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ANIMAL SCIENCE

Effect of Feeding *Leucaena leucocephala* Leaves and Pods on Feed Intake, Digestibility, Body Weight Change and Carcass Characteristic of Central-Highland Sheep Fed Basal Diet Wheat Bran and Natural Pasture Hay in Tigray, Ethiopia

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ABSTRACT

Feed intake, digestibility, body weight change, carcass characteristics and profitability of supplementing 20 yearling central-highland sheep (17±1.5 kg) fed basal diet of natural pasture hay (NPH) and wheat bran with dried *Leucana leucocephala* leaves (LLL) and pods (LLP) and their mixture were evaluated after 84 d of feeding trial followed by 7 d of fecal collection and carcass analyses. Treatment diets(partial DM basis) were: T_1 (control) = 90g wheat bran +3 g salt; T_2=90g wheat bran +3 g salt +207 g LLL; T_3= 90g wheat bran +3 g salt +207 g LLP; T_4= 90g wheat bran +3 g salt+103.5 g LLL +103.5 g LLP with NPH offered *ad libitum* for all treatments. Lambs were assigned to each treatment in RCBD. The crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of LLL were 21.8, 20.2 and 9.9 %/DM, respectively and that of LLP 18.9, 42.1 and 25.7 %/DM, respectively. The total DM intake was highest for T_2, T_3 and T_4 as compared to the control group. However, the total CP and digestible CP intakes were highest ($P<0.05$) for T_2 but lowest in T_1, T_3 and T_4. There was no significant difference ($P>0.05$) in total NDF and ADF intakes among the treatments. Coefficient of DM digestibility ($P<0.05$) of T_2, T_3 and T_4 was higher than that of T_1. Dressing percentage (DP) calculated onthe basis of slaughter body weight (SBW) was higher ($P<0.05$) for T_2 and T_4 than T_1. Rib eye muscle area (REMA) and hot carcass weight were higher ($P<0.05$) for T_2 followed by T_4 and T_3 but T_1 was least. Thus, T_2 (LLL supplementation) gave better nutrient digestibility, feed conversion efficiency and carcass characteristics and is recommended. However, all leucaena meal supplemented animals performed better than the control, thus can be used as supplements.

Highlights

- Inclusion of *Leucaena leucocephala* leaf and pod and their mixture in the diets of sheep
- Improved total DM, CP and digestible CP intakes; but not total NDF and ADF intakes
- Improved coefficient of DM digestibility,
- Improved dressing percentage, rib eye muscle area and hot carcass weight

Keywords: Feed intake, digestibility, weight change, carcass, *Leucana leucocephala*, sheep

The rise in human population increases the demand for livestock products, including mutton which is an opportunity for Ethiopia to improve and enhance the existing sheep production system (Getachew and Jane 2014). In Ethiopia, there are about 29.33 million sheep (CSA 2014/2015). The availability of diverse sheep breeds with variable and good attributes of meat quality, skin quality and prolificacy (Solomon *et al.* 2010) enhance prospects for intensified sheep fattening.

Forage legumes are rich in protein and some minerals and vitamins that can enhance the utilization of poor-quality roughages in small holder mixed farming systems; have the added advantage of improving soil fertility by fixing nitrogen, and thereby enhancing crop yield and maintaining soil fertility (Alemu *et al*. 2008).

Protein supplements like cottonseed, groundnut and sunflower cakes are expensive; and thus other possible protein supplements such as *leucaena* and *sesbania*, which are more readily available, renewable and affordable to the small-scale farmer must be evaluated. These fodder trees are mostly utilized as supplementary feeds for grasses and farm by-products (Mary 2006).

Ruminant production systems based on natural pastures often produce poor animal performance because of imbalance in energy and protein affecting rumen function. The incorporation of protein-rich leguminous forages such as *L. Leucocephala* in the diet of ruminants, can stimulate rumen function (Barros-Rodriguez *et al*. 2012).

In view of the above facts, the research was conducted with the objectives to assess the effect of supplementing *L.leucocephala* leaves and pods and their mixture on feed intake, digestibility, body weight changeand carcass characteristic of growing of central-highland intact male sheep found in Tigray.

MATERIALS AND METHODS

The experiment was conducted at Wukro Agricultural Poly-technique College which is located 45 km north of the capital of Tigray Regional State, Mekelle. It has an altitude of 2075 m.a.s.l., and is located between 13°0.47′ N latitude and 39°0.35′ E longitude. The mean annual rainfall is 400 mm and is unimodal (June to September). The mean annual temperature ranges between 17°C and 23°C (BoARD 2011).

Twenty yearling central-highland yearling male lambs (16.88±1.50 kg) were purchased from the local market. Age of lambs was determined by dentition. After 15 days of adaptation to the new environment, all the animals were vaccinated against pasteurellosis and anthrax, and were sprayed with acaricides, injected with ivermectin and drenched with albendazol against internal and external parasites, injected with oxytetracycline as preventive measure against bacterial infection.

Treatment diets were given gradually over the 15 days of adaptation period and then were full fed for 84 days. During the feeding and digestibility trials, each of the four treatment diets was randomly assigned to the experimental animals in five replications in RCBD. The experimental diets fed to lambs are shown in Table 1.

Natural pasture hay (NPH)and wheat bran were purchased from surrounding farmers and local market. The experimental feeds, *L. leucocephala* leaf (LLL) and pods (LLP) were collected from trees of the village farmers found around Wukro town between October 15 -18, 2015. LLL and LLP were dried under shed for 7 days. The seeds were ground by feed milling machine while the seed covers (pods) were ground manually then mixed and packed in sack.

Supplementary diets were offered to the animals in two equal portions at 08:00 and 16:00 h. The NPH was chopped manually to a length of approximately 3 - 6 cm before providing to the animals. The NPH was fed to the experimental animals *ad libitum* at no less than 10% refusal rate.

Table 1: The combinations of the treatment diets fed to the lambs

Treatment diets	Feeds					
	Natural pasture hay	Supplementary diets	Supplements (g partial DM)			
			Wheat bran	LLL	LLP	Salt
T_1	*Ad libitum*	S1	90	—	—	3
T_2	*Ad libitum*	S2	90	207	—	3
T_3	*Ad libitum*	S3	90	—	207	3
T_4	*Ad libitum*	S4	90	103.5	103.5	3

LLP: L. leucocephala leaves; LLP: Leucaena leucocephala pods

The daily feed offer and refusal of each animal were measured and feed intake calculated as a difference. Samples of feed offered were collected from each treatment diets separately. Samples of the refusals were collected daily from individual sheep over the experimental period and sub-sampled for chemical analysis.

After overnight feed withdrawal, body weight of each animal was taken at 15 days interval in the morning before feed offer. Daily weight gain (DWG) was calculated as the difference between final and initial live weights divided by the number of feeding days. The feed conversion efficiency was calculated by dividing the DWG with daily DM intake.

At the end of feeding trial, the animals were fitted with plastic fecal collection bags. After allowing for three days of adaptation, feces were collected for seven days. Daily feed intake and feces voided were recorded. Samples of feed refusal and 10% of feces were sub-sampled every day in the morning before the daily feed offered.

Daily feces were kept in separate plastic bags and stored in deep freezer at -20°C. The apparent percent digestibility of DM, OM, CP, NDF, ADF and ADL was determined as nutrient intake not recovered in the feces using the formula:

Apparent digestibility (%) = [(Nutrient intake – fecal nutrient output)/nutrient intake] × 100

The chemical analysis of the feed samples was conducted at Hawassa University in Animal Nutrition Laboratory. Fecal samples were thawed at room temperature, thoroughly mixed and dried in oven at 60°C for 72 h. Feed (offer and refusal) samples were partially dried to constant weight. Then dried fecal and feed samples were ground in a Wiley mill using 1 mm sieve (model 4) and kept in air tight containers until chemical analysis.

The chemical analyses were run in duplicates. The dry matter (DM), ash and crude protein (CP) were determined according to the procedure of AOAC (1990). Nitrogen (N) was determined according to Kjeldahl procedure and CP calculated as N × 6.25. The neutral detergent fiber (NDF), avid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the detergent extraction method (Van Soest *et al*. (1991). Metabolizable energy (ME) was estimated using the formula:

ME(MJ/Kg DM) = 0.016 × DOM (Mc Donald *et al*., 2002),

where, DOM = digestible organic matter (g/kg DM).

After overnight fasting, all animals were weighed and slaughtered by cutting the jugular vein and carotid artery with a knife. Blood was drained into pre-weighed bucket and weighed. The skin was carefully flayed and weighed with ears. Gastro-intestinal tract was removed with and without its contents and weighed to calculate gut fill. Empty body weight was calculated as slaughter weight minus gut content. Internal organs (lung-trachea, heart, liver, kidney, kidney fat and spleen and pancreas) were removed and weighed.

After 12 h chilling in a refrigerator,both the right and left halves were cut between the 11th and 12th ribs perpendicular to the backbone to measure the cross-sectional area of the rib-eye muscle and then traced first on transparency paper then on graph paper and the area was measured by using mechanical polar planimeter (model series L20MA). The mean of the right and left cross sectional areas were taken as a rib-eye muscle area. Percentage of total edible offal was taken as the sum of heart, liver, empty gut, kidney, testis, tongue, kidney fat, blood and abdominal fat. Percentage of total non-edible offal was considered as the sum of skin with feet, head except tongue, lung, trachea and esophagus, penis, spleen and pancreas, gall bladder and urinary bladder. Two dressing percentages were calculated as proportion of hot carcass weight to slaughter weight or empty body weight.

Data assembled on feed intake, digestibility, weight gain and carcass parameters were analyzed using the General Linear Model (GLM) procedure of SAS (SAS, 2002/3). Treatment means were separated by Duncan's multiple-range test. The statistical model used for the analysis of the data was:

$$Y_i = \mu + B_i + T_i + e_i$$

where, Y_i = response variable, μ = overall mean, B_i= block effect, T_i= treatment effect and e_i = random error

Exact Match

The mean of the right and left cross sectional areas were taken as a rib-eye muscle area.

RESULTS AND DISCUSSION

As shown in Table 2, higher value of CP content was observed in T2. The DM, ash, NDF, ADF and ADL contents were different among the treatment diets. The NDF and ADF were higher in wheat bran and LLL than in LLP.

The CP content of natural pasture hay(NPH) in the current study was higher than earlier reports (5.4% and 7.9%) by Dereje (2014) and Shumuye and Yayneshet (2011), respectively; and it was comparable to the report (9.85 %) of Hagos *et al*. (2015). Differences observed could be due to variations in stage of harvesting as suggested by McDonald *et al*. (2010). As can be seen grass hay alone was not enough to meet even maintenance requirement of the sheep. It was thus necessary to supplement the lambs with the concentrates (MacDonald *et al*. 2010). The NDF, ADF and ADL contents of NPH in the current study were comparable to earlier results (73.7 % NDF, 39.50 % ADF and ADL 6.35 %) reported by Hagos *et al*. (2015).

The CP content of WB was comparable with the result (17.4%) reported by Werknesh (2014) but it was higher than the result (14.2%) reported by Endalew (2011). The NDF and ADF content of the wheat bran in the current study was lower than the results (50% and 13.7 %; 47.4 % and 14.4 %; and 32.6% and 8.3) reported by Werknesh (2014), Derege *et al*. (2016) and Endalew (2011), respectively. The lower value of NDF and ADF in WB, as observed in the current study implies that it had higher digestibility and could support lamb's growth.

The CP content of LLL in the current study was similar (22.2 %)but lower (24.9%) than earlier reports (Weknesh, 2014 and Focha and Anigbogu, 2009, respectively). In addition, the results of ash, NDF, ADF and ADL contents of LLL in the current study were lower than earlier results (13.8, 34.0, 27.0 and 10.6, respectively) reported by Werknesh (2014). The CP content of the dietcontaining LLL increased because of the higher CP and lower fiber contents of LLL compared to that of either LLP or leaf-pod mix. According to Monoj *et al.* (2007) chemical composition of *L. leucocephala* could vary depending up on location, variety and age of plant, soil type/ fertility, season, method of harvesting and drying.

The CP content of LLP in the current experiment is comparable (18.6 %) but NDF and ADF were lower (56.1 and 42.1%) and ash (5.7%) higher than earlier reports by Nyambati *et al*. (2006). But the content of ash is comparable with that (10.61%) indicated by Afza *et al.* (2007). These differences might be due to difference in agro-ecology.

The LLP used in the current experiment was matured unlike the LLL that was green at the time of collection. The ADL content of the LLP in the current study was higher than that of LLL and leaf-pod mix. This finding agrees with earlier report where seed of LLP had higher concentration of tannins whereas most of the tannin was found in the empty pods in Kenya (Nyambati *et al*. 2006).

The DM intake (DMI) of NPH of sheep was reduced ($p<0.05$) with *Leucaena* supplementation (Table 3). Supplement diets made up to 12% (S1), 34% (S2) and 35% (S3 and S4) of total DMI and LLL, LLP

Table 2: Chemical composition of the feed ingredients and supplementary diets

Nutrients	NPH	WB	LLL	LLP	Supplementary diets			
					S_1	S_2	S_3	S_4
Dry matter (%)	93.62	93.26	92.07	93.98	93.80	92.92	93.01	92.67
Ash (%DM)	8.91	4.04	11.74	6.49	4.85	14.14	12.33	13.10
Crude protein (%DM)	9.81	17.32	21.84	18.94	17.43	20.26	17.40	18.59
Neutral detergent fiber (%DM)	72.29	40.47	20.22	42.12	41.66	31.59	40.07	40.80
Acid detergent fiber (%DM)	38.37	10.03	9.88	25.66	11.09	11.97	17.21	18.77
Acid detergent lignin (%DM)	4.13	1.66	1.98	4.73	1.15	3.26	3.95	3.50

LLL: L. leucocephala Leaf; LLP: L. leucocephala pod; NPH: natural pasture hay, S: supplementary diet; T_1*: 90g DM wheat bran +3 g DM salt;* T_2*: 90g DM wheat bran +3 g DM salt +207 g DM LLL;* T_3*: 90g DM wheat bran +3 g DM salt +207 g DM LLP;* T_4*: 90g DM wheat bran +3 g DM salt+103.5 g DM LLL +103.5 g DM LL; WB = Wheat bran.*

and LLL-LLP were about 23% of the total DMI. Supplement diets were completely consumed by all animals. Sheep fed T1 ate more hay than that of supplemented groups to compensate the deficit. Similar observation was reported earlier where DM intake of the basal diet of control group was higher in Farta goats supplemented with *Xanthium Spinosum* foliages (Endalew 2011) and in black head Somali sheep supplemented with different levels of corn silage (Yohannes *et al.* 2015).

The observations in this study agree with those of Focha and Anigbogu (2009) who concluded that there was no significant difference (p>0.05) in husk intake, but the total DM intake rose (p<0.05) with the increase in the level of LLL supplementation. Eniolorunda *et al.* (2011) reported that sheep in the control diet have less DM intake than LLL and biscuit waste supplemented Yankassa rams.

Barros-Rodriguez *et al.* (2014) reported that ruminants consuming *leucaena* can tolerate more than 50% inclusion in the diet, without having a negative impact on production however in animals not adapted to *leucaena* intake would be limited to less than 30% of the diet, mainly because of mimosine and its derivatives. In contrast, Mohamed *et al.* (2014) reported that livestock feed can contain more than 30% of LLL.

The digestible CP intake of sheep fed on T_2 was highest of all, whereas T_3 and T_4 had higher CP intake than that of T_1. In the current study, the increase in CP intake of diets containing LLL is due to the higher CP content of LLL compared to LLP and their mix. Getahun (2014) reported that *L. leucocephala* foliage contains high CP, calcium, phosphorus and gross energy revealing its paramount nutritional importance to supplement

Table 3: Feed intake and apparent digestibility of *Leucaena leucocephala* leaves and pods supplemented to wheat bran and natural pasture hayfed to Central highland sheep

Nutrient intake (g/h/d)	Treatment diets				S.L.	SEM
	T_1	T_2	T_3	T_4		
Hay dry matter	629[a]	551[b]	529[b]	530[b]	***	61
Supplement dry matter	87[c]	279[a]	279[a]	278[b]	***	00
Total dry matter	716[b]	830[a]	808[a]	808[a]	***	61
Total organic matter	659[c]	742[a]	711[b]	724[ab]	***	56
Total crude protein	78[c]	112[a]	102 [b]	102[b]	***	6
Total neutral detergent fiber	470	482	490	494	Ns	47
Totalacid detergent fiber	250	243	250	246	Ns	23
DM and nutrient digestibility (%)						
Dry matter	59.90[b]	69.65[a]	66.74[a]	68.90[a]	***	0.067
Organic matter	61.16[c]	69.97[a]	65.90[b]	69.15[ab]	***	0.069
Crude protein	65.47[c]	78.52[a]	74.64[b]	74.85[b]	***	0.058
Neutral detergent fiber	56.87[c]	64.93[ab]	61.41[b]	66.02[a]	***	0.087
Acid detergent fiber	63.02[a]	64.26[a]	57.56[b]	63.53[a]	**	0.086
Digestible nutrient and ME intake (g/h/day)						
Dry matter intake	434[b]	580[a]	540[a]	559[a]	***	83
Organic matter intake	407[c]	521[a]	470[b]	502[ab]	***	77
Crude protein intake	51[c]	89[a]	76[b]	76[b]	***	9
Neutral detergent fiber intake	273[b]	315[a]	303[ab]	327[a]	**	65
Acid detergent fiber intake	160	158	144	157	NS	33
Estimated ME intake (MJ/h/d)	6.0[c]	8.3[a]	7.5[b]	8.0[ab]	***	1.2

*[abc]: Means in the same row with different superscripts differ significantly *: P< 0.05;**: P<0.01; ***: P<0.001; ME: metabolizable energy; SEM: standard error of mean; SL: significance level; T_1: hay ad libitum +90g DM wheat bran +3 g DM salt; T_2: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLL; T_3: hay ad libitum+90g DM wheat bran +3 g DM salt +207 g DM LLP; T_4: hay ad libitum +90g DM wheat bran +3 g DM salt+103.5 g DM LLL +103.5 g DM LLP*

ruminants on poor quality roughages also supports the findings in this study. Similarly, Barros-Rodrguez *et al*. (2013) indicated that additional protein provided by *leucaena* to grass based diets increased availability of ammonia for rumen micro-flora, stimulating microbial growth and increasing breakdown and passage rates and consequently voluntary intake.

The apparent nutrient and DM digestibility are given in Table 3. Diets T_2, T_3 and T_4 had higher (P<0.05) DM, OM, CP and NDF digestibility than those of T_1. However, T_3 had lower OM, CP and ADF digestibility than those of T_2.

The DM digestibility of diets was lower (p<0.001) in non-supplemented than the supplemented sheep but there was no significant difference (p>0.05) among the *Leucaena* supplemented groups although it was numerically higher for T_2. This could be compared with results of Barros-Rodriguez *et al.* (2013) where apparent DM digestibility of legume containing diets were higher than that of grass based diet.

The DM digestibility of diets was close to (62.3 - 71.7%) but higher (50-68%) than earlier values reported of Farta goats supplemented with *Xanthium spinosum* foliages; and of Abergelle kids fed hay basal diet supplemented with *Ziziphus spina-christi, Sterculia africana* and *Terminalia brownie* (Endalew, 2011 and Bruh *et al.* 2014, respectively). T_2 and T_4 had higher OM digestibility than T_1 whereas T_3 was moderate. Estimated ME values (13.82, 14.31, 13.89 and 14.31 MJ/kg DM) of the treatment diets (T_1, T_2, T_3 and T_4, respectively) followed similar trend as that of OM digestibility. According to Nyambati *et al*. (2006) such differences mainly depend on digestible energy concentration. The DM digestibility of treatment feeds in the present study was also close to the findings (62.47 - 65.81%) reported of Dorper×Afar f1 sheep fed grass hay basal diet supplemented with tree legumes and concentrate mixture (Werknesh 2014).

The CP digestibility was greater for T_2 than T_3 and T_4, but values for T_1 was lowest of all diets. Similarly, Barros-Rodriguez *et al*. (2013) reported that providing supplements of *L leucocephala* in the diet of sheep can improve rumen function by increasing the rate of degradation of forages and stimulating voluntary intake. This increases availability of nutrients for metabolic processes resulting in improved growth rates, wool growth and reproductive performance. Nigusse *et al*. (2000) indicated that supplementation of up to 300 g/head/d of *leucaena* resulted in improved feed intake, and reproductive performances of Ethiopian highland rams offered chickpea haulm basal diet with no clinical symptoms of *leucaena* toxicity and ill effects on potential fertility.

The digestibility of NDF was the highest for supplemented than the control group and T_3 had the lowest ADF digestibility of all the diets. The quantity and quality of fiber fraction of a feed has the greatest influence on overall digestibility (McDonald *et al*. 2010).

Average daily body weight gain (ADG) and feed conversion efficiency (FCE) are given in Table 4. The ADG and FCE were highest (P<0.05) in sheep

Table 4: Body weight change, feed conversion ratio and efficiency of Central highland sheep fed *Leucaena leucocephala* leaves and pods and basal diet wheat bran and hay

Variables	Treatments					
	T_1	T_2	T_3	T_4	SL	SEM
Initial weight (kg)	17.28	16.64	16.76	16.84	ns	0.60
Final weight (kg)	21.96^b	23.92^a	22.00^b	22.56^b	***	0.53
Total weight change(kg)	4.68^d	7.28^a	5.24^c	5.72^b	***	0.57
Daily Weight gain (g/day)	55.71^d	86.67^a	62.38^c	68.10^b	***	6.89
FCE [BWG(g)/DMI(g)]	0.08^c	0.11^a	0.08^c	0.09^b	***	0.03

*$^{a, b, c, d}$: Means within a column not bearing a common superscript differ significantly; BWG: body weight gain; DMI: dry matter intake; FCE: Feed conversion efficiency; ns: non significant; SEM : Standard error of mean; SL: significance level; ***:P<0.001; T_1: hay ad libitum +90g DM wheat bran +3 g DM salt; T_2: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLL; T_3: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLP; T_4: hay ad libitum +90g DM wheat bran +3 g DM salt+103.5 g DM LLL +103.5 g DM LLP*

fed T_2 and lowest (P<0.05) in T_1 while T_3 and T_4 had intermediate ADG and T_4 had intermediate FCE. Although sheep fed T_1 had lower ADG than *Leucaena* supplemented groups, they still gained some weight because of wheat bran and good quality hay. The trend in ADG was higher for T2 fed sheep than the rest of the groups (Fig. 1).

The higher ADG and FCE for T_2 might be due to the contribution of LLL to increased CP intake compared with LLP and their mix. Nigussie *et al.* (2000) reported that inclusion of LLL hay up to 300 g/head/d improved total DM intake, CP intake, and resulted in ADG of 71 g which is lower than that of T_2. Getahun (2006) also reported a very small gain of 29 g/day when 300 g LLL was supplemented for wheat straw. The ADG obtained in this study was higher than the 69 g/day reported by Werknesh (2014) for Dorper × Afar F1 sheep fed grass hay basal diet supplemented with 299 g LLL/day.

The FCE of sheep fed T_2 was highest (p<0.001) of all whereas differences among T_1, T_3 and T_4 were not significant. The FCE in the current study was higher than the result (8%) reported by Werknesh (2014) for Dorper × Afar F1 sheep supplemented with *leucaena* leaf hay.

The mean values of carcass traits of the sheep are given in Table 5. Differences in pre-slaughter weight (PSW), empty body weight (EBW), hot carcass weight (HCW) and rib eye muscle area (REMA) among treatment diets were significant (p<0.05). Sheep fed on T2 had higher HCW than that of T_1 and T_3 whereas T_4 was different from T_1 but not T_2 and T_3. Dressing percentage (DP) on PSW basis of T_2 and T_4 were higher (P<0.05) than that of T_1 but, DP on EBW basis was not significantly different (P>0.05) among treatment diets. Sheep fed on T_2 had higher (p<0.05) REMA than that of T_1, T_3 and T_4 whereas no difference were observed between T_1 and T_3 and between T_3 and T_4.

Values of DP on EBW bases were higher than DP on PSW bases, which indicates the influence of digesta/gut fill on dressing percentage (Hagos 2015). In the current study, HCW was higher for T_2 and higher DP on PSW basis was observed for both T_2 and T_4 possibly due to the higher HCW and EBW of T_2 and T_4 which may be related with the higher nutrient digestibility resulting in higher ADG and HCW. This could be supported by the statement of McDonald *et al*. (2002) where nutrition, age, sex, genetics, season and other related factors affect the growth and carcass traits of animals.

Dressing percentage on EBW basis was not different (P>0.05) among treatments. Similar observations were reported in Somali goats' supplemented with graded levels of peanut cake and wheat bran mixtures (Simret 2005) and in Afar sheep supplemented *Prosopis juliflora pod* and other mixture diets (Nigus 2016). Dereje (2014) also reported lack of difference in DP on EBW basis and related it with elimination of the contribution of gut fill, which was high in non-supplemented sheep. According to Getahun (2006), DP describes

Table 5: Carcass characteristics of Central highland sheep fed *Leucaena* leaves and pods and basal diet wheat bran and hay

Carcass characteristics	Treatments				SL	SEM
	T_1	T_2	T_3	T_4		
Pre slaughter weight (kg)	20.56^{c}	22.82^{a}	20.8^{bc}	21.9^{ab}	**	0.90
Empty body weight (kg)	16.21^{c}	18.42^{a}	16.78^{bc}	17.93^{ab}	**	0.85
Hot carcass weight (kg)	8.40^{c}	10.08^{a}	8.88^{bc}	9.64^{ab}	**	0.62
Dressing percentage						
Pre-slaughter weight bases (%)	40.84^{b}	44.14^{a}	42.61^{ab}	43.92^{a}	*	1.53
Empty body weight bases (%)	51.83	54.69	52.90	53.81	ns	1.87
Rib eye area (cm^2)	5.60^{c}	7.98^{a}	6.26^{bc}	6.92^{b}	**	0.76

*$^{a, b, c}$: Means within a column not bearing a common superscript differ significantly; ns: non significant; *:P<0.05; **:p<0.01; SEM: Standard error of means; SL:significance level. T_1: hay ad libitum +90g DM wheat bran +3 g DM salt; T_2: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLL; T_3: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLP; T_4: hay ad libitum +90g DM wheat bran +3 g DM salt+103.5 g DM LLL +103.5 g DM LLP*

the carcass merit which helps to assess the meat proportion of the animal subjectively.

The larger REMA obtained for T_2 diets might be due to higher CP content of LLL compared with LLP, their mixture and the control feed (basal diet). This agrees with Endalew's (2011) report where higher REMA was obtained in supplemented groups compared to the non-supplemented goats fed on hay alone. Michael and Yaynshet (2014) also observed lower (P<0.05) REMA in the control group than wheat bran and cotton seed cake supplemented Central highland sheep. This might be probably due to the lower CP and higher NDF value of the control feed, hay. The observed REMA in the current study was higher than earlier results (4.1-5.8 cm^2) with Farta goats fed a basal diet of hay supplemented with dried foliages of kosheshila (*Xanthium spinosum*), wheat bran and their mixture (Endalew, 2011). Eniolorunda *et al*. (2011) also reported that Yankassa rams in the control diet had less REMA than LLL hay and biscuit waste supplemented groups.

In the current study, *Leucaena* meal supplemented sheep had higher size of heart, liver, tongue, total fat, tail and kidney were significantly higher (p<0.05) than non-supplemented ones (Table 6). Similar results were reported when Central highland sheep fed wheat straw was supplemented with mixtures of wheat bran and cotton seed cake (Michael and Yaynshet, 2014). Similarly, the higher weight of visceral fat in T_1 than T_3may also be due to higher digestible OM and CP intake, and higher OM and

Table 6: Supplementary effect of *Leucaena* leaves and pods and their mixtures on total edible and non-edible offals of central-highland sheep fed basal diet of wheat bran and natural pasture hay

Edible offal (g)	Treatments				SL	SEM
	T_1	T_2	T_3	T_4		
Tongue	56^c	85^a	72^b	78^{ab}	**	9
Heart	82^b	103^a	99^a	102^a	**	7
Liver	328^b	445a	424^a	402^a	**	39
Kidney	59^b	82^a	67^b	67^b	**	7
Kidney Fat	32^c	46^a	38^{bc}	40^{ab}	**	4
Reticulo-Rumen	526	479	505	486	ns	31
Omasum- Abomasum	206^a	166^b	191^{ab}	182^{ab}	*	18
Large and Small Intestine	637	567	588	557	ns	72
Tail	424^b	595^a	433^b	517^{ab}	**	63
Abdominal Fat	59^c	121^a	75^{bc}	98^{ab}	**	20
Testis	205^b	330^a	281^{ab}	304^a	*	57
Blood	716^c	943^a	802^{bc}	847^{ab}	***	59
TEO	3430^b	3961^a	3574^{ab}	3679^{ab}	**	230
Non-edible offal (g)						
Skin with feet	2356^a	2038^b	2308^a	2370^a	**	145
Head except tongue	1173^b	1494^a	1436^a	1377^{ab}	*	129
Lung +Trachea+ Esophagus	372	348	379	359	ns	31
Spleen	55	56	60	56	ns	17
Penis	40	57	45	46	ns	12
Gut fill	4450^a	4001^b	3937^b	3824^b	**	179
Gall bladder	9^c	15^a	11^{bc}	13^{ab}	**	2
Urinary bladder	15	17	16	16	ns	4
TNEO	8469	8026	8192	8062	ns	259

*[abc]: Means in the same row with different superscripts differ significantly *:P< 0.05; **:P < 0.01; ***:P< 0.001; ns: not significant; S.L: significant level; SEM: standard error of mean; TEO: total edible offal; TNEO=total non-edible offal; T_1: hay ad libitum +90g DM wheat bran +3 g DM salt; T_2: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLL; T_3: hay ad libitum +90g DM wheat bran +3 g DM salt +207 g DM LLP; T_4: hay ad libitum +90g DM wheat bran +3 g DM salt+103.5 g DM LLL +103.5 g DM LLP*

CP digestibility, which promoted higher internal fat deposition in omentum, kidney and heart (Hagos 2015). The reticulo-rumen and large and small intestine were not significantly different (p>0.05) among diets. Comparable result was reported in Central highland sheep fed urea treated wheat straw supplemented with mixtures of wheat bran and noug seed cake (Gebremeskel and Kefelegn 2011).

The non-edible offals (NEO) of Central highland sheep fed on LLL and LLP and basal diet hay and wheat bran are given in Table 6. Head except tongue, penis, lung, trachea and esophagus, spleen, gall bladder and urinary bladder are considered as inedible offal components in the current study. In the present study, there was no significant difference in most of NOE and total NEO among dietary treatments.

The significant difference (p<0.05) observed in head without tongue and gut fill between the sheep fed on control diet and supplements does not agree with earlier report of Endalew (2011) in Farta goats fed hay and supplemented with dried foliages of kosheshila (*Xanthium spinosum*), wheat bran and their mixture. Amount of gut content of the sheep fed on control diet was higher than *leucaena* supplemented sheep which agrees with earlier reports (Endalew, 2011, Michael and Yaynshet, 2014). Animals on poor feed are enforced to eat and fill their gut with less digestible roughage and have proportionally more gut content.

CONCLUSION

The CP content of air dried *Leucaena leucocephala* leaf (21.84%) and *Leucaenapod* (18.94)) were much higher than that of natural pasture hay(9.81%) but close to that of wheat bran (17.32%). Therefore supplementation with air dried *Leucaena* leaf and pod and their mixtures improved overall nutrient intake, digestibility, feed conversion efficiency and carcass characteristics of sheep. Thus leaves and pods of *Leucaena* can be used as protein supplement to small ruminants fed on poor quality roughages by smallholder farmers who have no access to conventional protein supplements.

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