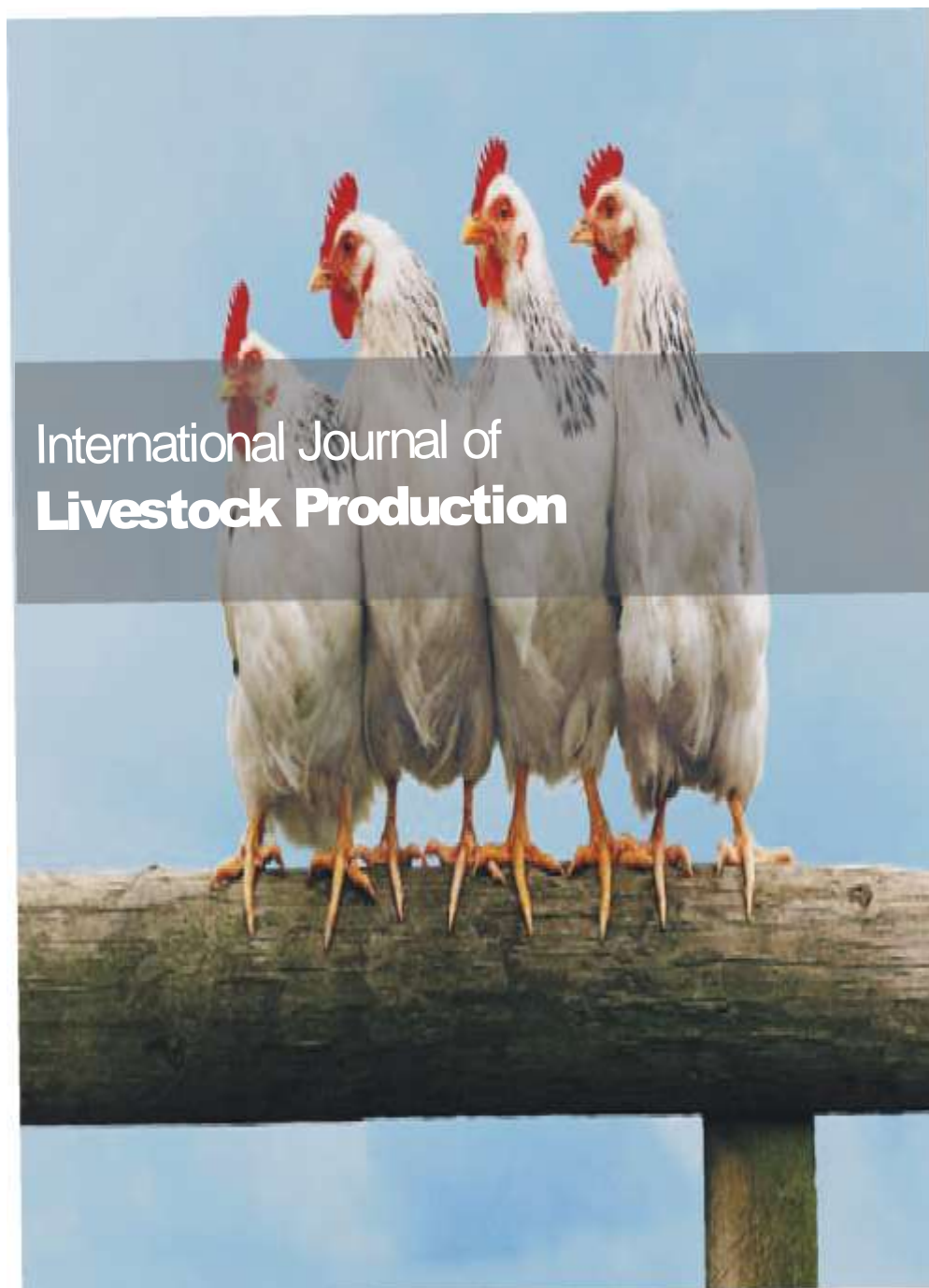


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Full Length Research Paper

Effect of supplementing Tsara (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*) leaves and concentrate mixture on carcass characteristics of Begait sheep fed hay as a basal diet

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The study was conducted with the objective of determining the carcass characteristics of Begait sheep fed hay basal diet and supplemented with different levels of Tsara (*Pterocarpus lucens*) leaves, pigeon pea (*Cajanus cajan*) leaves and concentrate mixture on iso-nitrogenous basis to supply 66.60 g/day crude protein on dry matter (DM) basis. Twenty five yearling male Begait sheep with initial body weight (BW) of 24.2±1.1 kg (Mean±SD) were used in a Randomized Complete Block Design (RCBD) based on their initial BW. The hay was fed on *ad libitum* basis to all sheep. Treatments were hay alone (T1) or supplemented with 400 g DM Tsara leaf (T2), 320 g DM pigeon pea leaf (T3), 360 g DM mixtures of Tsara and pigeon pea leaves (T4) and 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake; T5). The study consisted of 90 days feeding trial and carcass evaluation at the end. The average final body weight was 32.2, 31.6, 27.76, 28 and 26.88 kg (standard error of mean, SEM = 0.38) in the order of T5 > T2 > T3 = T4 > T1. Hot carcass weight of 14.9, 14.3, 11.3, 11.2 and 9.5 (SEM = 0.33) followed almost a similar trend to that of the final body weight except that values for T2 and T5 were similar. In conclusion, based on the biological performance results supplementation of concentrate mixture (T5) and Tsara (T2) induced a comparable response and were better than the supplemental regimes that contained pigeon pea and are therefore recommended.

Key words: Begait sheep, dressing percentage, edible offal components, empty body weight hot carcass weight, non-edible offal components, rib eye muscle area, slaughter weight.

INTRODUCTION

Small ruminants occupy an important economic and ecological niche in agricultural systems throughout the

developing countries (Devendra, 2005). According to FAO (2009), in Ethiopia, small ruminants (sheep and

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goats) are important components of the livestock sub-sector. Therefore, sheep and goats are among the major economically important livestock, playing an important role in the livelihood of resource poor farmers (Adane and Girma, 2008). They contribute a quarter of the domestic meat consumption, about half of the domestic wool requirements, about 40% of fresh skins and 92% of the value of semi processed skin and hide export trade (FAO, 2004). There is also a growing export market for sheep and goat meat in the Middle Eastern Gulf States and some African countries. At optimum offtake rates, Ethiopia can export 700,000 sheep and 2 million goats annually, and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market or consumption (Adane and Girma, 2008).

The current annual offtake rate of sheep and goats is however, only 33 and 35%, respectively (Adane and Girma, 2008; FAO, 2001). The average carcass weight of Ethiopian sheep and goats is 10 kg, which is the second lowest in sub Saharan Africa (FAO, 2001). On the other hand, the increased domestic and international demand for Ethiopian sheep and goats has established them as important sources of Inland Revenue as well as foreign currency. This increased demand also creates an opportunity to substantially improve food security of the population and alleviate poverty (EPA, 2002; Adane and Girma, 2008; FAO, 2009). However, currently the majority of indigenous sheep marketed have low live weight resulting in poor dressing percentage and carcass (Ameha et al., 2011). This is mostly associated with the deficiency of dietary energy and protein levels which can influence the quality and quantity of carcass (Bellof and Pallauf, 2004).

Inadequate nutrition is one of the complex factors that generally affect livestock productivity in the tropical countries. Total weight gained by ruminants during the rainy season is lost in the dry season due to feed scarcity; this feed fluctuation affects growth and carcass traits of small ruminants (Woods et al., 1994).

The available feed resources in Tigray region of Ethiopia are mainly crop residues, natural grazing and hay from natural pasture; these feed resources are characterized by their low crude protein content; which is below the critical requirement of ruminant production, 7% of crude protein and this level of crude protein reduces feed intake and dry matter digestibility of the animals (Devendra and McLeroy, 1982). On the other hand, the western and north western zones of Tigray region, northern Ethiopia, are endowed with a diversified livestock resources and wider rangelands with dominant browse species coverage (CSA, 2014). Among these resources, Begait sheep is one of the indigenous small ruminant breeds reared in the area; which is a sub type of north Sudan desert sheep and is characterized as tall, long tailed, consume large amounts of feed, muscular body size, dual purpose breeds (for milk and meat) and known for its good productive and reproductive

performance (FAO, 1991; Amare et al., 2012). In addition, Tsara (*Pterocarpus lucens*), pigeon pea (*Cajuns cajan*) and concentrate feeds like rice bran, sesame seed cake are available and commonly used by the farmers to feed their animals but not on a scientific basis.

However, different authors revealed that supplementation of sheep with forage legumes and concentrate based diets shows great improvements on the carcass performance of different Ethiopian indigenous sheep breeds (Hirut, 2008; Gebretinsae, 2011; Gebreslasie, 2012).

In addition, Hunegnaw and Brehan (2016) reported that the significantly higher results of valuable carcass traits when Wollo sheep fed grass hay and supplemented with legume forage leaf meal (pigeon pea, cow pea and lablab) as compared to sheep that supplemented with concentrate feed. Therefore, the objective of this study was to determine the carcass characteristics of Begait sheep supplemented with different levels of Tsara (*P. lucens*) and pigeon pea (*C. cajan*) leaves and concentrate mixture.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Shire-Maitsebri Agricultural Research Center (SMARC), Tselemti Woreda, North Western zone of Tigray Regional State, Ethiopia. The Woreda is located 405 km far to the North West of Mekelle, the capital of the region, 85 km far to the South of Shire along the Gondar way and 1172 km far from Addis Ababa, capital of Ethiopia. Elevation ranges from 800 to 2870 m above sea level (masl). Its geographical location is 13° 05' N latitude and 38° 08' E longitude. The average annual rainfall in the area is 758 to 1100 mm, with mono modal pattern falling from June to September. The annual temperature ranges from 16 to 38°C.

Experimental animals and their management

Begait sheep breed was used for the experiment. Twenty five yearling intact local male sheep with average live body weight of 24.2±1.1 kg (mean±SD) were purchased from Shiraro local market. The age of the animals was determined by dentition and by asking information from the owners. The sheep were quarantined for 21 days in the experimental area. During this quarantine period, they were dewormed and sprayed against internal and external parasites, respectively, and vaccinated against ovine pasteruolosis and anthrax.

Experimental design and dietary treatments

Randomized Complete Block Design (RCBD) having five blocks and treatments (five sheep per treatment) was used for the study. The experimental sheep were blocked into five blocks of five animals each based on their initial body weight and placed in an individual pen. Sheep within a block were randomly assigned to one of the five dietary treatments which were hay alone (T1) and supplementation with 400 g DM Tsara leaves (T2), supplementation with 320 g DM pigeon pea leaves (T3), supplementation with 360 g DM mixtures of Tsara and pigeon pea leaves (T4) and supplementation with 300 g DM concentrate mixture (T5).

Table 1. Layout of the experimental treatment.

Treatment	Basal diet natural pasture hay	Supplement feeds (g/day)		
		Concentrate mixture	Tsara Leaf	Pigeon pea leaf
T ₁	<i>Ad libitum</i>	0	0	0
T ₂	<i>Ad libitum</i>	0	400	0
T ₃	<i>Ad libitum</i>	0	0	320
T ₄	<i>Ad libitum</i>	0	200	160
T ₅	<i>Ad libitum</i>	300	0	0

Concentrate mixture = 75% rice bran: 25% sesame seed cake.

Consequently, supplements for the other treatments were arranged on iso-nitrogenous basis and samples of the feed supplements were analyzed for DM and CP content before the execution of the experiment and the results of analysis were used to make the supplemental diets on iso-nitrogenous basis.

The DM and CP contents obtained from laboratory analysis were 95 and 16.67% for Tsara; 95.5 and 20.74% for pigeon pea, 96 and 16.41% for rice bran and 95.5 and 39.55% for sesame seed cake on DM basis, respectively. According to the laboratory result, the 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake) supplied 66.60 g/day CP on dry matter basis. To supply the same amount of CP from the other feed treatments on iso-nitrogenous basis 400 g DM *Tsara*, 320 g DM pigeon pea and 360 g DM (200 g DM *Tsara* + 160 g DM pigeon pea) leaves were required for the experimental sheep in T₂, T₃ and T₄, respectively (Table 1). Therefore, treatments were no supplementation to a hay diet fed *ad libitum* (T₁) or hay supplementation with *Tsara* leaf (T₂), pigeon pea leaf (T₃), 50:50 combination of *Tsara* and pigeon pea (T₄), and concentrate mixture (T₅). Drinking water and common salt block were freely available to all experimental sheep throughout the experimental period.

Carcass parameters measurement

At the end of the digestibility trial, all sheep were allowed to fast overnight before slaughtering, weighed to determine slaughter weight (SW) and then slaughtered by severing the jugular vein and carotid arteries with a knife for carcass evaluation. On slaughtering, the blood was collected in a container, weighed and recorded. The skin was carefully flayed to avoid attachment of fat and muscle tissues to the skin and then weighed without feet and the feet below fetlock joints was weighed and recorded separately. The entire gastrointestinal tract (GIT) except esophagus was removed with its contents and weighed with and without its contents and the weight of the gut fill (content) was measured by difference.

The non-edible offal contents (NEOC), the head without tongue, skin, feet, spleen, pancreas, genital organ, lung and trachea, gall bladder, and the gut contents were weighed separately. Similarly, the edible offal components (EOC), namely, the liver, heart, kidney, stomach (reticulum, rumen, omasum, and abomasum), small and large intestine, blood, abdominal and kidney fat, testes, and tongue was recorded and weighed. The total non-edible offal contents (TNEOC) and total edible offal components (TEOC) were computed as the sum of all NEOC and EOC, respectively. An empty body weight (EBW) was determined by subtracting the weight of gut contents from slaughter weight. Hot carcass weight (HCW) was computed by excluding the contents of thoracic, abdominal and pelvic cavity, head, skin, and the limbs. Dressing percentage (DP) was calculated as a ratio of hot carcass weight to slaughter weight and hot carcass weight to empty body weight.

The rib-eye muscle area (REMA) which indicates the amount of valuable muscle in the carcass was allowed to chill for 12 h in a refrigerator for proper cutting. The cross sectional area of rib-eye muscle at the 11 and 12th ribs of each slaughtered sheep was traced from each side on transparency paper after cutting perpendicular to the backbone and measured by tracing the transparency paper on graph papers. The average measure of the left and right REMA was taken.

Statistical analysis

Data obtained from the study were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS, 2008) version 9.2. The differences among treatment means was tested using Tukeys' studentized range (HSD) test.

The model used for data analysis was:

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

where Y_{ij} = response variable, μ = overall mean, T_i = treatment effect, B_j = block effect, and ε_{ij} = random error.

RESULTS AND DISCUSSION

Carcass characteristics of Begait sheep

Slaughter weight, empty body weight, hot carcass weight and dressing percentage on slaughter weight basis took a similar trend as presented in Table 2. Despite a similar slaughter weight of the non-supplemented sheep with T₃ and T₄ ($P > 0.05$), empty body weight was the least for the non-supplemented sheep indicating for greater gut fill in T₁ to account for part of the weight gain that make the control treatment to have similar final body weight with two of the supplemented treatments. Hot carcass weight and dressing percentage on slaughter weight basis took a similar trend like that of empty body weight and was in the order of $T_5 = T_2 > T_3 = T_4 > T_1$. Therefore, *Tsara* leaf supplementation induced similar carcass yield and dressing percentage as compared to supplemental concentrate in the current study indicating the comparable feeding value of the fodder and concentrate mixture.

Table 2. Carcass characteristics of Begait sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Carcass characteristic	Treatment feeds					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
Initial body weight (kg)	24.52	24.76	23.76	23.96	23.84	0.41	ns
Final body weight (kg)	27.28 ^b	32.44 ^a	28.4 ^b	28.8 ^b	33.44 ^a	0.38	***
SW (kg)	26.88 ^b	31.60 ^a	27.76 ^b	28.00 ^b	32.28 ^a	0.49	***
EBW (kg)	17.80 ^c	24.06 ^a	19.86 ^b	19.829 ^b	24.92 ^a	0.44	***
HCW (kg)	9.49 ^c	14.31 ^a	11.29 ^b	11.24 ^b	14.90 ^a	0.33	***
Dressing percentage							
SW basis (%)	35.28 ^c	45.468 ^a	40.856 ^b	40.138 ^b	46.26 ^a	0.97	***
EBW basis (%)	53.28 ^b	59.54 ^a	57.24 ^{ab}	56.65 ^{ab}	59.86 ^a	1.14	**
REMA (cm ²)	8.48 ^d	10.91 ^b	9.78 ^c	9.05 ^{cd}	13.38 ^a	0.25	***

^{a-d}Mean values in a row having different superscripts differ significantly; ns = not significant; ** = significant at P < 0.01; SW = slaughter weight; EBW = empty body weight; HCW = hot carcass weight; REMA = rib-eye muscle area; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁ + 300 g DM/day Concentrate mixture.

Conversely, Hunegnaw and berhan (2016) reported significantly higher carcass yield and dressing percentage of Wollo sheep when fed grass hay and supplemented with legume forage leaf meal as compared to those that supplemented with concentrate. This might be due to the fact that supplementation induced higher total dry matter intake and digestibility of nutrients, consequently, this leads to greater nutrient availability that promote weight gain and tissue development (Mushi et al., 2009). In addition, Pralomokarn et al. (1995) indicated that carcass characteristics of animals increased as total dry matter and nutrient intake increased.

Dressing percentage on slaughter weight basis ranges from 35 to 46% in this study, which was comparable with the results of 32 to 44% for *Farta* sheep, local sheep and *Horro* rams reported by different studies (Zemicael and Solomon, 2009; Aschalew and Getachew, 2013; Chala et al., 2014). On the other hand, lower results for Tigray Highland sheep (Micheale and Yaynshet, 2014) and higher values local sheep, African dwarf sheep and growing Najidi lambs of Saudi Arabia (AL-Saiday et al., 2010; Fasae et al., 2011; Hagos, 2014) for dressing percentage as compared to that obtained in the current study has been reported.

The rib eye muscle area was in the order of T₅ > T₂ > T₃ > T₁, while values for T₄ was similar with T₃ and T₁. The values for REMA which is an indicator of muscling and lean meat production in the current study was in line with the findings of Gebreslassie (2012), higher than the findings reported by weldegebriel et al. (2014), Gebretnsae (2011), Hagos (2011), and Hagos (2014) and was lower than the findings reported by Mulu (2005) for different breeds of sheep.

Supplementation had a positive effect on the total edible offals as compared to the control diet, and value were in the order of T₂ > T₅ > T₃ > T₄ > T₁ (Table 3).

The average head, heart, testes, liver with bile, internal fat, reticulo-rumen and omaso-abomasum weight in the control diet in this study was significantly lower (P<0.001) than the supplemented groups. Increments in total edible offal associated with supplementation has also been reported before (Hirut, 2008; Gebretnsae, 2011; Gebreslassie, 2012) for Hararghe highland sheep, Tigray highland sheep and Tigray local sheep. Liver weight was higher in the supplemented than non-supplemented sheep, possibly due to glycogen deposition as an energy reserve. Similarly, the higher weights of reticulo-rumen, omaso-abomasum and large and small intestine in the supplemented Begait sheep in this study might be in agreement with the fact reported by Burrin et al. (1990) that the level of feed intake changes the relative proportion of visceral organs to body mass.

The non-edible offal components were all variable among treatments (P < 0.05), although there was lack of apparent trend (Table 4). One obvious trend is the high gut content in T₁ which was statistically similar with T₃ and T₄. This observation is consistent with the greater hay intake in T₁ which is less digestible in the non-supplemented sheep, and the relatively lower digestibility of the diet in T₃ and T₄ probably associated with the greater CT content of pigeon pea that might have deterred ruminal digestibility of nutrients and increased ruminal retention time (Bonsi et al., 1995). Total non-edible offal components were, however similar among treatments.

Conclusion

Based on the biological performance results, supplementation of concentrate mixture (T₅) and *Tsara* (*P. lucens*) leaf (T₂) induced a comparable response on

Table 3. Edible offal components of Begait sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Edible offal	Treatments					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
Head (g)	1019 ^e	1347 ^a	1223 ^c	1218 ^c	1250 ^b	1.47	***
Blood (g)	1122 ^c	1234 ^b	1040 ^d	1034 ^d	1281 ^a	2.17	***
Tongue (g)	94.90 ^a	77.80 ^c	71.30 ^d	87.70 ^b	84.65 ^b	0.90	***
Heart (g)	102.41 ^e	129.5 ^b	124.8 ^c	113.74 ^d	140.2 ^a	0.54	***
Kidney (g)	72.05 ^c	85.75 ^a	68.15 ^d	72.55 ^c	78.8 ^b	0.46	***
Testes (g)	197.1 ^d	302.46 ^b	258.90 ^c	298.70 ^c	421.70 ^a	1.16	***
Liver + Bile (g)	310 ^e	383.6 ^a	360.5 ^c	333.4 ^d	371.40 ^b	0.58	***
Internal fat (g)	173 ^e	376.40 ^a	229.60 ^c	185.30 ^d	358.66 ^b	0.75	***
Ret-Rum (g)	556.00 ^e	775.82 ^a	608.10 ^d	617.30 ^c	673.20 ^b	1.37	***
Oma-Abo (g)	214.90 ^d	240.20 ^b	221.00 ^c	215.80 ^d	262.20 ^a	0.98	***
SI and LI (g)	687.70 ^d	924.30 ^a	735.00 ^c	647.80 ^e	891.00 ^b	1.03	***
TEOs (kg)	4.55 ^e	5.88 ^a	4.94 ^c	4.83 ^d	5.82 ^b	0.005	***

^{a-e}Mean values in a row having different superscripts differ significantly; ** = significant at P < 0.01; *** = significant at P < 0.001; Ret-Rum = reticulo-rumen; Oma-Abo = Omasum and Abomasum; TEOs = total edible offals; SW = slaughter weight; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁+320 g DM/day pigeon pea; T₄ = T₁+360 g DM/day *Tsara* + pigeon pea; T₅ = T₁+300 g DM/day Concentrate mixture.

Table 4. Non-edible offal components of Begait sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Non edible offal	Treatment feeds					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
Skin (g)	2219 ^e	2522 ^b	2317 ^d	2406 ^c	2621 ^a	0.91	***
Penis and penis fat (g)	69 ^d	102.8 ^a	71.3 ^c	67.8 ^d	81.3 ^b	0.45	***
Feet (g)	673.2 ^d	762.9 ^b	638.9 ^e	702.4 ^{bc}	839.6 ^a	0.75	***
LTE (g)	420.6 ^d	469.2 ^a	393.7 ^e	440.4 ^c	451 ^b	1.11	***
Spleen (g)	71 ^{cd}	104.7 ^b	57.4 ^d	81.4 ^c	144.6 ^a	3.38	***
Pancreas(g)	62 ^b	70.6 ^a	67 ^{ab}	46.7 ^c	39.72 ^d	1.52	***
Bladder (g)	25.6 ^b	29.5 ^a	18.3 ^c	14.9 ^c	30.3 ^a	0.39	***
Gut content (kg)	9.3 ^a	7.35 ^b	7.97 ^{ab}	8.17 ^{ab}	7.36 ^b	0.40	**
TNEOs (kg)	12.84	11.41	11.53	11.93	11.56	0.40	ns

^{a-d}Mean values in a row having different superscripts differ significantly; ns = not significant; ** = significant at P < 0.01; *** = significant at P < 0.001; LTE = lung + trachea + esophagus; TNEOs = total non-edible offals; SW = slaughter weight; T₁ = Hay *ad libitum*; T₂ = T₁+ 400 g DM/day *Tsara*; T₃ = T₁+ 320 g DM/day pigeon pea; T₄ = T₁+ 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁+ 300 gDM/day Concentrate mixture.

the valuable carcass parameters and were better than the supplemental regimes that contained pigeon pea and are therefore recommended for Begait sheep reared by small holder farmers and investors.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

- Adane H, Girma A (2008). Economic Significance of Sheep and Goats. In: Alemu y and Merkel RC (eds.), Sheep and Goat Production Handbook for Ethiopia: ESGPIP (Ethiopia Sheep and Goat productivity Improvement Program), Brana printing enterprise, Ethiopia, pp. 1-4.
- Al-Saiday MY, Abouheif MA, Aziz M, Hafiz I, Al-Owaimer AN (2010).

- Impact of particle length of Alfalfa hay in the diet of growing lambs on performance, digestion and carcass characteristics. *Journal of Animal Science* 23(4):475-482.
- Ameha S, Alemu Y, Merkel RC, Gipson TA (2011). Export requirements for meat and live small ruminants; how can development agents assist producers to improve small ruminant export?. *Technical Bulletin No 47*.
- Aschalew A, Getachew A (2013). Supplementation of raw malted and heat treated grass pea (*Lathyrus Sativus*) grain on body weight gain and carcass characteristics of Farta sheep. *International Journal of Soil and Crop Science* 1(1):1-6.
- Bellof G, Pallauf J (2004). Deposition of protein, fat and energy in lambs. *German Merino Land sheep. Animal Science* 78(3):369-378.
- Bonsi MLK, Osuji PO, Tuah AK (1995). Effect of supplementing teff straw with different levels of leucaena or sesbania leaves on the degradabilities of teff straw, sesbania, leucaena, tagasaste and vernonia and on certain rumen and blood metabolites in Ethiopian Menz sheep. *Animal Feed Science and Technology* 52(1):101-129.
- Burrin DG, Ferrell CL, Britton RA, Bauer Marc (1990). Level of nutrition and visceral organ size and metabolic activity in sheep. *British Journal of Nutrition* 64:439-448.
- Chala M, Ulfina G, Tesfaw A, Lemma F (2014). Growth performance and carcass characteristics of Horro rams under different management practices at Ambo University, Ethiopia. *Global Journal of Animal Science Research* 2(2):184-189.
- Central Statistical Agency (CSA) (2014). Livestock and livestock characteristics (private peasant holdings), federal democratic republic of Ethiopia, Agricultural sample survey. *Statistical Bulletin* 573:2, August 2014 Addis Ababa, Ethiopia.
- Devendra C, McLeroy GB (1982). *Goat and sheep production in the tropics*. Longman.
- Devendra C (2005). Small Ruminants in Asia: Contribution to food security, poverty alleviation and opportunities for productivity enhancement. In: Ledin I (Ed), *Proceeding of international workshop on small ruminant production and development in South East Asia*. MEKARN, Nong Lam, HCMC, Vietnam pp. 19-32.
- Ethiopian Privatization Agency (EPA) (2002). *Investment and innovation policy review of Ethiopia*. United Nations Conference on Trade and Development. 138p. United Nations New York and Geneva 2002. Accessed 22 October 2011. <http://www.unctad.org/en/docs/poiteipcm4.en.pdf>.
- Food and Agriculture Organization of United Nation (FAO) (2001). *Production Year book*. Vol. 55. Rome, Italy.
- Food and Agriculture Organization (FAO) (2004). "Livestock sector brief Ethiopia: livestock information sector analysis and policy branch Rome Italy.
- Food and Agricultural Organizations of the United Nation (FAO) (2009). FAOSTAT data. Accessible at: <http://faostat.fao.org/faostat/collections?subset=agriculture>. Accessed date: April 24, 2014.
- Fasae OA, Adu IF, Dipeolu MA (2011). Growth performance, carcass characteristics and meat sensory evaluation of west African dwarf sheep fed varying levels of maize and cassava hay. *Tropical Animal Health Production* 43:503-510.
- Gebreslassie G (2012). Effects of Supplementing Wheat Bran and Graded Levels of Dried Accacia Saligna Leaves on Feed Intake, Body Weight Gain, Digestibility, Carcass and Semen Qualities of Highland Sheep M.Sc Thesis, Mekele University, Mekele, Ethiopia.
- Gebretnsae M (2011). Effects of supplementing edible branches of dried acacia Senegal and cactus cladodes on feed intake, digestibility, body weight gain and carcass characteristics of local sheep fed barley straw. MSc.Thesis, Haramaya University, Haramaya, Ethiopia.
- Hagos A (2011). Effect of Supplementation with Air Dried Leaves of African Wild Olive (*Olea africana*), Red Thorn (*acacia lahi*) and their Mixtures on Performance of Tigray Highland Sheep Fed Grass Hay. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Hagos H (2014). Effect of Supplementation of Concentrate Mixture, Dried Local Brewery Byproduct (atella), *faidherbia albida* and *sesbania sesban* on the Performance of Local Sheep Fed Hay Basal Diet M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Hirut Y (2008). Supplementation with concentrate mix to Hararghe highland sheep fed a basal diet of urea-treated maize stover: Effect on feed utilization, live weight change and carcass characteristics. M.Sc. Thesis Haramaya University, Haramaya, Ethiopia.
- Hunegnaw A, Berhan T (2016). 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. *International Journal of Advanced Research in Biological Science* 3(2):280-295.
- Micheale Y, Yaynshet T (2014). Feed utilization, digestibility and carcass parameters of Tigray highland sheep fed wheat straw supplemented with mixtures of wheat straw supplemented with mixtures of wheat and cotton seed cake in Tigray Ethiopia. *ABC Research Alert* 2(1).
- Mulu M (2005). Effect of Feeding Different Levels of Breweries Dried Grain on Live Weight Gain and Carcass Characteristics of Wegeera Sheep Fed on Hay Basal Diet. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Mushi DE, Safari J, Mtenga LA, Kifaró GC, Eik LO (2009). Growth and distribution of non-carcass components of Small East African and F1 Norwegian crossbred goats under concentrate diets. *Livestock Science* 126:80-86.
- Pralomokarn W, Kochapakdee S, Saithanoo S, Norton BW (1995). Energy and protein utilization for maintenance and growth of Thai native and Anglo-Nubian x Thai native male weaner goats. *Small Ruminants Research* 16(1):27-35.
- Statistical Analysis System (SAS) (2008). *SAS Version 9.2 User's Guide*, SAS Institute Inc., Cary, NC, USA.
- Weldegebriel B, Kefelegn K, Mulat H (2014). Body weight gain and carcass parameters of Tigray highland sheep supplemented with acacia seyal pods and wheat bran mixture in hay based feeding. *Journal of Biology, Agriculture and Health Care* 4(17):12-21.
- Wood CD, Bisvamber NT, Vanessa EP, Ciaran JP, Barry TR, Padmini SVD, John TR, Margaret G (1994). Interspecies differences and variability with time of protein precipitation activity of extractable tannins, crude protein, ash, and dry matter content of leaves from 13 species of Nepalese fodder trees. *Journal of Chemical Ecology* 20(12):3149-3162.
- Zemicael G, Solomon M (2009). Intake, digestibility, body weight and carcass characteristics of local sheep Teff straw supplemented with sesame seed meal or wheat bran and their mixtures. *East African Journal of Science* 3(1):37-42.

Full Length Research Paper

Feed intake, digestibility and growth performance of Begait sheep fed hay basal diet and supplemented with Tsara (*Pterocarpus lucens*), Pigeon pea (*Cajanus cajan*) leaves and concentrate mixture

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The study was conducted with the objective of measuring feed intake, digestibility, and growth performance of Begait sheep fed hay basal diet and supplemented with different levels of Tsara (*Pterocarpus lucens*) leaves, Pigeon pea (*Cajanus cajan*) leaves and concentrate mixture on iso-nitrogenous basis to supply 66.60 g/day crude protein (CP) on dry matter (DM) basis. Twenty five yearling male Begait sheep with initial body weight (BW) of 24.2±1.1 kg (Mean±standard deviation, SD) were used in a randomized complete block design (RCBD) based on their initial BW. The hay was fed to all sheep on *ad libitum* basis. Treatments were hay alone (T1), or supplemented with 400 g DM Tsara (*P. lucens*) leaf (T2), 320 g DM pigeon pea (*C. cajan*) leaf (T3), 360 g DM mixtures of Tsara (*P. lucens*) and pigeon pea (*C. cajan*) leaves (T4) and 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake; T5). The study consisted of 90 days feeding and 7 days of digestibility trials. Hay DM intake ranged from 850 to 985 g/day and was the highest for T1, while total DM intake was the highest for T2 (1299 g/day), lowest for T1 (985 g/day) and intermediate for the other three treatments (1143-1202 g/day). The CP intake was higher ($P<0.001$) for T2 (115 g/day), T4 (113 g/day) and T5 (115 g/day) than T3 (105 g/day) and was lowest for T1 (55 g/day). The apparent CP digestibility was lowest for T1 (43%), and was in the order of T5 (77%) > T2 (72%) > T4 (65%) while the value for T3 (66.4%) was similar with that of T2 and T4. The average daily gain (ADG) was 31, 85, 52, 54 and 107 g/day (SEM = 1.83) in the order of T5 > T2 > T3 = T4 > T1. In conclusion, based on the biological performance results supplementation of concentrate mixture (T5) and Tsara (T2) (*P. lucens*) leaf induced a comparable response of feed intake, digestibility and body weight gain and were better than the supplemental feeds that contained Pigeon pea and are therefore recommended.

Key words: Average daily gain, feed conversion efficiency, nutrient intake.

INTRODUCTION

Tree fodders are important in improving nutrient to grazing ruminants in arid and semi-arid environments where inadequate feeds are a major constraint for livestock production. They form part of the complex interactions between plants, animals and crops (Aganga and Tshwenyane, 2003). The use of tree leaves as

fodder for ruminants has been increasingly important in many parts of the arid and semi-arid zones of tropical Africa, particularly during the dry period where about 52% of the cattle, 57% of the sheep, 65% of the goats and 100% of the camels are found (von Kaufmann, 1986; Woods et al., 1994). Leaves from browse and fodder

trees serve as a major source of livestock feed improving dietary protein in the tropical countries (Woods et al., 1994; Kaitho et al., 1998). Many parts of the country, Ethiopia, experience extended periods of drought leading to shortages of fodder and drinking water. During these periods, sheep and goats are unable to meet their nutrient needs for their maintenance and will begin to lose weight as body reserves are depleted (Alemayehu, 2006).

According to UNECA (1997), the livestock production in Tigray, as in many parts of Ethiopia, is traditional and generally dependent on crop residues, natural grazing or browsing, hay from natural pastures, agro-industrial byproducts and to some extent on introduced forage crops. However, the available feed resources are limited in terms of quantity and quality, especially in the dry season. To mitigate the problem of feed availability in the dry season, use of browse plants would be regarded as the best option. Most browse plants have high crude protein content, ranging from 10 to more than 25%; they may be considered as a more reliable feed resource of high quality to develop sustainable feeding systems and in increasing livestock productivity (Okoli et al., 2003). Thus, there is a pressing need to evaluate the potential and feed values of the indigenous browse plants (multipurpose trees and shrubs) so that they could be used in developing sustainable feeding standards. *Pterocarpus lucens*, locally called *Tsara* is a 3 to 4 m small or exceptionally 15 m tall tree species of the family Leguminosae and subfamily Fabacea (Fredericksen and Lawesson, 1992). It is a species of the south Sahelian and north sudanian ecozones distributed from Ethiopia to Senegal (Orwa et al., 2009). In Tigray region of Ethiopia, *Tsara* (*P. lucens*) is the most preferred indigenous fodder tree used by livestock owners to feed their animals. In addition, pigeon pea (*Cajanus cajan*) and different concentrate feeds like rice bran, sesame seed cake and other concentrates are available. However, no research works appear to have been done on the nutritional utilization of the indigenous fodder trees in the area. Therefore, the objectives of the study were to measure the effect of supplementing different levels of *Tsara* (*P. lucens*), pigeon pea (*C. cajan*) leaves and concentrate mixture on dry matter intake, digestibility and growth performance of *Begait* sheep.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Shire-Maitsebri Agricultural Research

Center (SMARC), Tselemti district, north western zone of Tigray regional state, Ethiopia. The district is located at 405 km far to the North West of Mekelle, the capital of the region, 85 km far to the South of Shire along the Gondar way and 1172 km far from Addis Ababa, capital of Ethiopia. Elevation ranges from 800 to 2870 m above sea level (masl). Its geographical location is 13° 05' N latitude and 38° 08' E longitude. The average annual rainfall in the area is 758 to 1100 mm, with mono modal pattern falling from June to September. The annual temperature ranges from 16 to 38°C.

Experimental animals and their management

Begait sheep breed was used for the experiment. Twenty five yearling intact local male sheep with average live body weight of 24.2±1.1 kg (mean±SD) were purchased from Shiraro local market. The age of the animals was determined by dentition and by asking information from the owners. The sheep were quarantined for 21 days in the experimental area. During this quarantine period, they were dewormed and sprayed against internal and external parasites, respectively, and vaccinated against ovine pasteurellosis and anthrax.

Experimental feed preparation

P. lucens (*Tsara*) leaves were collected from area enclosures, watersheds, communal grazing areas and individual farm lands around Tselemti district. Leaves were collected from a stand tree by lopping of the minor branches of the plant and by hand plucking of the edible leaf parts. Pigeon pea leaf was collected from Shire-Maitsebri Agricultural Research Center experimental site. The collected leaves were then transported on fresh basis and air dried for about five days under shed till the stage of leaves is crushed easily by twisting. Finally, the dried feeds were well mixed, packed in sacks and stored properly in a well-ventilated dry concrete store.

P. lucens and pigeon pea leaves required for the whole experimental period were collected once within the first three weeks of September during the pre-podding or leafy stage of the plant. The concentrate feed, rice bran was purchased from Medhanialem rice dehuling cooperatives and sesame seed cake was purchased from the local sesame oil extractors in the area and were mixed in the ratio of 3 parts rice bran to 1 part sesame seed cake (75 RB: 25 SSC). The basal diet, hay used for the experiment was harvested from Shire-Maitsebri Agricultural Research Center site, baled and stored in a well-ventilated concrete floor to avoid spoilage and mould formation.

Experimental design and dietary treatments

Randomized Complete Block Design (RCBD) having five blocks and treatments (five sheep per treatment) was used for the study. The experimental sheep were blocked into five blocks of five animals each based on their initial body weight and placed in an individual pen. Sheep within a block were randomly assigned to one of the five dietary treatments which were; hay alone (T1) and supplementation with 400 g DM *Tsara* leaves (T2), supplementation with 320 g DM pigeon pea leaves (T3), supplementation with 360 g DM mixtures of *Tsara* and pigeon pea leaves (T4) and

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supplementation with 300 g DM concentrate mixture (T5). Consequently, supplements for the other treatments were arranged on iso-nitrogenous basis and samples of the feed supplements were analyzed for DM and CP content before the execution of the experiment and the results of analysis were used to make the supplemental diets on iso-nitrogenous basis.

The DM and CP contents obtained from laboratory analysis were 95 and 16.67% for *Tsara*; 95.5 and 20.74% for pigeon pea, 96 and 16.41% for rice bran and 95.5 and 39.55% for sesame seed cake on DM basis, respectively. According to the laboratory result, the 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake) supplied 66.60 g/day CP on dry matter basis. To supply the same amount of CP from the other feed treatments on iso-nitrogenous basis 400 g DM *Tsara*, 320 g DM pigeon pea and 360 g DM (200 g DM *Tsara* + 160 g DM pigeon pea) leaves were required for the experimental sheep in T2, T3 and T4, respectively. Therefore, treatments were no supplementation to a hay diet fed *ad libitum* (T1) or hay supplementation with *Tsara* leaf (T2), pigeon pea leaf (T3), 50:50 combination of *Tsara* and pigeon pea (T4), and concentrate mixture (T5). Drinking water and common salt block were freely available to all experimental sheep throughout the experimental period.

Measurements

Feeding trial

After an acclimatization or quarantine period of 15 days to the experimental diets and pens, the feeding trial was conducted for 90 days. The experimental sheep were offered the supplement feeds in two equal portions at 08:00 and 16:00 h daily throughout the feeding trial. Basal feed was offered at a 20% refusal adjustment. Feed refusals were weighed and recorded for each animal and the difference between daily offer and refusal was calculated to determine the daily feed intake of each experimental sheep. Samples taken from batches of feed offer, and refusals were collected per animal over the experimental period and pooled on treatment basis for chemical analysis. Initial and final body weights of the experimental sheep were measured using suspended weighing balance of 50 kg weighing capacity at the beginning and at the end of the experiment for two consecutive measurements after overnight fasting. To determine the weight change, subsequent body weight measurements were made at 10 days interval throughout the experimental period. Average daily body weight gain and feed conversion efficiency were calculated as follows:

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

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

Digestibility trial

Digestibility trial was conducted at the end of the feeding trial and all sheep were harnessed with a fecal collecting bag to collect feces for the determination of digestibility. Sheep were allowed to acclimatize to the fecal collection bags for three days. This was followed by collection of feces for seven days, which was done every morning before provision of feed and water. Feces collected were weighed daily and 20% of the daily feces voided by each

animal was sampled and pooled over the collection period for each sheep separately and placed in airtight polyethylene plastic bags and stored in a deep freezer (-4°C) up to the completion of the digestibility trial.

At the end of the digestibility trial, fecal samples collected from each animal were thoroughly mixed, and 10% of the total sample collected from each animal were sub-sampled, weighed and partially dried at 60°C for 72 h. The partially dried sample of feces was ground to pass through a 1 mm sieve and stored in airtight polyethylene plastic bags until required for further analysis. During the digestibility period, feed offered and refused was recorded daily and feed samples from each feed offered and refusals from each animal were taken daily to make a composite sample. Thus, there were a total of 5 composite feed offer samples and 5 refusal samples, which were collected from each animal separately and pooled per treatment. The apparent digestibility coefficient (DC) was calculated as:

$$\text{DC (\%)} = \frac{\text{Total amount of nutrient in feed} - \text{Total amount of nutrient in feces}}{\text{Total amount of nutrient in feed}} \times 100$$

Chemical analysis

All representative samples of the daily feed offer and refusals during the feeding and the digestibility trial and fecal samples from the digestibility trial were analyzed for dry matter (DM), ash, and crude protein (CP) according to the procedures of AOAC (1990).

The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of each sample were also analyzed, according to the procedure described by VanSoest and Robertson (1985). The energy value of the treatment feeds was also estimated according to McDonald et al. (2010) as metabolisable energy (ME, MJ/kg) = 0.016 × DOMD; where DOMD = Digestible OM intake (gram) per kilogram DM. Condensed tannin was analyzed by vanillin-HCl methanol method of Price et al. (1978).

Statistical analysis

Data obtained from the study were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS, 2008) version 9.2. The differences among treatment means were tested using Tukey's studentized range (HSD) test. The model used for data analysis was:

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

where Y_{ij} = response variable, μ = overall mean, T_i = treatment effect, B_j = block effect and ϵ_{ij} = random error

RESULTS AND DISCUSSION

Chemical composition of the feed samples

The chemical composition of the feeds used in the current study is presented in Table 1. CP content of the natural pasture hay 5.56% was lower than the 7.5 to 8% maintenance requirement of animals (VanSoest, 1982). The CP content of *Tsara* (*P. lucens*), pigeon pea (*C. cajan*) leaves and the concentrate mixture (75% rice bran and 25% sesame seed cake) used in this study was 16.5,

Table 1. Chemical composition of treatment feeds.

Feed offer	Chemical composition (% for DM and % DM for others)						
	DM	Ash	CP	NDF	ADF	ADL	CT
Hay	95.75	10.25	5.56	78.74	53.90	14.53	1.87
<i>Tsara (P. leucens)</i>	95.5	7.50	16.51	53.92	36.83	13.49	6.80
Pigeon pea (<i>C. cajan</i>)	95.75	6.75	20.61	49.21	32.65	9.10	7.71
<i>Tsara</i> + pigeon pea	96.5	7.25	18.81	53.46	34.22	17.13	8.32
Concentrate mixture	95.25	9.75	21.80	48.90	14.60	7.58	0.75
Hay refusal							
Hay (T ₁)	95	8.16	2.45	82.92	56.91	21.80	0.66
Hay (T ₂)	96	8.85	2.54	82.26	55.64	20.95	0.78
Hay (T ₃)	96	8.33	2.32	81.95	56.36	21.64	0.76
Hay (T ₄)	96.5	8.55	2.63	82.56	56.54	20.86	0.82
Hay (T ₅)	96.75	8.53	2.67	81.5	55.50	21.45	0.80

ADF = Acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; CT = condensed tannin; DM = dry matter; NDF = neutral detergent fiber; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁ + 300 g DM/day Concentrate mixture.

20.61 and 21.80%, respectively. Lonsdale (1989), classified feeds as low, medium and high protein sources if they contain less than 12, 12 to 20 and greater than 20% C, respectively. Accordingly, in this study, the CP content of hay is low, *Tsara (P. lucens)* medium however pigeon pea (*C. cajan*) and concentrate mixture feeds are classified as high protein sources, respectively.

The NDF and ADF contents of the hay in this study were 78.74 and 53.90%, and that of ADL content was 14.5%. Therefore, the NDF content of the hay in this study is high to impact the intake and digestibility of dry matter (Beyene, 1976). The high fiber content of hay in this study might be due to the maturity of the hay at harvesting time. Since as a plant matures its cell wall constituents or structural carbohydrates like cellulose, and other components such as lignin increases and the percentage of CP decreases (McDonald et al., 2002). *Tsara* leaf showed higher NDF, ADF and ADL contents (53.92, 36.83, and 13.49%, respectively) followed by Pigeon pea leaves 49.21, 32.65 and 9.10%, respectively. The NDF, ADF and ADL content of the concentrate mixture in this study was 48.90, 14.60 and 7.58%, respectively. In general, Rajupreti (2006) revealed that a feed that contained more than 45% ADF and 65% NDF content is considered as low quality feed. However, the feed stuffs used in this study can be classified as medium to high quality supplemental feeds except hay.

In this study, lower CT levels were recorded for hay and concentrate mixture, than the CT levels in *Tsara (P. lucens)* leaves and pigeon pea leaves. The CT concentration of pigeon pea leaves in this study was higher. It has been believed that forage containing tannin above 5% can be considered as tannin rich forage and become a serious anti nutritional factor in plant materials

fed to ruminants (Barry and Manley, 1984; Leng, 1997). Furthermore, Lohan et al. (1980) noted that condensed tannins with 5 to 10% of the feed are considered anti-nutritive and are toxic; whereas this is contradicted by the idea reported by Waghorn et al. (1999) which reveals the presence of CT at dietary concentrations below approximately 10% in the diet may increase the performance of the ruminants. At higher levels, tannins become highly detrimental (Barry and Duncan, 1984), as they reduce digestibility of fiber in the rumen (Reed et al., 1985) by inhibiting the activity of bacteria (Chesson et al., 1982) and anaerobic fungi (Akin and Rigsby, 1985) and also lead to reduced intake (Leng, 1997).

Dry matter and nutrient intake

The average daily dry matter intake (DMI) and nutrient intake of Begait sheep during the feeding trial period is presented in Table 2. Hay intake was the highest for T1 ($P < 0.05$) and similar for the supplemented groups with the exception that values for T2 > T4 ($P < 0.05$). More hay intake in the non-supplemented group could be an attempt by the experimental sheep in order to satisfy their nutrient requirements. However, Gizat (2011) noted supplementation to have increased intake of the basal diet hay from 623.7 g/day in the control group to the range of 640.9 to 653.9 g/day in the supplemented group when *Wogera* sheep was fed grass hay as a basal diet and supplemented with 300 g/day brewery dried grain, cottonseed cake and their mixture. The variation in the two studies might be due to the high NDF content of the basal diet used in this study that probably limited intake of hay by *Begait* sheep. The result of hay DMI in this

Table 2. Daily dry matter and nutrient intakes of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Intake (g/day)	Treatment feeds					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
Hay DM	985.19 ^a	910.18 ^b	868.68 ^{bc}	850.57 ^c	891.77 ^{bc}	11.77	***
Supplement DM	-	389.06 ^a	274.69 ^c	351.24 ^b	299.67 ^c	6.22	***
Total DM	985.19 ^c	1299.24 ^a	1143.37 ^b	1201.82 ^b	1191.44 ^b	14.02	***
DMI (% BW)	3.61 ^b	4.01 ^a	4.02 ^a	4.17 ^a	3.56 ^b	0.06	***
DMI (g/kgW ^{0.75})	82.53 ^b	95.61 ^a	92.81 ^a	96.57 ^a	92.79 ^b	1.28	***
Nutrient Intake (g/day)							
OM	884.21 ^c	1176.77 ^a	1035.79 ^b	1089.17 ^b	1070.82 ^b	12.71	***
CP	54.78 ^c	114.84 ^a	104.91 ^b	113.36 ^a	114.91 ^a	1.50	***
NDF	775.74 ^c	926.46 ^a	819.18 ^{bc}	857.52 ^b	848.72 ^b	10.15	***
ADF	531.02 ^{cd}	633.88 ^a	557.90 ^{bc}	578.66 ^b	524.42 ^d	6.94	***
ME (MJ/day)	8.51 ^c	13.18 ^a	11.62 ^b	12.64 ^{ab}	13.21 ^a	0.32	***

^{a-d}Mean values in a row having different superscripts differ significantly; *** $P < 0.001$; SL = Significance level; SEM = standard error of the mean; DM = dry matter; BW = body weight; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ME = metabolizable energy; MJ = mega joule; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁ + 300 g DM/day Concentrate mixture.

study was higher than the 751.73 g/day for the control group and 695.28 to 724.35 g/day in the supplemented group reported by Gebreslasie (2012) of yearling Tigray highland sheep rams supplemented with graded levels of air dried *Acacia saligna* leaves (100 to 400 g/day) and 200 g/day wheat bran.

The supplement feeds were consumed 97.3, 85.84, 97.56 and 99.89% for T₂, T₃, T₄ and T₅, respectively. The primary reason for intake variation of the supplements among treatments appeared to be due to differences in amount fed in an attempt to make the supplemental diet iso nitrogenous. Conversely, the low supplement DM intake in T₃ might be attributed to the relatively higher level of CT in pigeon pea leaves which may limit intake (Bate-Smith, 1973; Mehanisho et al., 1987; Aletor, 1993). Total DMI and OM intakes (OMI) were the highest for T₂, lowest for T₁ and intermediate for the other three treatments, and supplementation increased the total DMI by 31.88, 16.15, 21.99 and 20.94% and OMI by 33.17, 17.14, 23.18 and 21.11% for T₂, T₃, T₄ and T₅, respectively. The total DMI as percent of body weight and metabolic body weight basis in this study was lower ($P < 0.001$) in T₁ and T₅ as compared to the other treatments. Comparable values have been reported for different Ethiopian sheep breeds (Abebaw, 2007; Awet, 2007; Hirut, 2008). In general, total DMI and OMI was relatively higher in this study than previous ones (Abebaw, 2007; Awet, 2007; Gebreslassie, 2012; Hagos, 2014) for other breeds of sheep. Such differences might be mainly attributed to the relatively higher body weight of *Begait* sheep breeds.

The CP intake of *Begait* sheep was lowest for T₁ and values for T₂, T₄ and T₅ was higher ($P < 0.001$) than that

of T₃. Differences in CP intake among the supplemented groups are a consequence of reduced intake of pigeon pea as compared to the other supplemental diets. Intake of ME was lowest for T₁, and among the supplemented treatments values for T₃ was lower than T₂ and T₅ ($P < 0.001$). According to ARC (1980), the metabolisable energy and protein requirement for growth of a 30 kg sheep gaining 50 to 100 g daily is 7.0 to 8.5 MJ/day and 55 to 65 g/day, respectively, which indicates that the result of the current study is above the satisfactory energy and protein requirement for maintenance and growth (30.6-106.67 g/day gain) of *Begait* sheep. Associated with total DMI, the NDF and ADF intake of the non-supplemented sheep was lower than the supplemented ones with the exception of T₃.

The trend of total DMI of *Begait* sheep fed hay as a basal diet and supplemented with different levels of *Tsara* (*Pt. lucens*) and pigeon pea (*C. cajan*) leaves and concentrate mixture across the feeding period is presented as indicated in Figure 1. The figure indicated that sheep supplemented with *Tsara* (*P. lucens*) T₂ showed a consistently higher DM intake followed by T₄, T₅ and T₃ whereas, T₁ shows lower DM intake throughout the study period. In addition similar trends of fluctuation in DMI were observed in all dietary treatments throughout the experimental period this might be associated with the prevailing weather condition (Temperature and Precipitation).

Apparent dry matter and nutrient digestibility

The apparent digestibility of DM and OM were lower ($P <$

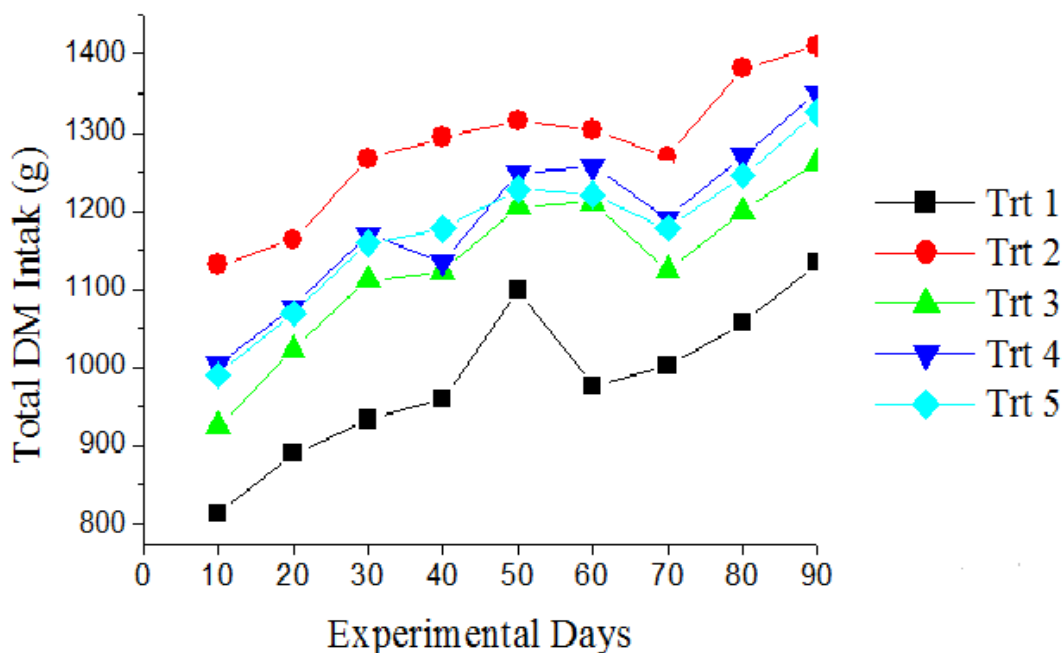


Figure 1. Trends in total Dry matter intake of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture. T₁ = Hay *ad libitum*; T₂ = T₁+ 400 g DM/day *Tsara*; T₃ = T₁+ 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅= T₁ + 300gDM/day Concentrate mixture.

Table 3. Dry matter and nutrient digestibility of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Apparent digestibility (%)	Treatment feeds					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
DM	56.78 ^b	67.03 ^a	65.13 ^a	64.53 ^a	69.29 ^a	1.31	***
OM	58.82 ^b	67.96 ^a	67.23 ^a	66.12 ^a	71.38 ^a	1.27	***
CP	43.17 ^d	71.55 ^b	66.42 ^{bc}	64.77 ^c	77.12 ^a	1.25	***
NDF	55.66 ^b	62.86 ^a	59.03 ^{ab}	57.07 ^{ab}	63.01 ^a	6.35	**
ADF	50.79	55.26	53.85	48.39	52.39	1.79	ns

^{a-d}Mean values in a row having different superscripts differ significantly; ns = not significant; ** = significant at $P < 0.01$; *** = significant at $P < 0.001$; ADF = Acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁ + 300 g DM/day Concentrate mixture.

0.001) for the non-supplemented group, and similar among the supplemented treatments (Table 3). Improvements in DM and OM digestibility due to supplemental protein and/or energy have been well documented (Yohannes, 2011; Gebreslassie, 2012; Hagos, 2014). This is obviously a result of increased nutrient supply to rumen microbes for their proliferation in abundance to colonize and digest more of the DM or OM consumed (Bonsi et al., 1995).

The CP digestibility was also increased ($P < 0.001$) as a result of supplementation. Among the supplemented

groups, apparent digestibility of CP was in the order of T₅ > T₂ > T₄ and values for T₃ was similar to that of T₂ and T₄, which might be associated with differences in the CP content of the supplements. The CP digestibility result of the basal diet hay in the current study was similar to the 47.4 and 39.59%, reported by Hagos (2011) and Abebaw (2007), respectively. But lower values CP digestibility for hay of 36 to 37% (Gizat, 2011; Melese, 2011) and higher values 63% (Yilkal, 2011) as compared the current result has also been noted.

This variability in the digestibility of the basal diet hay

Table 4. Body weight change and feed conversion efficiency of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Parameter	Treatment feeds					SEM	SL
	T ₁	T ₂	T ₃	T ₄	T ₅		
Initial body weight (kg)	24.52	24.76	23.76	23.96	23.84	0.41	Ns
Final body weight (kg)	27.28 ^b	32.44 ^a	28.4 ^b	28.8 ^b	33.44 ^a	0.38	***
Body weight change (kg)	2.76 ^d	7.68 ^b	4.64 ^c	4.84 ^c	9.60 ^a	0.17	***
ADG (g/day)	30.67 ^d	85.33 ^b	51.56 ^c	53.78 ^c	106.67 ^a	1.83	***
FCE (g ADG/g TDMI)	0.03 ^d	0.068 ^b	0.046 ^c	0.044 ^c	0.092 ^a	0.0021	***

^{a-d}Mean values in a row having different superscripts differ significantly; ns = not significant; *** $P < 0.001$; SL = Significance level; SEM = standard error of the mean; ADG = average daily gain; FCE = feed conversion efficiency; TDMI = total dry matter intake; T₁ = Hay *ad libitum*; T₂ = T₁ + 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ + 360 g DM/day *Tsara* + pigeon pea; T₅ = T₁ + 300 g DM/day Concentrate mixture.

might be attributed to differences in nutrient contents of the basal diet hay, especially to supply the minimum nitrogen required by the rumen microbes.

The digestibility of NDF was improved by supplementation in T₂ and T₅ but not in T₃ and T₄, while ADF digestibility was unaffected by treatment ($P > 0.05$). Generally, supplementation with CP might induce better digestibility of NDF. The lack of effect of supplementation on NDF digestibility of T₃ and T₄ might be associated with the relatively higher level of CT in pigeon pea leaves as compared to *Tsara* leaves and concentrate mixture (Degen et al., 1995).

Body weight change and feed conversion efficiency

Body weight change, daily body weight gain (ADG) and feed conversion efficiency (FCE) of *Begait* sheep fed hay and supplemented with *Tsara* (*P. lucens*), pigeon pea (*C. cajan*), mixture of *Tsara* and pigeon pea leaves and concentrate mixture is presented in Table 4. As expected, the initial body weight of the experimental sheep was similar among treatments ($P > 0.05$). Final body weight, body weight change, ADG and FCE vary among treatments ($P < 0.001$) and were positively affected by supplementation. Final body weight of T₃ and T₄ was similar with the non-supplemented group apparently due to the slightly higher initial body weight of sheep under T₁ that was carried over to the final body weight. However, T₁ performed the least in body weight change, ADG and FCE. Among the supplemented treatments body weight change, ADG and FCE was in the order of T₅ > T₂ > T₃ = T₄ ($P < 0.001$).

The ADG of 31 g/day for sheep fed on the sole basal diet appears to be in contrary to the expectation for the hay containing CP below the maintenance level (Van Soest, 1982). This in part could be due to the high consumption of the basal diet by sheep in the control treatment that probably enables the animal to harvest sufficient nutrient for a positive ADG. Despite an iso

nitrogenous supplemental diet supply for the supplemented treatments as well as a similar CP and ME intake among T₂, T₄ and T₅, ADG and FCE was highest for T₅ followed by T₂ and least for pigeon pea leaves containing treatments. This might possibly be associated with differences in the CT content of the supplemental diets that might have hindered the nutrient digestibility and availability for growth. Consequently, sheep in T₅ gained double as compared to sheep in pigeon pea containing diets. Based on such performance parameters, *Tsara* appeared to be better as a supplemental diet as compared to pigeon pea although the latter is 4% richer in CP content. This suggests that for such kind of forages, the level of anti-nutritional factors should be given enough attention in addition to the contents of nutrients to better utilize them through proper level of supplementation.

The FCE observed in this study was consistent with the trend of ADG, which is in agreement with the idea reported by Pond et al. (1995) that states diets that promote high rates of gain will usually result in a greater efficiency than diets that do not allow rapid gain, as the rapidly gaining animals utilize less of the total feed intake for maintenance and more of it for body weight gain.

The trend of body weight change across the feeding period for *Begait* sheep in the current study is depicted in Figure 2. There was a consistent increase in body weight throughout the experiment for all the supplemented treatments. But a sharp increase in body weight was observed for T₂ and T₅. However, for the non-supplemented sheep, animals tend to gain weight for the first 30 days and almost stabilize then after.

Conclusion

Based on the results of feed intake, apparent digestibility and body weight gain of the supplemented *Begait* sheep; supplementation of concentrate mixture (T₅) and *Tsara* (*P. lucens*) leaf (T₂) induced a comparable response and

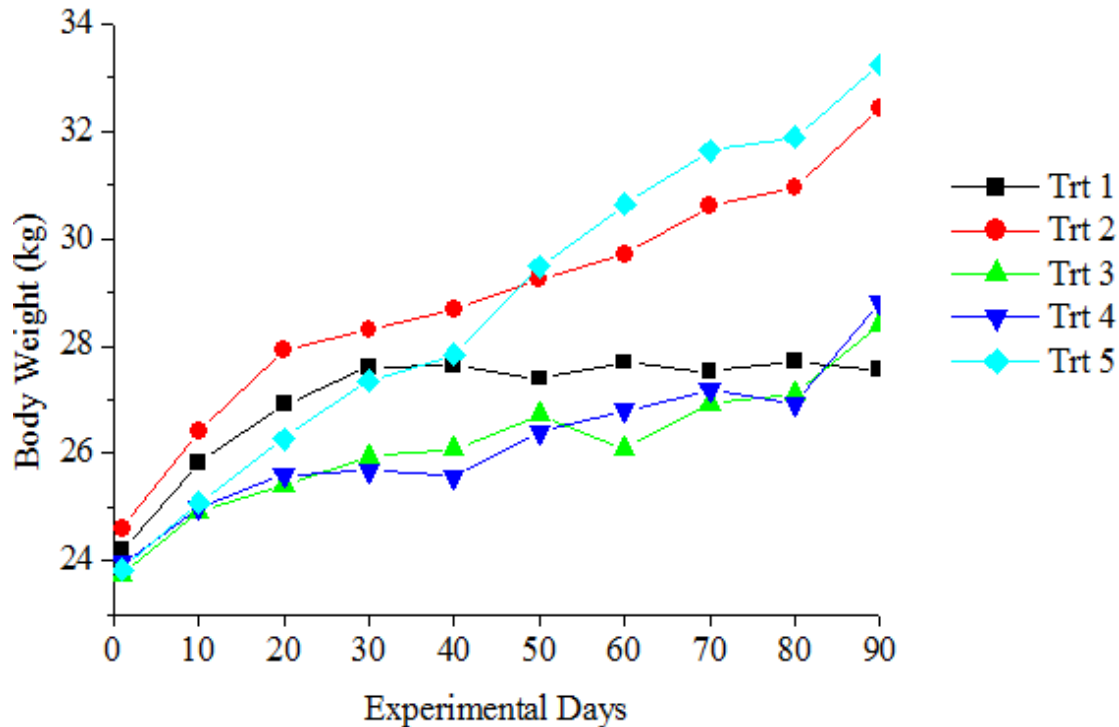


Figure 2. Trends in body weight changes of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture. T₁ = Hay *ad libitum*; T₂ = T₁+ 400 g DM/day *Tsara*; T₃ = T₁ + 320 g DM/day pigeon pea; T₄ = T₁ +360 g DM/day *Tsara* +pigeon pea; T₅= T₁ + 300 gDM/day Concentrate mixture.

were better than the supplemental feeds that contained pigeon pea, and are therefore recommended for further demonstration at the farmers level.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

- Abebaw N (2007). Effect of Rice Bran and/or Noug Seedcake Supplementation on Feed Utilization and Live Weight Change of Farta Sheep Fed Native Grass Hay. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Aganga AA, Tshwenyane SO (2003). Feeding values and Anti-nutritive factors of forage tree legumes. *Pakistan Journal of Nutrition* 2(3):170-177.
- Akin DE, Rigsby LL (1985). Influence of phenolic acids on rumen fungi. *Agronomy Journal* 77:180-182.
- Alemayehu M (2006). Country pastures/ forage resource profiles. Ethiopia. FAO (Food and Agricultural Organization of the United Nations).
- Aletor VA (1993). Allelochemicals in plant food and feeding stuffs; nutritional, biochemical and physiopathological aspects in animal production. *Veterinary and Human Toxicology* 35(1):57-67.
- Association of Official Analytical Chemists (AOAC) (1990). Official Method of Analysis. 15th ed. AOAC Inc. Arlington, Virginia, USA.
- Agricultural research council (ARC) (1980). The nutrient requirements of ruminant livestock. Common wealth Agricultural bureaux, Farnham Royal, England UK. pp. 114-151.
- Awet E (2007). Feed utilization, body weight and carcass parameters on intact and castrated Afar sheep fed on urea treated teff straw supplemented with wheat bran. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Barry TN, Duncan SJ (1984). The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. I. Voluntary intake. *Journal of AOAC* 65:496-497.
- Barry TN, Manley TR (1984). The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. Quantitative digestion of carbohydrate and Protein British. *Journal of Nutrition* 51:493-504.
- Bate-Smith EC (1973). Haem analysis of tannin, the concept of relative astringency. *Phytochemistry* 12:907-912.
- Beyene C (1976). Laboratory evaluation and estimation of nutritive value of some Ethiopian feedstuffs and formulae plus animal evaluation of noug seed cake. A PhD Thesis Cornell University Ithaca, New York.
- Bonsi MLK, Osuji PO, Tuah AK (1995). Effect of supplementing teff straw with different levels of leucaena or sesbania leaves on the degradabilities of teff straw, sesbania, leucaena, tagasaste and vernonia and on certain rumen and blood metabolites in Ethiopian Menz sheep. *Animal Feed Science and Technology* 52(1-2):101-129.
- Chesson A, Stewart CS, Wallace RJ (1982). Influence of plant phenolic acids on growth and cellulolytic activity of rumen bacteria. *Applied Environmental Microbiology* 44:597-603.
- Degen AA, Becker K, Makkar HPS, Borowy N (1995). Acacia saligna as a fodder tree for desert livestock and the interaction of its tannins with fibre fractions. *Journal of Science and Food Agriculture* 68:65-71.
- Fredericksen P, Lawesson JE (1992). Vegetation types and patterns on

- Senegal based on Multivariate Analysis of field and NOAA-AVHRR satellite data. *Journal of Vegetation Science* 3:535-544.
- Gebreslassie G (2012). Effects of Supplementing Wheat Bran and Graded Levels of Dried *Accacia Saligna* Leaves on Feed Intake, Body Weight Gain, Digestibility, Carcass and Semen Qualities of Highland Sheep M.Sc Thesis, Mekele University, Mekele, Ethiopia.
- Gizat T (2011). Feeds and Feeding Practices of Traditional Fattening and Evaluation of Supplemental Value of Cotton Seed Cake and Breweries Dried Grain to Wogera Sheep Fed Grass Hay. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Hagos A (2011). Effect of Supplementation with Air Dried Leaves of African Wild Olive (*Olea africana*), Red Thorn (*acacia lahi*) and their Mixtures on Performance of Tigray Highland Sheep Fed Grass Hay. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Hagos H (2014). Effect of Supplementation of Concentrate Mixture, Dried Local Brewery Byproduct (*atella*), *faidherbia albid*a and *sesbania sesban* on the Performance of Local Sheep Fed Hay Basal Diet M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Hirut Y (2008). Supplementation with concentrate mix to Hararghe highland sheep fed a basal diet of urea-treated maize stover: Effect on feed utilization, live weight change and carcass characteristics. M.Sc. Thesis Haramaya University, Haramaya, Ethiopia.
- Kaitho RJ, Nsahlai IV, Williams BA, Umunna NN, Tamminga S, Van Bruchem J (1998). Relationship between preference, rumen degradability, gas production and chemical composition of browses. *Agroforestry System* 39:129-144.
- Leng RA (1997). Tree foliage in ruminant nutrition. Published by FAO Rome.FAO-139.
- Lohan OP, Lall D, Pall RN, Negi SS (1980). Note on tannins in tree fodders. *Indian Journal of Animal Science* 50:881-883.
- Lonsdale C (1989). Raw Materials for Animal Feed Compounders and Farmers. Chalcombe Publications. P. 88.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA (2002). *Animal Nutrition*, 6th ed, Prentice Hall, Harlow, England, London.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG (2010). *Animal Nutrition*, 7thed, Prentice hall, Harlow, England, London.
- Mehanisho H, Butter LG, Carlson DM (1987). Dietary tannin and salivary praline-rich proteins; interactions, induction and defense mechanism. *Annual Reviews on Nutrition* 7:423-430.
- Melese D (2011). Effect of Supplementation of Hay with Graded Levels of Rapeseed Cake and Rice Bran Mixture on Feed Intake, Digestibility, Body weight Change and Carcass Characteristics of Farta Sheep. M.Sc. Thesis Haramaya University, Haramaya, Ethiopia.
- Okoli IC, Anunobi MO, Obua BE, Enemu V (2003). Studies on selected browses of southeastern Nigeria with particular reference to their proximate and some endogenous anti-nutritional constituents. *Livestock Research for Rural Development* 15(9) Retrieved December24,2007.Accessableat:<http://www.lrrd.org/lrrd15/9/okol159.htm>. Accessed date April 26, 2014.
- Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A (2009). *Agroforestry Database: a tree reference and selection guide version 4.0*. Access bleat: <http://www.worldagroforestry.org/af/treedb/>. Accessed date may 3, 2014.
- Price ML, VanScoyoc S, Butler LG (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal of Agricultural Food and Chemistry* 26:1214-1218.
- Pond WG, Church DC, Pond KR (1995). *Basic Animal Nutrition and Feeding* 4th ed., John Wiley and Sons, New York.
- Rajupreti C (2006). Nutrient content of feeds and fodder in Nepal. 1stEdition printed by Nirav printing and general order suppliers, Gwarko, NepalReed JD, Horvath PJ, Allen MS, Van Soest PJ (1985). Gravimetric determination of soluble phenolics including tannins from leaves by precipitation with trivalent ytterbium. *Journal of the Science of Food and Agriculture* 36:255-261.
- Statistical Analysis System (SAS) (2008). *SAS Version 9.2 User's Guide*, SAS Institute Inc., Cary, NC, USA.
- United Nations Economic Commission for Africa (UNECA) (1997). *Livestock development in Tigray: forage development strategy as a major entry point towards a sustainable minimum grazing system, Part I. Sustainable Development and Environmental Rehabilitation Program (SAERP)*, UNECA, Addis Ababa.
- VanSoest PJ (1982). *Nutritional Ecology of the Ruminants*. O and B books, Corvallis, Oregon, USA.
- VanSoest PJ, Robertson JB (1985). Methods of analysis of dietary neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74:3585-3597.
- Von Kaufmann R (1986). An introduction to the sub-humid zone of West Africa and the ILCA subhumid zone programme. In: *Livestock systems research in Nigeria's sub-humid zone. Proceedings of the second ILCA/NAPRI symposium held in Kaduna, Nigeria, 29 Oct. - 2 Nov. 1984*. ILCA, Addis Ababa, Ethiopia.
- Waghorn GC, Reed J, Ndlovu LR (1999). Condensed tannins and herbivore nutrition. In *Proceedings of the XVIII International Grassland Congress. Association Management Centre Calgary* 3:153.
- Woods CD, Tiwari B, Plumb VE, Powell CJ, Roberts BT, Sirimane VDP, Rositer JT Gill M (1994). Interspecies differences and variability with time of protein precipitation activity of extractable tannins, crude protein, ash and dry matter contents of leaves from 13 species of Nepalese fodder trees. *Journal of Chemistry and Ecology* 20:3149-3162.
- Yilkal T (2011). Supplementation with different forms of processed lupin (*Lupinus albus*) grain in hay based feeding of Washera sheep: effect on feed intake, digestibility, body weight gain and carcass parameters. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Yohannes U (2011). Supplementation of different level of corn silage with linseed meal on performance of Black head Ogaden sheep fed grass hay. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

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