F., Fajemisin, B.A. and Adamu, A. M. 1990. The utilization of sorghum fed to sheep as influenced by urea or graded levels of lablab supplementation. National Animal Production Research Institute Ahmadu Bello University, Shika-Zaria, Nigeria. In: Proceedings of the First Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya 10-14 December 1990.

Ajebu, N., Asdesach, C. and Aster, A. 2013. Substitution of pigeon pea leaves for noug seed (*Guizotia abyssinica*) cake as a protein supplement to sheep fed low quality tropical grass hay.*Ethio. J. Appl. Sci. Techno.,* **4:**1-13.

Ajebu, N. 2010. Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial by-products. *Tropical Animal Health and Production*, **42**: 815–824.

Amare, D. 2007. Effects of supplementation of cactus (*Opuntiaficus-indica*)- tef straw based diets with oil seedcakes on feed utilization, body weight changes and carcass traits of Tigray highland sheep. MSc. thesis presented to school of Graduate Studies of Haramaya University, Ethiopia,90p.

Andrea, N.M. and Pablo, E.C. 1999. A tropical forage supplementation to poor quality ruminant diets: A Review of *Lablab purpureus. Livestock Research for Rural Development*, **11**:2-42.

AOAC 1990. Methods of analysis, 15th ed.; Association of Official Analytical Chemists, AOAC. INC., Arlington, Virgina, USA.

ARC (Agricultural Research Council). 1980. The Nutrient Requirements of Ruminant Livestock. Technical Review by Agricultural Research Council Working Group.Published on behalf of the Agricultural Research Council by the Common Wealth Agricultural Bureaux, Famham Royal, England. pp. 114-151.

Aschalew, A. and Getachew, A. 2013. Supplementation of raw, malted and heat treated grass pea (*Lathyrus sativus*) grain on body weight gain and carcass characteristics of Fartasheep. *International Journal of Soil and Crop Sciences*, **1**: 1-6.

Assefu, G. 2012. Comparative feedlot performance of Washera and Horrosheep fed different roughage to concentrate ratio. MSc. thesis presented to school of graduate studies of Haramaya University, Ethiopia, 68p.

Belete, S., Abubeker, H., Abule, E. and Nura, A. 2012. Performance of Arsi-Balekids supplemented with graded levels of pigeon pea in dry season in Mid Rift Valley of Ethiopia. *African Journal of Agricultural Research*, **8**(20):2366-2370.

Berhan, T. and Asnakew, A. 2015. Live weight gain and carcass yield characteristics of intact male Hararghehighland goats fed varying levels of hay to concentrate ratios. *Scholarly Journal of Agricultural Science*, **5**(5):178.

Betsha, S. 2005. Supplementation of graded levels of peanut cake and wheat bran mixtures on nutrient utilization and carcass parameters of Somali goats. MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 75p.

Bimrew, A. 2008. Supplementation of different levels of rice bran and noug seed (*Guizotia abissynica*) cake mixtures on nutrient utilization of Fartasheep fed natural pasture hay. Msc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia,79p.

Biru, K. 2008. Effects of supplementation with sweet potato tuber and haricot bean screenings on feed utilization, growth and carcass characteristics of Adilo sheep. MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 87p.

CSA (Central Statistics Agency of Ethiopia), Agricultural Sample Survey. 2010. Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Vol. II, pp. 94.

Desta, H. 2009. Technical Bulletin no. 28. Sheep Breeds of Ethiopia: a Guide for Identification and Utilization**:** http://www.esgpip.org. Accessed March, 2015.

Ermias, T. 2008. The effect of supplementation with barley bran, linseed meal and their mixtures on the performance of Arsi-Balesheep fed a basal diet of faba bean haulms. An MSc.thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 81p.

Feleke, G., Tegene, N. and Ajebu, N. 2009. Feed intake and utilization in sheep fed graded levels of dried moringa (*Moringa stenopetala*) leaf as a supplement to rhodes grass hay. *Trop Anim Health Prod*, **20,** 11:9.

Fentie, B. 2007. Effect of supplementation of hay with noug seed (*Guizotiaabyssinica)*cake, wheat bran and their mixtures on feed utilization, digestibility and live weight change in Fartasheep. MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 87p.

Getahun, K. 2014. Effect of concentrate supplementation on performances of Ethiopian lowland Afar and Blackhead Ogadenlambs. *Animal and Veterinary Sciences*, **2**:36-41.

Gilmour, A.R., Cullis, J.J., Fogarty, N.M. and Banks, R. 1994. Genetic parameter for ultrasonic fat depth and eye muscle measurement in live poll Dorset sheep. *Aust. J. of Agric. Res.*, **45:**1281-1291.

Habru District Agriculture and Rural Development Office (HARDO). 2010. Socio-economic survey report of Gubalafto, Ethiopia. 1-5p.

Hirut, Y., Solomon, M. and Mengistu, U. 2011. Effect of concentrate supplementation on live weight change and carcass characteristics of Hararghehighland sheep fed a basal diet of urea-treated maize stover.*Livestock Research for Rural Development,* **23**:12.

IAR (Institute of Agricultural Research). 1991. Strategic Planning for Livestock Research in the Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia.

Kassahun, A. and Solomon, A. 2008. Breeds of Sheep and Goats. In: Sheep and Goat Production Handbook for Ethiopia. 9p.

McDonald, P., Edward, RA, Green, J.F.D. and Morgan, G.A. 2002. Animal Nutrition 6th ed. Pearson Educational Limited. Edinburgh, Great Britain. 544p.

Melese, G., Berhan, T. and Mengistu, U. 2014. Effect of supplementation with non-conventional feeds on feed intake and body weight change of Washerasheep fed urea treated finger millet straw. *Greener Journal of Agricultural Sciences,* **4** (2):67-74.

Ministry of Agriculture (MoA). 1998. Agro-ecological Zones of Ethiopia. Addis Ababa, Ethiopia.

MoARD, 2007. Livestock Master Plan Study Phase I Report Volume T – Sociological Aspects

Mulu, M., Berhan, T. and Alemu, Y. 2008. TheEffect supplementation of grass hay with different levels of brewery dried grain on feed intake digestibility and body weight gain in intact Wogera lambs. *East Africa Journal of Sciences,* **2**: 105-110.

Mulugeta, F. and Gebrehiwot, T. 2013. Effect of sesame cake supplementation on feed intake, body weight gain, feed conversion efficiency and carcass parameters in the ration of sheep fed on wheat bran and teff (*eragrostisteff*) straw.*Momona Ethiopian Journal of Science,* **5**(1):89-106.

Negussie, M. 2008. Effects of supplementation of napier grass with green leaf desmodium or lablab on feed intake, digestibility and live weight change of Washera sheep. MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 85p.

Nsahalai, I.V and Ummuna, N.N. 1996. Sesbaniaand lablab supplementation of oat hay basal diet fed to sheep with or without maize grain. *Anim. Feed Sci. Technol.*,**61**: 275-289.

SARC (Sirinka Agricultural Research Centre), 2008. Socio-economic survey report of North Wollo. Sirinka, Ethiopia, 1-5p.

SAS (Statistical Analysis System), 2001. SAS/STAT Guide to Personal Computers, Version 7. Statistical Analysis System Institute. Inc., NC. North Carolina, USA.

Solomon, G. and Kibrom, G. 2014. Forage production potential and nutritive value of cowpea (*Vignaunguiculata*) genotypes in the northern lowlands of Ethiopia. *Journal of Agricultural Research and Development*, **5**(4): 66-71.

Tamminga, S. 1979. Protein degradation in the fore stomachs of ruminants. *J.Anim.Sci*.,**49**:1615.

Taye, B. 2004. Effects of days of harvesting on yield, chemical composition, and *in vitro* organic matter digestibility of *Pennisetum purpureum* sole or intercropped with *Desmodium intortum* or *Lablab purpureus*.MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 79p.

Tesfa, G., Tegene, N., Girma, A. and Goetsch, A.L. 2013. Effect of supplementing grazing Arsi-Bale sheep with molasses-urea feed block on weight gain and economic return under farmers' management condition. *Journal of Cell and Animal Biology*, 7(10):125-131.

Tessema, Z. 2000. Productivity, chemical composition and digestibility of elephant grass (*Pennisetum purpureum*) as influenced by height of harvest and different sources of fertilizer application.MSc. thesis presented to the school of graduate studies of Alemaya University of Agriculture, Alemaya, Ethiopia, 67p.

Topps, J.H. 1995. Forage legumes as protein supplements to poor quality diets in the semiarid tropics. In: Wallace R.J. and Lahlou-Kassi A. 1995. Rumen Ecology Research Planning. Proceedings of a Workshop Held at ILRI, Addis Ababa, Ethiopia, 13–18 March 1995.

Upton, M. 1979. Farm Management in Africa: The Principle of Production and Planning. Oxford University Press, Great Britain. pp. 282-298.

Van Soest, P.J. 1994. Nutritional Ecology of Ruminants. 2ndEd. Cornell University Press, London. 476p.

Van Soest, P.J. and Robertson, J.B. 1985. Analysis of Forages and Fibrous Feeds. Laboratory Manual for Animal Science, Vol. 613. Cornell University, New York.

Xianjun, Yuan, Chengqun, Yu, Shimojo, M. and Tao, Shao. 2012. Improvement of fermentation and nutritive quality of straw-grass silage by incubation of wet hulless-barley distillers grain in Tibet. *Asian-Aust. J. Anim. Sci.*, **25**(4):479-485.

Yenesew, A., Solomon, M. and Azage, T. 2013. Effect of supplementation of grazing sheep with groundnut cake and wheat bran. *Wudpecker Journal of Agricultural Research*, **2**(8: 212 – 217.

Yeshambel, M., Mengistu, U. and Getachew, A. 2012. Intake, digestibility, live weight changes and rumen parameters of Washera sheep fed mixtures of lowland bamboo (*Oxytenanthera abyssinica*) leaves and natural pasture grass hay at different ratios. *Pakistan Journal of Nutrition*, **11** (4): 322-331.

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