ORIGINAL ARTICLE

Substitution of pigeon pea leaves for noug(*Guizotia abyssinica*) seed cake as a protein supplement to sheep fed low quality tropical grass hay

AjebuNurfeta[a], AsdesachChurfo[b], AsterAbebe[a]

School of Animal and Range Sciences, College of Agriculture, Hawassa University, P.O.Box 222

[b]Wolayta Zone, DamotWoyde District, Southern Nations and Nationalities Peoples Regional State, Soddo

Corresponding author: Tel: +251916032359, Fax: +251462206711; e-mail: ajebu_nurfeta@yahoo.com

ABSTRACT

Effect of substitution of noug(*Guizotia abyssinica*) seed cake with pigeon pea (*Cajanus cajan)* leaves as a crude protein (CP) supplement for sheep fed rhodes grass hay was evaluated. Twenty four yearling male sheep with a body weight of 17.3±0.2kg (mean ±SD) were randomly assigned to treatments in a completely randomized block design. Animals were fed grass hay ad libitum with different proportion of noug seed cake and pigeon pea leaves: T1= 100% noug seed cake; T2= 35% pigeon pea leaves +65%noug seed cake; T3= 65% pigeon pea leaves+ 35%noug seed cake and T4= 100% pigeon pea leaves in concentrate mixture (20% maize, 35% wheat bran, 1.5% limestone, and 0.5% salt). An 8 day digestibility and 70 day growth experiment was conducted. The intake of total dry matter (DM), organic matter (OM) and body weight gain did not differ significantly ($p>0.05$) between treatments. The highest ($p<0.05$) CP intake was in sheep fed T2 diets, whereas the lowest was in those fed T4 diet. The digestibility of DM, OM, neutral detergent fiber and acid detergent fiber were similar ($P>0.05$) among treatments. The CP digestibility for T1 and T2 diets was higher ($p<0.05$) than that of T4. The nitrogen (N) retention was not affected by treatments. The weight gain and the positive N retention suggest that pigeon pea leaves could replace noug seed cake as a protein supplement to Rhodes grass hay basal diet for sheep.

Keywords: Adilo Sheep, *Cajanus cajan*, Growth, *Guizotia abyssinica*, Rhodes grass

INTRODUCTION

In most part of sub-Saharan Africa in general and Ethiopia in particular feeding of ruminant animals depend on crop residues and poor quality hay. However, crop residues and tropical grasses are characterized by high fiber content and low protein, energy, mineral and vitamin contents. As a result, the digestibility and intake of these feeds are low which results in poor performance. Despite the potential economic benefits, cereal grain supplementation to low-quality feeds is unaffordable by smallholder farmers in addition to scarcity and its use as human food (Nurfeta, 2010). Noug seed cake or protein supplements are not available or expensive for smallholder farmers in the rural area. Therefore, there is a need to look for protein sources that farmers could get from their own farm with minimum cost. One potential way for increasing the availability of feeds for smallholder farmers could be through the use of fodder trees and shrub legumes.

One of such fodder legumes is pigeon pea (*Cajanus cajan*) whose leaves are an important fodder and serves as valuable source of feed for farm animals (Foster *et al*., 2009). Pigeon pea is a relatively drought-resistant plant, which can thrive in a harsh environment in tropical region of the world, particularly sub-Saharan Africa. It has dual use: seeds for food and plant leaves/twigs as feed. Joshi *et al.* (2001) indicated that pigeon pea is the preferred pulse crop in dry land areas where it is intercropped or grown in mixed cropping systems with cereals or other short duration annuals. The dry leaves and the left over pods after threshing are used as animal feed. More than any other legume adapted to Africa, pigeon pea uniquely combines optimal nutritional profiles, high tolerance to environmental stresses, high biomass yield and most nutrient and moisture contributions to the soil (Odeny, 2007). Pigeon pea has a potential to produce high biomass ranging from 40.0 to 57.6 t DM ha^{-1} (Akinola *et al*., 1975). Yield of edible forage is about 50% of this value because of the woody stem (Whiteman and Norton, 1981). Alexander *et al.* (2007) evaluated 200 pigeon pea germplasm and observed a forage DM yield ranging from 0.76 to 10.5 t DM/ha. In fact, yield of DM could be affected by variety, sowing date, sowing density and growing condition (Akinola *et al*., 1975). Pruning time and pruning height is also reported to affect forage yield (Karbo *et al*., 1998).

Pigeon pea leaf is an excellent source of protein (Ahmed and Nour, 1997) ranging from 16.3-27 % (Alexander *et al*., 2007).The CP content of pigeon pea leaves is similar to that of leucaena leaves and similar performance was observed when grazing goats were supplemented with pigeon pea and leucaena(Karachi and Zengo, 1998).Also, pigeon pea has similar intake and CP content with that of alfalfa (Park et al., 1989). Therefore, the use of pigeon pea forage could be an effective substitute for more expensive industrial concentrates (Foster *et al*., 2009). According to Ondiek *et al.* (2000) replacing conventional supplements with tree leaves makes such supplements less expensive compared with commercial supplements. Pigeon pea can be fed along with low quality roughages to improve their utilization and to increase growth rates (Ahmed and Nour, 1997; Karachi and Zengo, 1998) and milk yield (Ahmed and Nour, 1997). Moreover, improvement in animal performances has been reported for grazing goats supplemented with pigeon pea leaves (Karachi and Zengo, 1998) and when pigeon pea leaves are fed as a supplement (Jokthan, 2006). However, information on feeding value of dried pigeon pea leaves in relation to sheep performance is scanty especially as a substitute to conventional protein supplement. Therefore, the objective of the study was to assess the effect of substitution of noug seed cake with dried pigeon pea leaves in a concentrate mixture on feed intake, digestibility, nitrogen utilization and weight gain in sheep.

MATERIAL AND METHODS

Experimental animals and their management

The study was conducted at Hawassa University, College of Agriculture, Hawassa, Ethiopia. Twenty-four yearling Adilo intact male sheep with an average initial body weight of 17.3±0.2 kg (mean ±SD) were purchased from local market. Before the commencement of the experiment, they were de-wormed against internal parasites with albendazole and injected with oxytetracycline (2 ml) to prevent pneumonia. They were allowed an adaptation period of 2 weeks to the environment. They were housed individually in pens.

Experimental feed preparation

Concentrate ingredients were purchased from local market. Pigeon pea (*Cajanus cajan)* leaves were bought from farmers on contract bases from Wolayta zone, Humbo district, Ambe locality (*Kebele*). Fresh leaves were harvested in January 2012 from pigeon pea trees after seed collection and the leaves were trimmed from their twigs on a plastic sheet. The trimmed leaves were then spread thinly on plastic sheet under shade and turned regularly to ensure uniform drying for safe storage. The air dried pigeon pea leaves were transported to the experimental site. Dried pigeon pea leaves were milled by traditional mortar and pestle before mixing with other ingredients. For ease of feeding pigeon pea leaves and concentrate ingredients were mixed together for each treatment separately. Rhodes (*Chlorisgayana*) grass hay was purchased from the nearby state farm and transported to the experimental site. During feeding, grass hay was chopped into the size of 5 to 10 cm for ease of feeding.

Experimental design and treatments

The design used for this experiment was completely randomized block design. The experimental sheep were blocked based on their initial body weight into six blocks of four animals each. The treatment feed were randomly assigned to each sheep in each block. Animals were fed grass hay *ad libitum* with different proportion of noug(*Guizotia abyssinica*) seed cake and pigeon pea leaves in concentrate mixture: T1 = 100% noug seed cake; T2 = 35% pigeon pea leaves + 65% noug seed cake; T3 = 65% pigeon pea leaves + 35% noug seed cake and T4 = 100% pigeon pea leaves. The proportions of ingredients are shown in Table 1.

Table 1. The proportion (%) of ingredients (on DM basis)

Ingredient	Treatments			
	T1	T2	T3	T4
Maize	20	20	20	20
Noug seed cake	43	28	15	0
Pigeon pea leaf	0	15	28	43
Wheat bran	35	35	35	35
Limestone	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

T1 = 0% pigeon pea leaf: 100% noug seed cake; T2 = 35% pigeon pea leaf: 65% noug seed cake; T3 = 65% pigeon pea leaf: 35% noug seed cake; T4 = 100% pigeon pea leaf: 0% noug seed cake in concentrate mixture.

Feeding trial

The sheep were housed in individual pens with concrete floor and fed in separate feeding troughs. Two hundred gram (200 g) of the feed mixtures were offered into two equal meals at 08:00 AM and 01:00 PM. Rhodes grass hay was offered *ad libitum* (≈20% refusal on DM basis). Hay and pigeon pea leave-concentrate mixture were offered separately. The sheep were allowed 14 days of adaptation to experimental diets and pens, and the actual data collection continued for 70 days. Sheep had free access to clean water. The amount of feed offered and refused was recorded daily to estimate intake. To monitor body weight change, body weights were measured fortnightly in the morning before offering feed and water. The initial and final weights were taken twice on two consecutive days, and the average of the two was taken as initial and final weights, respectively. Daily body weight change was calculated by the difference between final and initial body weight divided by feeding days.

Digestibility trial

After 70 days of feeding experiment, all sheep were transferred to metabolic cages for the digestibility trial. The sheep were accustomed to the metabolic cages and to fecal bag and urine collection harnesses for 3 days. Total fecal and urine output were collected for 8 days. About 10% of the daily fecal output were taken and bulked and stored in a freezer at minus 20°C until analysis. A sub-sample of feces was dried daily at 105°C overnight to determine the dry matter (DM) content of the feces. The total urine outputs of each sheep were collected daily in bottles containing 100 ml of 10% H_2SO_4 and the volume recorded. A 10% aliquot was taken and stored in a freezer (-20°C). At the end of the experiment, samples of feces and urine were taken from the freezer, kept at room temperature and allowed to thaw for 12 h before pooling for each sheep. Samples of feces to be used for chemical analysis other than nitrogen (N) were dried at 60°C for 48 h. The dried feces and feed samples were milled using a cross-beater mill (Thomas-Wiley, Philadelphia, USA) through 1-mm sieve and kept in screw-capped plastic bottles until analysis. Feces for N determination were left in a freezer until analysis.

Chemical analysis

Dry matter contents of feed offered, feed refused and fecal samples were analyzed by drying the samples at 105 °C overnight. For chemical analysis, feces, feed offered and refused were dried at 60°C for 48h.The dried samples was ground to pass through a 1-mm screen and stored for chemical analysis. The acid detergent fiber (ADF) and neutral detergent fiber (NDF) concentrations were determined according to Van Soest *et al*. (1991) using ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA) without the use of alpha amylase. Crude ash concentrations were determined by combusting the sample at 550 °C for 3 hours (AOAC, 1990). Total N concentrations were determined by micro Kjeldahl method and CP contents were calculated as N × 6.25. Metabolizable energy and microbial N production was estimated using the following formula: Metabolizable energy (ME) = Organic matter intake × 19 × 0.82 (ARC, 1980); Microbial N production = Metabolizable energy intake × 1.34 (ARC, 1984).

Statistical analysis

The collected data on feed intake, digestibility, nitrogen utilization and weight gain were analyzed using General Liner Model (GLM) procedure of the Statistical Analysis System (SAS) computer package (2001). Mean comparisons were determined by using Duncan multiple range test and significance was set at 5% level. The model used for the data analysis was $Yij= \mu+Ti+Bj+eij$; whereYij= is the response variable (feed intake, digestibility, nitrogen utilization and weight gain); μ =is the overall mean; Ti =is the treatment effect; Bj =is the block effect; eij = is the random error.

RESULTS AND DISCUSSION

Chemical composition

Except for Rhodes grass hay, all other ingredients had high CP contents (Table 2). The NDF and ADF contents of Rhodes grass hay and pigeon pea leaves were high compared with other ingredients. The CP content of Rhodes grass hay observed in this experiment is low compared to the results (37.5 g/kg DM, 51.5 g/kg DM) reported by Gebregiorgis *et al.* (2011) and Nurfeta (2010), respectively. This variation could be due to the difference in stage of maturity of the grass during harvest, soil fertility and climate. Mbwile and Udén (1997) reported that age of harvest and day of season affect the CP content of Rhodes grass hay. It has been indicated that with advancing plant maturation the proportion of cell wall constituent increase and therefore, the proportion of the structural carbohydrates such as cellulose increase and the percentage of CP decreases (McDonald et al., 2002). The Rhodes grass hay used in current experiment had CP content below the minimum microbial requirement (70 g CP/ kg DM) in feeds assumed to support acceptable ruminal microbial activity and the maintenance requirement of the host animal (McDonald *et al.*,2002), which indicates that supplementation is required in order to improve the nutritive values of such poor quality feed.

Table 2. Chemical composition (g/kg DM) of the ingredients used in the experiment

Ingredients	Ash	Crude protein	Neutral detergent fiber	Acid detergent fiber
Rhodes grass hay	79.0	28.2	738	413
Pigeon pea leaf	75.6	230	537	339
Noug seed cake	54.8	318	358	261
Wheat bran	38.3	129	360	102
Maize	14.4	98.2	247	35.9

The NDF and ADF contents of Rhodes grass hay in the present study are lower than the values reported (79.2% and 45.3%; 79.7% and 53.6% DM) by Bishaw and Melaku (2008) and Nurfeta (2010), respectively. However, the NDF content in this study was higher than the values of 66.1%, while ADF content was lower than the value of 53.3% reported by Gebregiorgis *et al.* (2011). The high NDF and ADF contents of the grass hay could have negative impact on intake and digestibility because feeds with high NDF content reduce intake due to bulkiness and hence rumen fill effect, while ADF content could reduce the availability of nutrients since there is a negative relationship between ADF and digestibility of feeds (McDonald *et al.*, 2002). The higher the NDF and /or the ADF composition of a feedstuff, the lower is the nutritive values of that feedstuffs (Van Soest, 1994).

The CP content of pigeon pea in the current experiment is within the range (162.5 to 250 g/kg DM) reported by Alexander *et al.* (2007) for 200 pigeon pea germplasm. However, the CP content of pigeon pea leaves in the present study is higher than the values (213 and 200 g/kg DM) reported by Shenkute*et al.* (2013) and Cheva-Isarakul (1992), respectively. Foster et al. (2009), Jokthan (2006) and Karbo *et al.* (1998) reported CP contents of 137, 158 and 132 g/kg DM, respectively, which is lower than the value observed in this experiment. According to Maasdorp *et al.* (1999), plant species/variety, soil, climate, grazing, plant fraction and stage of maturity at sampling affect the nutritive value of forages. The high CP content of pigeon pea leaves in the present study, therefore, suggests that it can serve as protein supplement in ruminant rations.

The CP content of noug seed cake (NSC) found in the current study was higher than values (257, 292 g/kg DM) reported by Dessie *et al.* (2010) and Amare*et al.* (2010) but lower than the value (345 g/kg DM) reported by Hagos and Melaku (2009) . The difference in the CP content of NSC could be attributed to the type of extraction method used and variety of the noug seed used (Amare *et al.*, 2010). The same author indicated that the chemical composition of oil seed cakes vary widely depending on crop species and method of processing.

The NDF contents of NSC in this study is lower than the value (387 g/kg DM) reported by Bishaw and Melaku (2008), but comparable with the value (362 g/kg DM) reported by Nega and Melaku (2009). The ADF content of NSC in the present study is lower than the values (304 g/kg DM) reported by Bishaw and Melaku (2008). As indicated earlier, this difference in NDF and ADF content might be attributed to the varieties of the seeds used and the grain processing methods used in the extraction of oils.

Feed intake

The total DM, OM, ME, NDF and ADF intake and microbial N production were not significantly different among the treatments (Table 3). The highest ($p<0.05$) CP intake was in sheep fed T2 diets, whereas the lowest was in those fed T4 diet. However, when expressed per metabolic body weight the CP intake was similar among T1, T2 and T3 diets.

The similarities in total DM and OM intakes among treatment shows that substituting noug seed cake with pigeon pea leaves in a concentrate mixture had no negative effect on intake of the diet. Patra *et al.* (2006) fed concentrate containing soybean and leaf mixtures and observed similar DM intake among treatments in does fed wheat straw. In a dairy cow diets where moringa leaf meal was used as a replacement with soybean meal, similar intake of DM and OM were reported between different levels of substitution (Mendieta-Araica *et al*., 2011) which is similar to this experiment. On the other hand, Foster *et al*. (2009) found reduced DM and OM intakes with increasing levels of pigeon pea hay lage as a supplement to grass hay compared with the control which they attributed to the more thick and woody stem of pigeon pea which could have caused a gut fill compared to the grass used. However, in the current study only pigeon pea leaves were used. Similarly, Smith *et al.* (1990) reported that supplementation of pigeon pea to the basal diet of maize stover increased the total DM intake in lambs. Also, Shenkute *et al*. (2013) revealed improvement in intake with increasing levels of pigeon pea in grazing goats. Jokthan (2006) also reported increased CP intake with increasing levels of pigeon pea forage in sheep fed a basal diet of rice straw. Generally, the results indicate that supplementation of Rhodes grass hay with different proportion of pigeon pea leaves and noug seed cake improved total DM intake, similar to when either are part of the concentrate mixture, without affecting the intake of the basal diet.

Despite variation in CP intake, there was similarity in the performance of sheep among treatments. Such variation in CP intake was due to the differences in CP content of the supplemented feeds. Improvement in intake could be observed through dietary protein supplementation. This could increase the supply of nitrogen to the rumen microbes which could lead to an increase in rumen microbial population and efficiency, thus enabling them to increase the rate of breakdown of the digesta. According to Van Soest (1994) as the rate of breakdown of digesta increases, feed intake is increased accordingly.

Body weight change

Average daily weight gain was not significantly different among treatments (Table 4).The similarity in body weight gain among treatments reflects that the supplements are comparable in their nutrient supply. This could be due to the similar DM intake and digestibility. Forage to concentrate ratio was reported to affect average daily gain where increasing the concentrate portion increased average daily gain, improved feed conversion efficiency and carcass characteristics in kids (Haddad, 2005). In the current experiment, even though the weight gain among treatments was not significant statistically, sole noug seed cake supplementation (T1) resulted in a gain of 20.9 g/day which is similar to those supplemented with sole pigeon pea leaves (T4) (20.5 g/day) which indicates the significance of pigeon pea leaves as a CP supplement. Similarly, Ahmed and Abdalla (2005) fed different sources of protein (cotton seed cake, sesame seed cake, groundnut cake and sunflower seed cake) to sheep and observed similar weight gain among the different sources. Similar weight gain was also reported when cotton seed cake substituted *Leucaena leucocephala* at varying levels (Ndemanisho *et al*., 1998). On the other hand, Das and Ghosh (2007) partially replaced concentrate at three different levels (0, 25 and 50%) with jackfruit and observed lower body weight gain at the highest level of replacement. Likewise, Jokthan (2006) supplemented rice straw at 0.5, 1.0 and 1.5% of the body weight of sheep and observed weight loss at 0.5% whereas weight gain was observed at high levels of supplementation with no significant difference among the higher levels.

Table 3. Feed intake and microbial N production (g/day) of sheep fed different proportions of pigeon pea leaf and noug seed cake in concentrate mixture as a supplement to Rhodes grass hay

Parameters	Treatments				SEM
	T1	T2	T3	T4	
Dry matter					
Hay	372	393	394	404	17.3
Concentrate	191	194	194	194	0.00
Total	563	587	588	598	13.4
Total (g/kg $LW^{0.75}$)	67.5	68.8	70.3	70.2	1.47
Organic matter					
Hay	319	338	338	348	15.3
Concentrate	170	172	173	174	0.00
Total	489	510	511	522	11.9
Total (g/kg $LW^{0.75}$)	58.6	59.9	61.1	61.3	1.31
Crude protein	51.6^{ab}	51.9^{a}	51.2^{b}	50.3^{c}	0.16
Total (g/kg $LW^{0.75}$)	6.21^{a}	6.12^{ab}	6.15^{a}	5.95^{b}	0.06
ME intake (MJ/day)*	7.6	7.96	7.95	8.2	0.18
Microbial N production (g/day)**	10.2	10.7	10.7	10.9	0.24
Neutral detergent fiber	340	358	357	369	10.6
Acid detergent fiber	179	191	192	185	6.0

Means with different superscripts in a row are significantly different (P<0.05). SEM = standard error of the means; T1 = 0% pigeon pea leaf: 100% noug seed cake; T2 = 35% pigeon pea leaf: 65% noug seed cake; T3 = 65% pigeon pea leaf: 35% noug seed cake; T4 = 100% pigeon pea leaf: 0% noug seed cake in concentrate mixture; *Metabolizable energy (ME) = Organic matter intake × 19 × 0.82 (ARC, 1980); **Microbial N production = Metabolizable energy intake × 1.34 (ARC, 1984).

Table 4. Body weight gain of sheep fed different proportions of pigeon pea leaf and noug seed cake in concentrate mixture as a supplement to Rhodes grass hay

Body weight change	Treatments				SEM
	T1	T2	T3	T4	
Initial (kg)	17.3	17.8	17.3	17.9	0.7
Final (kg)	18.8	19.0	19.0	19.3	0.7
Total gain (kg)	1.5	1.2	1.7	1.4	0.3
Gain (g/day)	20.9	17.4	24.1	20.5	3.3

Means with different superscripts in a row are significantly different (P<0.05). SEM = standard error of the means; T1 = 0% pigeon pea leaf: 100% noug seed cake; T2 = 35% pigeon pea leaf: 65% noug seed cake; T3 = 65% pigeon pea leaf: 35% noug seed cake; T4 = 100% pigeon pea leaf: 0% noug seed cake in concentrate mixture.

The similarity in weight gain among treatment could be due to the similarity in the DM intake and digestibility. Furthermore, Karachi and Zengo (1998) and Keba (2009) reported increased body weight gain by increasing the amount of pigeon pea leaves which is not consistent with the current experiment. According to Shenkute *et al*. (2013) significant improvement in body weight was observed in grazing goats supplemented with different levels of pigeon pea leaves compared with the control. The weight gain in the current experiment is much lower that the range of weight gain (70.2-92.7 g/day) reported by Shenkute *et al*. (2013) for different levels of pigeon pea supplemented for grazing goats. It is not clear why such poor performance was observed in the current experiment. However, the modest weight gain in sheep fed pigeon pea indicates that in areas where noug seed cake is not available especially for smallholder farmers, pigeon pea leaves could be used as a CP supplement..

Apparent digestibility of nutrients

Except CP, the apparent digestibility of DM, OM, NDF and ADF were similar among the treatments ($p>0.05$). Sheep fed T1 and T2 diets had higher ($p<0.05$) CP digestibility than those fed T4 diet, whereas T3 had intermediate digestibility (Table 5). The digestibility of nutrients in the current experiment is similar which is consistent with the result reported by Ahmed and Abdalla (2005) and Maglad *et al*. (1984) in sheep fed different protein sources. Patra *et al*. (2006) fed concentrate containing soybean and leaf mixtures and observed similar digestibility of DM, OM and CP among treatments in does fed wheat straw. Moreover, Haddad (2005) fed different ratio of forage to concentrate and observed an increase in DM, OM and CP, while the digestibility of NDF and ADF decreased with increasing levels of concentrate in the diet. Except CP digestibility, similar digestibility was observed when moringa leaf meal replaced soybean meal in dairy cows fed a basal diet of hay (Mendieta-Araica *et al*., 2011).

The study made by Richards *et al*. (1994) indicated that the digestibility of OM and fiber declined with increasing levels of gliricidia in relation to concentrate in goats. Also, Ndemanisho *et al*. (1998) reported declined digestibility of DM, OM and CP with increasing levels of leucaena as a substitute to cotton seed cake. The variation in digestibility value among legume supplementation could be due to the presence of condensed tannin in tropical tree legumes (Reed *et al*., 1990). However, low levels of tannin (0.4-4.3%) were reported for pigeon pea leaves (Alexander *et al*., 2007) from 200 pigeon pea lines.

The apparent digestibility of DM in the current study was similar to the value (50.2%) reported by Cheva-Isarakul (1992) in sheep fed a basal diet of rice straw supplemented with pigeon pea leaves. On the other hand, the digestibility of OM is higher than the value reported by the same author. However, apparent digestibility of DM in the present study was lower than the digestibility of fresh pigeon pea leaves and tops (58.7%) reported by Foster *et al*. (2009). The same author reported that DM and OM digestibility decreased due to the supplementation of pigeon pea in sheep fed a basal diet of hay compared with the control. In the current experiment, the digestibility were similar with that of noug seed cake except CP. Smith *et al*. (1990) reported that the digestibility of DM and OM increased as a result of supplementation of pigeon pea to maize stover.

In the current experiment, the CP digestibility decreased with increasing levels of pigeon pea leaves supplementation .Das and Ghosh (2007) partially replaced concentrate at three different levels (0, 25 and 50%) of jackfruit and observed decreased CP digestibility with increased levels of jackfruit leaves. Digestibility of CP generally increases as CP intake increases because metabolic fecal nitrogen is inversely related to CP intake and is higher at lower intake than at higher intake (Foster *et al*., 2009). The apparent digestibility of CP in all treatments was lower than the result (65.1 %) reported by Cheva-Isarakul(1992).

Nitrogen utilization

During digestibility experiment, the nitrogen intake of sheep fed T2 diet was higher ($p<0.05$) than other treatments, while sheep fed T3 had lower ($p<0.05$) N intake compared with T1 and T2. Nitrogen excretion in feces in T4 was higher ($p<0.05$) than T1, while T2 and T3 diets had intermediate values. Urinary nitrogen loss and nitrogen retention were similar ($p>0.05$) among treatments (Table 6).

Table 5. Digestibility (%) in sheep fed different proportions of pigeon pea leaf and noug seed cake in concentrate mixture as a supplement to Rhodes grass hay

Variables	Treatments				SEM
	T1	T2	T3	T4	
Dry matter	53.9	51.2	51.8	51.2	1.6
Organic matter	60.4	57.8	58	56.9	1.4
Crude protein	61.7[a]	60.2[ab]	56.2[bc]	53.1[c]	1.5
Neutral detergent fiber	50.6	49.4	49.1	50.4	1.9
Acid detergent fiber	43.9	43.4	43.6	42.9	1.9

Means with different superscripts in a row are significantly different (P<0.05). SEM = standard error of the means; T1= 0% pigeon pea leaf: 100% noug seed cake; T2 = 35% pigeon pea leaf: 65% noug seed cake; T3 = 65% pigeon pea leaf: 35% noug seed cake; T4 = 100% pigeon pea leaf: 0% noug seed cake in concentrate mixture.

Table 6. Nitrogen (N) balance of sheep fed different proportions of pigeon pea leaf and noug seed cake in concentrate mixture as a supplement to Rhodes grass hay

Parameter	Treatments				SEM
	T1	T2	T3	T4	
N intake (g/day)	8.35[b]	8.52[a]	8.17[c]	8.27[bc]	0.03
Feces N excretion (g/day)	3.18[b]	3.38[ab]	3.57[ab]	3.87[a]	0.13
Urine N excretion (g/day)	3.63	3.20	3.05	3.02	0.18
N retained (g/day)	1.53	1.93	1.55	1.38	0.19

Means within rows with different superscripts are significantly different (P<0.05); SEM standard error of the means; N = nitrogen; T1= 0% pigeon pea leaf: 100% noug seed cake; T2 = 35% pigeon pea leaf: 65% noug seed cake; T3 = 65% pigeon pea leaf: 35% noug seed cake; T4 = 100% pigeon pea leaf: 0% noug seed cake in concentrate mixture.

In general, nitrogen intake and fecal and urinary nitrogen are determinants of nitrogen balance. Nitrogen intake depends upon DM intake. Smith *et al*. (1990) reported increased N intake in lambs supplemented with pigeon pea to the basal diet of maize stover. The value of N intake in the current result was low compared to the result (10.1 and 10.2 g/day) reported by Foster *et al*. (2009) and Hao and Ledin (2000) in sheep and goats supplemented with pigeon pea and tree leaves. However, the nitrogen intake (8.17-8.52 g/day) in the present study was comparable with the values (8.22 g/day and 8.7 g/day) reported by Hao and Ledin(2000) and Gebregiorgis *et al*. (2011) in goats and sheep supplemented with *Glyricidia maculate* and *Moringa stenopetala*, respectively.

Consistent with the current experiment, Jokthan (2006) observed similar N retention among different levels of pigeon pea supplementation in sheep fed rice straw. Also, similar N retention was observed in does fed concentrate containing soybean and leaf mixtures as a supplement to wheat straw (Patra *et al*., 2006). It has been indicated that the types of protein supplement affect N retention (Ahmed and Abdalla, 2005) which was not seen in the current experiment. Nitrogen retention in this study was lower than the value (2.8 g/day) reported by Foster et al. (2009)in sheep fed grass hay diets supplemented with pigeon pea leaves but higher than the value (1.42 g/day) reported by Hao and Ledin(2000) in growing goats fed *Glyricidia maculate*as a protein supplement. Compared with other treatments, the numerically higher nitrogen retention observed in T2 reflects the high nitrogen intake in this diet. Though not significant, numerically sheep fed T4 diets had lower N retention which could be due to the result of poor digestibility of nitrogen or due to the poor usage of absorbed nitrogen (Woods *et al*., 1962). The positive N retention in all treatment indicates the adequate nutritional level of the different proportion of supplements. Therefore, substituting noug seed cake with pigeon pea leaves in a concentrate mixture could improve efficiency of nitrogen utilization in the body.

CONCLUSION

The similarity in intake, digestibility and weight gain among different levels of pigeon pea and noug seed cake indicates that smallholder farmers can supplement low quality feeds with pigeon pea leaves. The result suggests that pigeon pea could replace noug seed cake in sheep feeding. Noug seed cake or protein supplements are not available or expensive for smallholder farmers in the rural area. Therefore, the use of pigeon pea could serve dual purpose: as a food and feed. Intervention in disseminating the use of pigeon pea is essential as the forage could be a useful feed in improving the productivity of sheep under small scale production system.

Acknowledgement

The authors would like to thank The Norwegian Agency for Development Cooperation (NORAD) and Research and Development Directorate of Hawassa University for funding the research.

REFERENCES

Ahmed, MMM, Abdalla, HA. 2005. Use of different nitrogen sources in the fattening of yearling sheep. *Small Rumin. Res*.56: 39-45.

Ahmed, MMM,Nour, HS. 1997: Legume hays as a supplement for dairy goats during the dry season. *Small Rumin. Res*.26: 189-192.

ARC (Agricultural Research Council), 1980.The Nutrient Requirement of Ruminant Livestock. Supplement 1. Agricultural Research Council. Commonwealth Agricultural Bureaux Farham Royal, UK, pp.78-80.

ARC (Agricultural Research Council), 1984.The Nutrient Requirements of Ruminant Livestock, Supplement No.1.Report of the protein group of the Agricultural Research Council Working Party on the Nutrient Requirements of Ruminants.CAB, Farham Royal, UK.

Akinola, JO, Whiteman, PC. 1975. Agronomic studies on pigeon pea (*Cajnuscajan*L. Millsp). 1. Field responses to sowing time. *Aus. J. Agri. Res*.26:43-79.

Alexander, G, Ravi, D, Reddy, RCh,Saxena, KB, Hanson, JUpadhyaya, HD,Blümmel, M. 2007.Forage yield and quality in pigeon pea germplasm lines. An open access Journal .ICRISAT. Volume 3, Issue 1.

AOAC.1990.Official Methods of Analysis, Vol.I, 15thedn. Association of Official Analytical Chemists, Washington,DC, pp. 69–88.

Asmare, B,Melaku, S,Peters , KJ. 2010. Supplementation of Farta sheep fed hay with graded levels of concentrate mix consisting of noug seed meal and rice bran. *Trop.Anim. Health Prod*.42: 1345–1352.

BishawF, Melaku, S. 2008. Effect of supplementation of hay with noug seed cake (*Guizota abyssinica*), wheat bran and their mixtures on feed utilization, digestibility, and live weight change in Fartas heep.Trop. Anim. Health Prod.40: 597-606.

Cheva-Isarakul, B. 1992.Pigeon pea as a ruminant feed. *Asian Australas J Anim. Sci* 5: 549-558.

Das, A,Ghosh, SK.2007. Effect of partial replacement of concentrate with jackfruit (*Artocarpus heterophyllus*) leaves on growth performance of kids grazing onnative pasture of Tripura, India. *Small Rumin. Res.*67: 36-44.

Dessie, J, Melaku, S, Tegegne, F, Peters, KJ. 2010. Effect of supplementation of Simada sheep with graded levels of concentrate meal on feed intake, digestibility and body-weight parameters. Trop. Anim. Health Prod.42: 841–848.

Foster, JL, Adesogan, AT, Carter, JN, Blount, AR., Myer, RO, Phatak,SC. 2009. Intake, digestibility, and nitrogen retention by sheep supplemented with warm-season legume hays or soybean meal. J. Anim. Sci.87:2891–2898.

Gebregiorgis, F, Negesse, T, Nurfeta, A. 2011.Feed intake and utilization in sheep fed graded levels of dried moringa (*Moringa stenopetala*) leaf as a supplement to Rhodesgrass hay. Trop. Anim. Health Prod.44: 511-517.

Haddad, SG. 2005. Effect of dietary forage: concentrate ratio on growth performance and carcass characteristics of growing Baladi kids. *Small Rumin. Res.*57: 43-49.

Hagos, T,Melaku, S. 2009. Feed intake, digestibility, body weight and carcass parameters of Afar rams fed tef (*Eragrostistef*) straw supplemented with graded levels of concentrate mix. Trop. Anim. Health Prod.41: 599–606.

Hao, NV, Ledin, I. 2000. Performance of growing goats fed *glyricidia maculate* as a protein supplement. In: T.R. Preston and R.B. Ogle (Eds), Proceedings National Workshop-Seminar sustainable Livestock Production on Local Feed Resources, Ho Chi Minh City, Vietnam, January 18-20th 2000.

Jokthan, GE. 2006. Effect of supplementing rice straw with pigeon pea forage on performance of Yankasa sheep. MSc thesis, Ahmadu Bello University, Zaria, Nigeria.

Joshi, PK, Rao, P, Gowda, CLL, Jones, RB, Silim, SN, Saxena, KB, Kumar, J. 2001. The world chickpea and pigeon pea economies: facts, trends, and outlook. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Karachi, M, Zengo, M. 1998. Legume forages from pigeon pea, leucaena and sesbania as supplements to natural pastures for goat production in western Tanzania. Agroforest Syst.39: 13-21.

Karbo, N, Bruce, J, Nyamekye, L, Fianu, FK. 1998. Effective management of pigeon pea (*Cajanus cajan*) in crop/livestock integrated farming systems in northen Ghana. Ghana Intl.J.Agri. Sci.31: 161-167.

Keba, F. 2009. Sheep production system in Damot Gale Woreda and supplementary value of pigeon pea (*Cajanus cajan*) and sweet potato root (Ipomoea batatus) in sheep fattening diets. MSc Thesis, Hawassa University, Ethiopia.

Maasdrop, BV, Muchenje, V, Titterton, M. 1999. Palatability and effect of dairy cow milk yield of dried fodder from the forage trees *Acacia boliviana*, *Calliandra calothyrsus* and *Leucaena leucocephala*. *Anim. Feed. Sci. Technol*.77: 49–59.

Maglad, M, Lutfi, AA, Wasfi, IA, Adam, SE. 1984.Plasma and ruminal constituents of sheep fed various nitrogen supplements. Trop. Anim. Prod. 9: 157-163.

Mbwile, RP, Uden, P.1997: Effect of age and season on growth and nutritive value of Rhodes grass (*Chlorisgayana*cv.Kunth). Anim. Feed. Sci. Technol.65: 87-98.

McDonald, P, Edwards, RA,Greenhalgh, JFD, Morgan, CA. 2002. Animal Nutrition, 6thed., Prentice Hall, USA.

Mendieta-Araica, B,Spörndly, R, Reyes-Sánchez, N,Spörndly, E. 2011. Moringa (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. *Lives Sci*.137: 10-17.

Ndemanisho, EE, Mtenga, LA, Kimbi, EFC, Kimambo, AE, Mtengeti, EJ. 1998. Substitution of dry *Leucaena leucocephala* (DLL) leaves for cotton seed cake (CSC)as a protein supplement to urea treated maize stover fed to dairy weaner goats. Anim. Feed. Sci. Technol.73: 365-374.

Nega, A, Melaku, S. 2009. Feed intake, digestibility and body weight change in Farta sheep fed hay supplemented with rice bran and/ or utilization and live weight change of Farta sheep noug seed (*Guizotia abyssinica*) meal. Trop. Anim. Health Prod.41: 507-515.

Nurfeta, A.2010. Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial by-products. Trop. Anim. Health Prod.42: 815-824.

Odeny, DA. 2007. The potential of pigeonpea (*Cajanus cajan* (L.) Millsp.) in Africa. Natl. Resour. Forum 31: 297–305.

Ondiek, JK, Tuitoek, JK, Abdulrazak, SA, Bareeba, FB, Fujihara, T. 2000. Use of *Leucaena leucocephala* and *Gliricida sepium* as nitrogen sources in supplementary concentrates for dairy goats offered Rhodes grass hay. Asian Australas J AnimSci13:1249-1254.

Park, YW, Reynolds, GA, Stanton, TL. 1989. Comparison of dry matter intake and digestibility of sun-cured pigeon pea, alfalfa and coastal Bermuda grass by growing dairy goats. Small Rumin. Res.2: 11-18.

Patra, AK, Sharma, K, Dutta, N, Pattanaik, AK. 2006. Effect of partial replacement of dietary protein by a leaf mixture on nutrient utilization by goats in pre-and late gestation. Small Rumin. Res.63: 66-74.

Reed, JD, Soller, H, Woodward, A. 1990.Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of pehnolics on nitrogen utilization. Anim.Feed. Sci. Technol.30: 39-50.

Richards, DE, Brown, WF, Ruegsegger, G, Bates, DB. 1994. Replacement value of tree legumes for concentrates in forage-based diets I. Replacement value of *Gliricidia sepium* for growing goats. Anim. Feed. Sci. Technol.46: 37-51.

SAS.2001.*SAS User's Giude*, SAS Institute Inc., Cary, NC, USA.

Shenkute, B, Hassen, A, Ebro, A, Amen, N. 2013.Performance of Arsi-Bale kids supplemented with graded levels of pigeon pea in dry season in Mid Riftvalley of Ethiopia. *Afr. J. Agri. Res.*8 (20): 2366-2370.

Smith, T, Manyuchi, B, Mikayiri, S. 1990: Legume supplementation of maize stover. In: PANESA/ARNAB (Pastures Network for Eastern and Southern Africa/African Research Network for Agricultural By-products). Utilization of research results on forage and agricultural by-product materials as animal feed resources in Africa. Proceedings of the first joint workshop held in Lilongwe, Malawi, 5-9 December 1988. PANESA/ARNAB, Addis Ababa, Ethiopia,p.833.

Van Soest PJ. 1994. Nutritional Ecology of the Ruminant. 2nd ed. Cornell University Press, Ithaca, USA,p.476.

Van Soest, PJ, Robertson, JB, Lewis, BA, 1991.Methods of dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci.74: 3583-3597.

Whiteman, PC,Norton, BW. 1981. Alternative uses of pigeon pea. In: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Proceedings of the International workshop on pigeon peas, volume 1, 15-19 December 1980, Patancheru, A.P., India. PP 365-377.

Woods, WR, Richardson, H, Kruse, K, Gallup, WD,Tillman, AD, 1962. Further studies on the nutritive value of cotton seed meal for ruminants. J. Anim. Sci.21: 284-289.