Supplementary Value of Camel's Foot Tree (*Piliostigma thonningii*) Leaf Meal as a Replacement for Concentrate Mixture on the Performance of Gumuz Sheep Fed Finger Millet Straw Based Diet

Almaz Ayenew[1,2*], Adugna Tolera[2], Ajebu Nurfeta[2] and Getnet Assefa[3]

[1]Department of Animal Science, Debre Markos University, P.O. Box 269, Debre Markos, Ethiopia
[2]School of Animal and Range Science, Hawassa University, College of Agriculture, P.O. Box 5, Hawassa, Ethiopia
[3]Ethiopian Institute of Agricultural Research (EIAR), P.O. Box-2003, Addis Ababa, Ethiopia

Abstract: The objective of the experiment was to evaluate the effects of substitution of Camel's foot tree (*Piliostigma thonningii* (PT)) leaf meal for concentrate mix (CM) on the performances of Gumuz sheep. During the 90 days feeding trial, thirty five yearling male Gumuz sheep with an average initial body weight of 20.21 ± 2.82 kg (mean ± SD) were grouped into seven blocks of five animals, and each animal was randomly assigned to one of the five dietary treatment feeds within a block. The dietary treatments included feeding of *ad libitum* finger millet straw supplemented with 100% CM (T1); 75% CM + 25% PT (T2); 50% CM + 50% PT (T3), 25% CM + 75% PT (T4) and 100% PT (T5) on dry matter (DM) basis. The supplements were offered at the rate of 300 g DM/day. The total DM and organic matter intakes for T1 were greater ($P<0.05$) than those sheep fed T4 and T5 diets while T2 and T3 had an intermediate value. The lowest ($P<0.05$) supplement and CP intakes were recorded for T5. The digestibility of DM, organic matter, crud protein, neutral detergent fiber and acid detergent fiber was similar ($P>0.05$) up to 50% PT leaf meal substitution level. Sheep fed T5 diet had the lowest ($P<0.05$) DM and nutrient digestibility. The average daily gain for T1, T2, T3 and T4 was higher ($P<0.05$) than those consuming T5 diets. The slaughter weight for T1 was higher ($P<0.05$) than T5 while T2, T3 and T4 had an intermediate values. The hot carcass weight and empty body weight were similar ($P > 0.05$) among treatments. An increase in proportion of PT leaf meal beyond 75% resulted in BW loss of 19.2 g/d. It was concluded that PT leaves could serve as alternative CP supplement in crop residue based feeding and substitution of concentrate with PT leaf meal beyond 50% had no beneficial role in sheep feeding.

Keywords: *Average daily gain, Dry matter, Straw, Substitution*

Introduction

Inadequate feed supply both in terms of quantity and quality is the major constraints that affect livestock production in Ethiopia (Getahun, 2008). To mitigate the problem of feed availability and quality, the use of browse plants would be regarded as good options (Takele *et al*., 2014). Most browse plants have high crude protein content and hence could be considered as a more reliable feed resource of high quality to develop sustainable feeding systems and to increase livestock productivity under small production system (Okoli *et al*., 2003). Thus, there is a pressing need to evaluate the potential and feed values of the indigenous browse plants so that they could be used in developing sustainable feeding standards. Several studies on multi-purpose fodder trees have been conducted in different parts of Ethiopia (Abebe *et al*., 2008; Mulubrhan *et al*., 2011; Belete *et al*., 2012). Most studies dealt with the chemical composition and socio-economic aspects of the fodder tree species. However, for efficient utilization of feed resources and development of feeding strategies for fodder trees, laboratory based nutritive value analysis should be supported by feeding trial studies. Therefore, it is imperative to assess the effects of feeding fodder tree leaves on animal performance. Among the indigenous browse species grown and utilized by farmers in Ethiopia, PT is drought-tolerant and a multipurpose tree used as a source of medicine, wood, food and year-round sources of fodder for animals. In the northwestern Ethiopia, farmers traditionally manage PT in their farm lands and backyards as a palatable fodder source for ruminant and non-ruminant livestock (Tesfaye, 2008). Okunade *et al.* (2014) reported that PT leaf contains 14.2% crude protein. Although PT is widely grown in Ethiopia, little work has been done so far on the feeding value of this browse species. Therefore, this study was designed to evaluate the effects of PT leaf meal supplementation as a replacement for concentrate mixture on feed intake, digestibility, weight gains and carcass characteristics of Gumuz sheep fed a basal diet of finger millet straw.

*Corresponding Author. E-mail: almazayenew@yahoo.com

Published by Haramaya University, 2019

This is an open access article under the CC BY-NC license (https://creativecommons.org/licenses/by-nc/4.0/).

ISSN: 2616-8804 (Print)

Materials and Methods

Description of the Study Area

This experiment was conducted at Pawe Agricultural Research Center of the Ethiopian Institute of Agricultural Research. The area is located 575 km North West of Addis Ababa representing the hot to warm moist agro-ecological zone. The center is located between 36°20'-36°32' east longitude and 11°12'-11°21' north latitude. Pawe Agricultural Research Center is located at an elevation of 1120 meter above sea level with annual minimum and maximum temperature of 16.3 and 32.6 ^{O}C, respectively. It receives an annual rainfall ranging from 900 to 1587 mm (MZARDO, 2010).

Experimental Animals and their Management

Thirty five yearling intact male Gumuz sheep with an initial body weight of 20.21 ± 2.82 kg (mean ± SD) were purchased from Pawe market. The animals were kept for 21 days in isolated holding house to acquaint to the new environment and to observe the existence of any disease condition before the commencement of the experiment. The animals were dewormed, against internal parasites using Albendazol and vaccinated against Pasteurellosis. At the end of the quarantine period, sheep were grouped into seven blocks of five sheep each based on their initial body weight and transferred to individual pens. Sheep were offered the respective treatment diets for fifteen days to get them adapted to the experimental feeds prior to the beginning of the actual experiment. The experimental sheep were offered finger millet straw basal diet *ad libitum* allowing a refusal of 20%. The supplements were offered at 300 g/head/day on DM basis in equal portions at 0800 and 1600 hours. Mineral salt lick and water were made available at all times. Mineral salt lick was tied using string and suspend for each experimental sheep.

Experimental Feed Preparation and Treatments

The finger millet straw used for the feeding trial was purchased from farmers in the vicinity of Pawe Agricultural Research Center. The PT leaves were harvested from plants grown within Pawe Agricultural Research Center and nearby communal free grazing areas during the peak season (June- July) of vegetative growth (high leaf production). The collected leaves were air dried under shade, thoroughly mixed, chopped using a chopper, packed using sacks and stored in a well-ventilated store for subsequent use. Noug seed cake and wheat bran was purchased from the oil extraction factory and milling industry, respectively. The concentrate mix was formulated using noug seed cake and wheat bran at a ratio of 1:2. The experimental diets were made to be iso-nitrogenous to have 20% CP. Kearl (1982) recommended 72g daily CP intake to support 100 g daily gain for average 20 kg growing sheep under extensive management of tropical environment on which the present CP requirement was based. The dietary treatments included feeding of *ad libitum* finger millet straw supplemented with 100% CM (T1); 75% CM + 25% PT (T2); 50% CM + 50% PT (T3), 25% CM + 75% PT (T4) and 100% PT (T5) on DM basis.

Digestibility Trial

After adaptation period, each animal was fitted with fecal collection bags for 3 days of acclimatization period prior to the actual total collection of feces for 7 consecutive days. Feed samples from each feed and refusals from each animal were collected every day to make a weekly composite feed sample for each feed and refusal for each animal. From the composite feed sample and refusal for each animal, subsamples were taken after thoroughly mixing for chemical analysis. Total daily feces voided by each animal were weighed in the morning prior to offering water and feeds. Twenty percent of the daily fecal excretion of each animal was sampled and dried at 55 ^{o}C for 72 hours. The dried samples were pooled over the 7 days collection period, composited in a plastic bag for each animal. From the composite samples, sub-samples (10%) were taken for each animal after thoroughly mixing, dried at 100 ^{o}C overnight and ground to pass through 1 mm sieve and kept in airtight containers for chemical analysis. Apparent digestibility of DM and nutrients were determined using the following formula;

$$\text{Apparent digestibility coefficient} = \frac{(\text{Nutrient intake} - \text{nutrient in feces})}{\text{Nutrient intake}}$$

Growth Trial

The feeding trial was conducted for 90 days following the digestibility trial using the same animals and experimental diets. Feed offered and refused were collected, weighed and recorded daily for each animal to determine daily feed intake. Samples of feed offered and refusals of each animal were collected over the experimental period for each feed and sub-sampled for chemical analysis. The initial and final body weights of experimental animals were recorded on the first day and the last day of the experiment, respectively, using weighing balance to determine body weight change. Thereafter, animals were weighed every 10 days in the morning after overnight fasting using Salter Scale with a sensitivity of 100 g. The average daily weight gain (ADG) was calculated as the difference between final and initial body weights divided by a number of feeding days. The feed conversion efficiency (FCE) of experimental animals was determined by dividing the ADG with the amount of feed consumed daily.

Carcass Parameters

At the end of the feeding trial, 25 sheep (5 sheep per treatment) were randomly selected and slaughtered after an overnight fasting. Slaughter weight was recorded and animals were killed by severing the jugular vein using a knife. After slaughtering and complete bleeding, the blood for each animal was collected and weighed. Then the head was decapitated, the carcasses were eviscerated and the internal organs and tissues were weighed. Hot carcass weight was measured after removing edible and non-edible offals. Empty body weight was calculated as slaughter weight less gut content. The rib eye muscle area was determined by measuring area of the *Longissimus dorsi* muscle by cutting the carcass between the 12th and 13th ribs. The cross sectional areas of each rib-eye (*longissimus dorsi*) muscle at the 12th and 13th rib was traced with a transparent paper, then transferred to square paper and the area of rib-eye was calculated for each carcass side (right and left carcass) by counting squares. Each area was measured and then averaged to give a rib-eye area for each sheep carcass. Dressing percentage was calculated as a ratio of hot carcass weight and slaughter weight or empty body weight basis. Edible offal (EO) component was taken as the sum of liver, blood, tongue, kidneys, heart, stomach, large and small intestine, tail fat, kidney fat, omental fat, heart fat and mesenteric fat. Non-edible offal component (NEO) was computed as the sum of spleen, pancreas, head without tongue, skin and feet, testis and penis, lung, trachea, esophagus, gut content, genital fat, gall bladder and urinary bladder.

Chemical Analysis

Samples of feeds used in the experiment, refusals and feces were ground to pass a 1 mm sieve mesh and analyzed for DM, ash and CP contents according to AOAC (1990). Total nitrogen (N) content of the feed and feces samples was determined using micro-kjeldahl method and the CP content was calculated as N × 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL, only for feed samples) were analyzed according to the procedures of Van Soest and Robertson (1985). Condensed tannin (CT) was determined following the Butanol-HCl method of Porter *et al.* (1986).

Statistical Analysis

Data were analyzed using analysis of variance following the General Linear Model (GLM) procedure of Statistical Analysis Systems version 9.1 (SAS, 2008). Difference among treatment means were separated using Tukey HSD test. The model used for data analysis was:

$$Yij = \mu + Ti + Bi + \varepsilon ij$$

Where: Yij = the response variable (the observation in jth block and ith treatment).

μ = Overall mean,
Ti= Treatment effect,
Bj = Block effect,
εij = Random error

Results

Chemical Composition of Treatment Feeds

The CP content of finger millet straw was low while the NDF and ADF were high as compared to other experimental feed ingredients (Table 1). On the other hand, the concentrate mix, noug seed cake and wheat bran had high CP, low level of NDF and ADF contents. The PT leaf has high CP, NDF, ADF and ADL content than wheat bran but lower than noug seed cake in its CP and ADF content.

Dry Matter and Nutrient Intakes

The straw intake for T1 was greater (P<0.05) than those sheep fed T5 diets while T2, T3 and T4 had similar value (Table 2). The total DM and OM intake was the lowest for T5, and the value for T4 was lower than T1 (P<0.05), while the values for T2 and T3 were similar with T1 and T4. The lowest (P<0.05) supplement and CP intakes were recorded for T5, while values for other treatments were similar.

Table 1. Chemical composition (% DM, unless specified) of feeds offered during the experiment

Chemical Components	Feeds and composition				
	Finger millet straw	Noug seed cake	Wheat bran	*P. thonningii*	Concentrate mix*
Dry matter (%)	93.70	92.11	90.17	91.12	90.75
Crude protein	3.32	31.10	15.12	20.51	19.81
Ash	8.41	8.33	4.91	10.21	5.93
Neutral detergent fiber	70.62	37.63	39.16	46.47	38.7
Acid detergent fiber	45.24	31.15	14.93	28.33	19.79
Acid detergent lignin	4.97	12.21	3.89	14.25	6.38
Condensed tannin	-	-	-	3.93	-

**Concentrate mix (67% wheat bran and 33% noug seed cake); DM= Dry matter.*

Apparent Dry Matter and Nutrient Digestibility

The apparent digestibility of DM, OM, CP and NDF for T1, T2 and T3 were higher (P<0.05) than those animals fed with T4 and T5 diets (Table 3).

Body weight change

The average daily gain (ADG) and feed conversion efficiency (FCE) for T1, T2, T3 and T4 were higher (P<0.05) than those consuming T5 diets (Table 4). However, significant differences (P>0.05) were not observed among PT leaf meal supplemented groups (T2, T3 and T4) in terms of ADG and FCE. In general, the ADG was modest except T5 diet on which animals lost weight.

Table 2. Daily dry matter and nutrient intakes of Gumuz sheep fed finger millet straw basal diet supplemented with different proportions of concentrate mixture and *Piliostigma thonningii* leaf meal

Intake (g/day)	Treatments					SEM	*P- value*
	T1	T2	T3	T4	T5		
Dry matter:							
Straw	460[a]	410[ab]	396[ab]	382[ab]	358[b]	10.7	0.030
Supplement	300[a]	300[a]	299[a]	292[a]	210[b]	6.6	0.000
Total	760[a]	710[ab]	695[ab]	674[b]	569[c]	13.9	0.000
Organic matter	703[a]	655[ab]	638[ab]	616[b]	517[c]	13.2	0.000
Crud protein	75[a]	74[a]	73[a]	71[a]	54[b]	1.4	0.000
Neutral detergent fiber	441[a]	412[a]	407[ab]	400[ab]	351[b]	7.9	0.003
Acid detergent fiber	267[a]	251[ab]	251[ab]	249[ab]	222[b]	4.7	0.03
Acid detergent lignin	42[d]	45[cd]	50[ab]	55[a]	48[bc]	0.6	0.002

[a,b,c] Means within a row with different superscripts differ significantly (P < 0.05); SEM= Standard error of the mean; T1= Supplemented with 100% CM; T2= Supplemented with 75% CM + 25% PT leaf meal; T3= Supplemented with 50% CM + 50% PT leaf meal; T4= Supplemented with 25% CM + 75% PT leaf meal; T5= Supplemented with 100% PT leaf meal.

Table 3. Apparent dry matter and nutrient digestibility coefficients of Gumuz sheep fed finger millet straw basal diet supplemented with different proportions of concentrate mix and *Piliostigma thonningii* leaf meal

Nutrients	Treatments					SEM	*P- value*
	T1	T2	T3	T4	T5		
Dry matter	0.76[a]	0.77[a]	0.75[a]	0.68[b]	0.69[b]	0.5	0.000
Organic matter	0.76[a]	0.77[a]	0.75[a]	0.68[b]	0.69[b]	0.5	0.000
Crud protein	0.77[a]	0.79[a]	0.78[a]	0.72[b]	0.69[b]	0.5	0.000
Neutral detergent fiber	0.70[a]	0.72[a]	0.69[a]	0.62[b]	0.64[b]	0.6	0.000
Acid detergent fiber	0.67[ab]	0.68[a]	0.66[ab]	0.58[c]	0.61[bc]	0.7	0.000

[a,b,c] Means within a row with different superscripts differ significantly (P < 0.05); SEM= Standard error of the mean; T1= Supplemented with 100% CM; T2= Supplemented with 75% CM + 25% PT leaf meal; T3= Supplemented with 50% CM + 50% PT leaf meal; T4= Supplemented with 25% CM + 75% PT leaf meal; T5= Supplemented with 100% PT leaf meal.

Table 4. Body weight change and average daily gain of Gumuz sheep fed finger millet straw basal diet supplemented with different proportions of concentrate mix and *Piliostigma thonningii* leaf meal

Parameter	Treatments					SEM	*P- value*
	T1	T2	T3	T4	T5		
Initial body weight (kg)	20.5	20.4	19.7	20.5	20.1	0.47	0.987
Final body weight (kg)	24.1[a]	23.0[a]	22.1[ab]	21.7[ab]	18.4[b]	0.51	0.002
Body weight change (kg)	3.7[a]	2.7[a]	2.4[a]	1.3[a]	-1.7[b]	0.44	0.000
Average daily gain (g/day)	40.9[a]	29.4[a]	26.2[a]	14.1[a]	-19.2[b]	4.84	0.000
FCE (g weight gain /g DM intake)	0.05[a]	0.04[a]	0.04[a]	0.02[a]	-0.03[b]	0.01	0.000

[a,b,c]Means within the same row not bearing a common superscript differ significantly at P < 0.05; FCE= Feed conversion efficiency; SEM= Standard error of mean; T1= Supplemented with 100% CM; T2= Supplemented with 75% CM + 25% PT leaf meal; T3= Supplemented with 50% CM + 50% PT leaf meal; T4= Supplemented with 25% CM + 75% PT leaf meal; T5= Supplemented with 100% PT leaf meal.

Carcass Parameters

The slaughter weight for T1 was higher (P<0.05) than T5 while T2, T3 and T4 had similar values with all other treatments (Table 5). The hot carcass weight and empty body weight were similar (P > 0.05) among treatment groups. There was no consistent trend on dressing percentage (slaughter body weight basis) but those sheep fed T2 diet had higher (P<0.05) value compared with those sheep fed T4 diet while T1, T3 and T5 had similar values with all other treatments. The weights of total edible and non-edible offal were higher (P<0.05) in sole concentrate mixtures supplemented group (T1) than sole PT supplemented group (T5). Rib-eye muscle area was higher (P <0.05) in T2 compared with T5 diet.

Discussion

Chemical Composition of Treatment Feeds

The finger millet straw has low CP content which is below the CP requirement for ruminant animals for proper rumen function (McDonald *et al.,* 2002). The CP content of finger millet straw is comparable with the values (3.6 and 3.4 % DM) reported by Almaz *et al.* (2012) and Ajebu *et al.* (2013) but lower than the value (5.4 % DM) reported by Abdulwaheed *et al.* (2016). The variation in chemical composition of finger millet straw used in the different studies might be associated with variety differences and environmental factors such as the geographical location, fertility of the soil and level of fertilization, sowing season and rainfall variation of the different areas from where the straw was obtained

(Seyoum and Zinash, 1998). The high CP content (20.5%) of PT leaf meal compared to other browse trees such as *Ficus thonningii* (18.3% CP, reported by Mulubrhan *et al.* (2014)) indicated the potential of this tree leaf to be used as a supplement for poor quality roughage in ruminant diets. Research results on the chemical composition of PT appears to be limited and the CP content observed in the current study is higher than the values (14.2 and 11.5%) reported by Okunade *et al.* (2014) and Rubanza *et al.* (2003), respectively. This difference could be explained by the season, and age of the plants when samples were collected (Funmilayo *et al.*, 2013). Studies on forage qualities indicated that variability in the nutrient content of browse species could be attributed to season, harvesting regimen, location, soil type and age of the plants (Smith, 1992; Norton, 1994).

Table 5. Carcass characteristics of Gumuz sheep fed finger millet straw basal diet supplemented with different proportions of concentrate mix and *Piliostigma thonningii* leaf meal

Parameter	Treatment					SEM	*P- value*
	T1	T2	T3	T4	T5		
Slaughter body weight (kg)	24.1[a]	22.4[ab]	20.3[ab]	21.9[ab]	18.3[b]	0.67	0.01
Empty body weight (kg)	17.2	16.2	14.0	15.0	12.9	0.54	0.08
Hot carcass weight (kg)	8.84	8.56	6.42	6.68	6.22	0.35	0.05
Dressing percentage							
Empty body weight basis	51.4	53.3	45.3	44.3	48.3	1.21	0.07
Slaughter body weight basis	36.6[ab]	38.4[a]	31.1[ab]	30.3[b]	34.1[ab]	0.99	0.02
Total edible offal (kg)	3.24[a]	2.87[ab]	2.58[ab]	2.69[ab]	2.49[b]	0.1	0.02
Total non-edible offal (kg)	10.8[a]	9.77[a]	9.48[ab]	10.12[a]	7.7[b]	0.3	0.002
Rib eye area (cm^2)	6.69[ab]	8.01[a]	6.73[ab]	5.97[ab]	4.99[b]	0.34	0.002

[a,b,c]Means within the same row not bearing a common superscript differ significantly ($P < 0.05$); SEM= Standard error of mean; T1= Supplemented with 100% CM; T2= Supplemented with 75% CM + 25% PT leaf meal; T3= Supplemented with 50% CM + 50% PT leaf meal; T4= Supplemented with 25% CM + 75% PT leaf meal; T5= Supplemented with 100% PT leaf meal.

Dry Matter and Nutrient Intake

Higher DM intake at higher level of concentrate mix could be associated with higher digestibility and low fiber fraction in the concentrate mix, which increased the basal diet intake and resulted in better total DM intake. A positive relationship between the digestibility of feeds and intake was also reported (McDonald *et al.,* 2010). The low intake of OM, CP, NDF and ADF in sole PT supplemented sheep could be attributed to the low total dry matter intake. However, the proportion of NDF consumed in sole PT supplemented groups slightly exceeded the critical level of 60% reported to decrease voluntary feed intake and feed conversion efficiency, and to increase rumination time (Reed and Goe, 1989). Moreover, the total dry matter, and organic matter intake decreased beyond 50% inclusion of PT leaf meal in the diet. The digestibility of DM, OM, CP and NDF was also low beyond 50% inclusion of PT leaf meal in the diet. These might be due to the high ADL content of PT leaf meal. The ADL content of PT leaf is 14.3%, which was above the maximum level of 10% reported to decrease feed intake and digestibility in ruminants (Reed *et al.,* 1986). The ADL fraction is known to be indigestible and affects the digestibility of cell-wall carbohydrates by forming complexes with the cellulose and hemicellulose fractions through physical encrustation (Kellems and Church, 1998). The complex apparently hinders exposure of the cellulose and hemicellulose fractions to microbial enzymes (McDonald *et al.,* 1995). Moreover, according to McDonald *et al.* (1995) and Buxton (1996) high fiber content in feeds could limit total feed intake by physical fill effects and by reducing the digestibility of the feed. Allen (1996) also indicated that DM intake is limited by high fiber content in forages fed to ruminants. Getnet (2007) reported similar observations where the intake of total DM and OM decreased when the proportion of leaf meal increased in the diet of sheep fed as a supplement to natural pasture hay. The total DM intake in sole PT supplemented groups was lower as compared to the results reported by Yeshambel *et al.* (2018) in sheep supplemented with sole *Ficus thonningii* leaf meal. According to Oladotun *et al.* (2003) variations in feed intake can be attributed to differences in breed, body weight and type of diet. As it is observed during the feeding experiment the willingness of the animals to consume the dried leaf meal is low compared to the fresh leaves which indicate that drying might have decreased the palatability of the leaf meal.

Apparent Dry matter and Nutrient Digestibility

The similar digestibility of DM, OM, CP and NDF up to 50% PT supplemented groups could be related to similar amount of total DM and CP intake. The higher DM, OM, CP and NDF digestibility coefficient in the concentrate supplemented group compared with sole PT supplemented ones could be due to higher crude protein intake in these treatments. Higher CP intake could increase population of the microorganism which in turn increase the rate of fermentation of the crude fiber in the rumen (ARC, 1980). According to McDonald *et al.* (2010) feed with higher crude protein content could promote higher microbial populations and growth thereby enhances rumen fermentation and improve digestibility. The lower apparent DM, CP, OM and NDF digestibility in the sole PT leaf meal supplemented sheep might be due to the high ADL in PT leaf meal compared with concentrate mix. The ADL could bind nutrients, most importantly the proteins and reduce its availability in the process of digestion (McDonald *et al.,* 2002). Eroarome (2002) reported similar observations where voluntary dry matter intake of dry forms of *Leucaena leucocephala* leaves was lower than the fresh form leaves in the diet of goats fed as a supplement to guinea grass (*Panicum maximum*). According to Palmer and Schlink (1992) drying depress voluntary intake which might be due to the fact that drying increase the concentration of neutral detergent fiber and lignin contents of forage thereby resulting in longer rumen retention time, slower rate of passage and consequently reduced voluntary intake of dried leaves (Parachristous and Nastis, 1996). Moreover, ILCA (1990) reported a relatively higher intake of fresh *Leucaena leucocephala* leaves than dry leaves by the West African Dwarf sheep.

Body Weight Change

In the current study, inclusion of PT above 75% to substitute concentrate mixture reduced the body weight gain of Gumuz sheep. This could be due to low intake and digestibility of PT leaf meal at high level of inclusion possibly due to the high ADF and lignin content as compared to concentrate mix. Higher lignin content above the maximum level of 10% could affect feed utilization by animals (Reed *et al.,* 1986) and the ADL in PT used in the present study is above this threshold indicating that it affected digestibility. Generally, the weight loses occurred in sheep supplemented with sole PT showed that this tree leaves may contain some limiting factors, which could possibly hinder the nutrients from being properly utilized by microorganisms and the animal at large. Dutta *et al.* (1999) observed a weight loss in goats fed a basal diet of rice straw supplemented with *Prosopis cineraria* leaves because of the presence of high tannin and high fiber in the leaves. On the other hand, the positive weight gain observed in the other treatment groups in the current study could be due to the inclusion of concentrate mix beyond microbial nutrient requirement (Van Soest, 1994). The similarity in weight gain among T1, T2, T3 and T4 indicates the prospect of PT leaf to substitute commercial concentrate supplements up to 50% level. Similar results were reported by Mulubrhan *et al.* (2014) where up to 50% concentrate replacement with *Ficus thonningii* leaf improved intake and increased body weight of goats.

Carcass Parameters

In the present study, slaughter weight, total edible and non-edible offal values were greater in sheep supplemented with sole concentrate mix compared with sole PT supplemented group. This might be explained by comparatively high intake of DM, OM and CP, which is directly related to better weight gain of sheep. This is supported by Kirton *et al.* (1995) that reported dietary status has an impact on the production efficiency of animals. Generally, the dressing percentage (on EBW bases) values of the current study were comparable with the average dressing percentages of tropical sheep (40–50%) reported by William and Jenkins (2003).

Conclusion

The PT leaf meal contains high CP. However, its sole supplement to low quality crop residue resulted in lower intake of DM, OM and CP, low digestibility and consequently loss of weight. From these results, it could be possible to conclude that PT leaf meal contain some limiting factors that could hinder feed intake and needs further investigation. In general, substitution of concentrate with PT leaf meal beyond 50% had no beneficial role. Therefore, PT leaves could serve as alternative CP supplement in finger millet straw based feeding of Gumuz sheep to replace CM up to 50% without significantly affecting performance.

Acknowledgements

The Authors would like to acknowledge Ethiopian Institute of Agricultural Research (EIAR) for the financial support, Pawe Agricultural Research Center for facilitating the financial support and allowing access to the necessary facilities, Pawe Agricultural Research Center staff members for their valuable assistance during the conduct of the experiment.

Conflict of Interests

The authors declare that they have no competing interests.

References

Abdulwaheed, A. B., Balakrishna, G. D., Ramesh, G. B., Vishnu, S. D., Janarda S. D., Shalu, K. & Woledegerima Kide (2016). Water consumption rate of konkan kanyal goats (*Capra hircus*) fed finger millet straw supplemented with varying levels of dried poultry dropping based diets. *Aceh Journal of Animal Science*, 1 (2): 62-69.

Abebe Mekoya, Oosting, S. J., Fernandez-Rivera, S. & Van der Zijpp, A. J. (2008). Multipurpose fodder trees in the Ethiopian highlands: Farmers' preference and relationship of indigenous knowledge of feed value with laboratory indicators. *Journal of Agricultural Systems*, 96: 184-194.

Ajebu Nurfeta, Meseret Abe & Tegene Negesse (2013). On farm evaluation of the effect of urea treatment and concentrate supplementation of *teff* and finger millet straw on dry matter degradability, feed intake and weight gain of Washera sheep. *Ethiopian Journal of Animal Production,* 13 (1):103-120.

Allen, M. S. (1996). Physical constraints on voluntary intake of forages by ruminants. *Journal of Animal Science,* 74: 3063-3075.

Almaz Ayenew, Birhan Tamir & Solomon Melaku (2012). Feed Intake, Digestibility and Live Weight Change of Lambs Fed Finger Millet (*Eleusine coracana*) Straw Supplemented with *Atella*, Noug Seed (*Guizotia abyssinica*) Cake and Their Mixtures. *Tropical and Sub Tropical Agriculture,* 45 (3): 105-111.

AOAC (1990). Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists Inc., Arlington, Virginia, USA.

ARC (Agricultural Research Council) (1980). The nutrient requirements of ruminant livestock. Common Wealth Agricultural Bureau. Slough, England. UK.

Belete Shenkute, Abubeker Hassen, Tessema Assafa, Nura Amen & Abule Ebro (2012). Identification and Nutritive Value of Potential Fodder Trees and Shrubs in the Mid Rift Valley of Ethiopia. *The Journal of Animal & Plant Sciences*, 22 (4): 1126-1132.

Buxton, D. R. (1996). Quality-related characteristics of forages as influenced by plant environment and agronomic factors. *Animal Feed Science and Technology*, 59: 37-49.

Dutta, N., Sharma, K. & Hasan, Q. Z. (1999). Effect of supplementation of rice straw with *Leucaena leucocephala* and *Prosopis cineraria* leaves on nutrient utilization by goats. *Asian-Australian Journal of Science,* 12 (5):742-746.

Eroarome, M. A. (2002). Voluntary Intake and Digestibility of Fresh, Wilted and Dry Leucaena (*Leucaena leucocephala*) at Four Levels to a Basal Diet of Guinea Grass (*Panicum maximum*). *Asian-Australasian Journal* of *Animal Sciences*, 15 (8): 1139-1146.

Funmilayo, B., Olaniyi, B. & Adegboyega, A. (2013). Feed resources and seasonal nutrient composition of predominant forages for small ruminant production in two local Government Area of Osun state, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 3 (17): 15-24.

Getahun Legesse (2008). Productive and economic performance of small ruminants in two production systems of the highlands of Ethiopia, PhD Dissertation, University of Hohenheim, Stuttgart, Germany.

Getnet Assefa (2007). Evaluation of Tagasaste (*Chamaecytisus palmensis*) as forage for ruminants, PhD Dissertation, Humboldt-University of Berlin, Germany.

ILCA (1990). Annual Report (1989), International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Kearl, L. C. (1982). Nutrient Requirements of Ruminants in Developing Countries. PhD Dissertation, Utah State University, Logan, Utah, USA.

Kellems, R.O. & Church, D. C. (1998). Livestock Feeds & Feeding, 4thed., Prentice-Hall, Inc., New Jersey, USA.

Kirton, A. H., Bennet, L. G., Dobbie, L. J., Mercer, K. G. & Duganzich, M. D. (1995). Effect of sire breed, sex and growth path on carcass composition of cross-breed lambs. *Journal of Agricultural Research*, 38:105-114.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A. & Wilkinson, R. G. (2010). Animal Nutrition, 7th ed., Pearson Education Limited, United Kingdom.

McDonald, A. A., Edwards, R. A., Greenhalgh, J. F. D. & Morgan, C. A. (2002). Animal Nutrition. 6th ed., Pearson education (Singapore) Pte Ltd., India.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D. & Morgan, C. A. (1995). Animal Nutrition. 5th ed., Longman Group, Harlow, United Kingdom.

Mulubrhan Balehegn, Lars, E. O. & Yayneshet Tesfay (2014). Replacing commercial concentrate by *Ficus thonningii* improved productivity of goats in Ethiopia. *Tropical Animal Health Production,* 46 (5): 889-894.

Mulubrhan Balehegn, Lars, E. O. & Yayneshet Tesfay (2011). Forage and Multipurpose Uses of *Ficus thonningii* in Northern Ethiopia, LAP Lambert Academic Publishing AG & Co KG.

MZARDO (2010). Annual report on general agricultural related activities. MZARDO (Metekel Zone Agricultural and Rural Development Office), Metekel, Gilgelbeles.

Norton, B. W. (1994). Anti-nutritive and toxic factors in forage tree legumes. In: R. C. Gutteridge & H. M. Shelton (Eds.), Forage tree legumes in tropical agriculture, CAB International, pp: 202-215.

Okoli, I. C., Anunobi, M. O., Obua, B. E. & Enemuo, 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 December 31, 2018, from http://www.lrrd.org/lrrd15/9/okol159.htm

Okunade, S. A., Isah, O. A., Aderinboye, R. Y. & Olafadehan, O. A. (2014). Assessment of chemical composition and in vitro degradation profile of some guinea savannah browse plants of Nigeria. *Tropical and Subtropical Agro-ecosystems,* 17: 529-538.

Oladotun, O. A., Aina, A. B. J. & Oguntona, E. B. (2003). Evaluation of formulated agro-industrial wastes as dry season feed for sheep. *Nigerian Journal of Animal Production,* 30 (1):71-80.

Palmer, B. & Schlink, A. C. (1992). The effect of drying on intake and the rate of digestion of the legume *Calliandra calothyrus*. *Tropical Grass Lands,* 26: 89-93.

Parachristous, T. G. & Nastis, A. S. (1996). Changes in chemical compositions and in vitro digestibility of oesophageal fistula and hand plucked forage samples due to drying method and stage of maturity. *Animal Feed Science and Technology,* 46: 87-95.

Porter, L. J., Hrstich, L. N. & Chan, B. G. (1986). The conversion of procyanidins and prodelphinidins to cyanidin and delphinidin. *Phytochemistry*, 25 (1): 223-230.

Reed, J. A. & Goe, M. R. (1989). Estimating the Nutritive Value of Cereal Crop Residues: Implications for developing feeding standards for draught animals. ILCA. Bulletin No4 ILCA, Addis Ababa, Ethopia.

Reed, J. D., Yilma Kebede & Fossel, L. K. (1986). Factors affecting the Nutritive value of sorghum and millet crop residues. In: J. D. Reed, B. S. Capper & P. J. M. Neate (Eds.), Plant breeding and the nutritive value of crop residues, Proceedings of ILCA workshop held at Addis Ababa, Ethiopia, pp: 233-251.

Rubanza, C. D. K., Shem, M. N., Otsyina, R., Ichinohe, R. T. & Fujihara, T. (2003). Nutritive Evaluation of Some Browse Tree Legume Foliages Native to Semi-arid Areas in Western Tanzania. *Asian-Australian Journal of Animal Science*, 16 (10): 1429-1437.

SAS (Statistical Analysis Systems Institute) (2008). Version 9.1, SAS Institute Inc., Cary, North Carolina, USA.

Seyoum Bediye & Zinash Sileshi (1998). The composition of Ethiopian feed stuffs, Research report No. 6, Institute of agriculture research (IAR), Addis Ababa, Ethiopia, p: 33.

Smith, O. B. (1992). Fodder trees and shrubs in range and farming systems in tropical humid Africa. In: A. Speedy & P. Pugliese (Eds.), Legume Trees and other Fodder Tress as Protein Sources for Livestock, FAO, Animal Production and Health Paper 102, United Nations, Rome, Italy.

Takel Geta, Lisanework Nigatu & Getachew Animut (2014). Biodiversity of indigenous multipurpose fodder trees of Wolayta zone, southern Ethiopia: Ecological and Socio-Economic Importance. *International Journal of Emerging Technology and Advanced Engineering,* 4 (5):494-503.

Tesfaye Desalew (2008). Assessment of feed resources and rangeland condition in Metema District of North Gondar Zone, Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Van Soest, P. J. (1994). Nutritional ecology of the ruminant, 2nd ed., Cornell University, London, pp: 244-252.

Van Soest, P. J. & Robertson, J. B. (1985). Analysis of forages and fibrous foods: a laboratory manual for animal science, Cornell University, Ithaca, NY.

Williams, C. B. & Jenkins, T. G. (2003). A dynamic model of metabolizable energy utilization in growing and mature cattle. II. Metabolizable energy utilization for gain. *Journal of Animal Science*, 81:1382-1389.

Yeshambel Mekuriaw & Bimerew Asmare (2018). Nutrient intake, digestibility and growth performance of Washera lambs fed natural pasture hay supplemented with graded levels of *Ficus thonningii* (*Chibeha*) leaves as replacement for concentrate mixture. *Journal of Agriculture and Food Security*, 8 (9): https://doi.org/10.1186/s40066-018-0182-4