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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 (*Cajunus 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, bailed 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:

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

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

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:

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

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 Turkeys' 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, Ti = 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
Tsara (*P. leucens*)	95.5	7.50	16.51	53.92	36.83	13.49	6.80
Pigeon pea (*C. cajan*)	95.75	6.75	20.61	49.21	32.65	9.10	7.71
Tsara + 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; T_1 = Hay *ad libitum*; T_2 = T_1+ 400 g DM/day *Tsara*; T_3 = T_1 + 320 g DM/day pigeon pea; T_4 = T_1 +360 g DM/day *Tsara* +pigeon pea; T_5 = T_1 + 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						
	T_1	T_2	T_3	T_4	T_5	SEM	SL
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; T_1 = Hay *ad libitum* ; T_2 = T_1+ 400 g DM/day *Tsara*; T_3 = T_1 + 320 g DM/day pigeon pea; T_4 = T_1 + 360 g DM/day *Tsara* + pigeon pea; T_5 = T_1+ 300 gDM/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*<

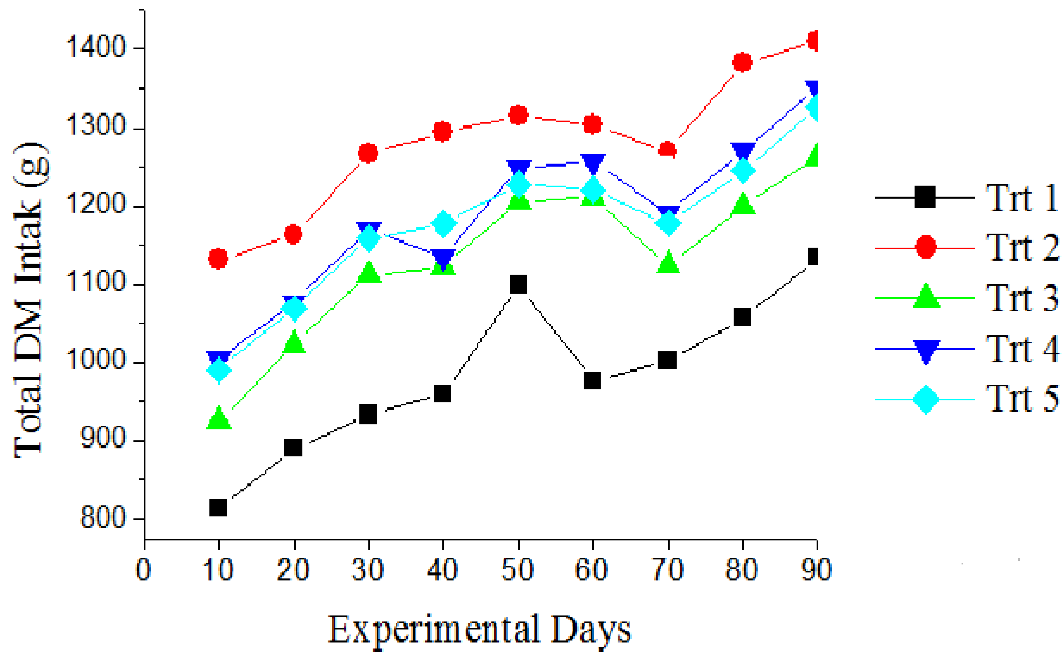

Figure 1. Trends in total Dry matter intake of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture. T_1 = Hay *ad libitum* ; T_2 = T_1+ 400 g DM/day *Tsara*; T_3 = T_1+ 320 g DM/day pigeon pea; T_4 = T_1 + 360 g DM/day *Tsara* + pigeon pea; T_5 = T_1 + 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

$^{a\text{-}d}$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; T_1 = Hay *ad libitum* ; T_2 = T_1 + 400 g DM/day *Tsara*; T_3 = T_1 + 320 g DM/day pigeon pea; T_4 = T_1 + 360 g DM/day *Tsara* + pigeon pea; T_5 = T_1 + 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 CT 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; T_1 = Hay *ad libitum* ; T_2 = T_1 + 400 g DM/day *Tsara*; T_3 = T_1 + 320 g DM/day pigeon pea; T_4 = T_1 +360 g DM/day *Tsara* + pigeon pea; T_5 = T_1 + 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 *Begit* 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

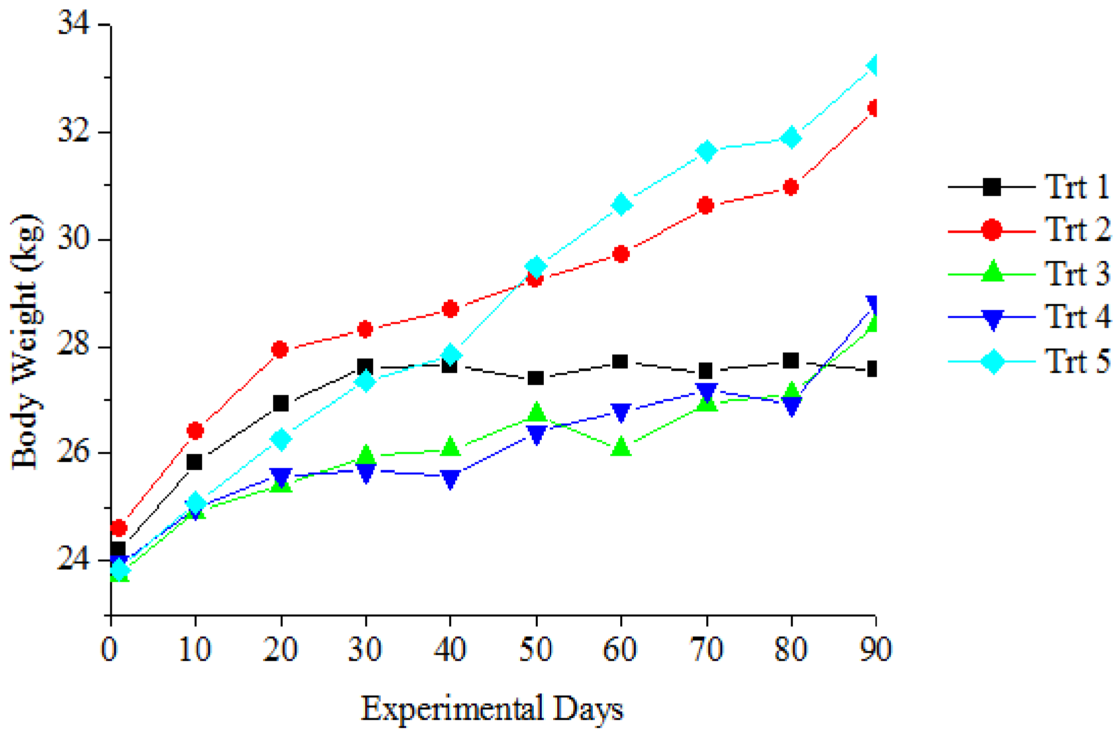

Figure 2. Trends in body weight changes of *Begait* sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture. T_1 = Hay *ad libitum*; $T_2 = T_1$+ 400 g DM/day *Tsara*; $T_3 = T_1$ + 320 g DM/day pigeon pea; $T_4 = T_1$ +360 g DM/day *Tsara* +pigeon pea; $T_5 = T_1$ + 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.

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