Trop Anim Health Prod (2013) 45:379–385
DOI 10.1007/s11250-012-0227-9

REGULAR ARTICLE

Partial replacement of dried *Leucaena leucocephala* (Lam.) de Wit leaves for noug (*Guizotia abyssinica*) (L.f.) Cass. seed cake in the diet of highland sheep fed on wheat straw

Temesgen Tesfay · Yayneshet Tesfay

Accepted: 10 July 2012 / Published online: 23 July 2012
© Springer Science+Business Media B.V. 2012

Abstract This study investigated the effect of replacing noug (*Guizotia abyssinica*) (L.f.) Cass. seed cake by dried *Leucaena leucocephala* (Lam.) de Wit leaves on feed intake, live weight gain, nutrient digestibility, and nitrogen balance of highland sheep in Tigray Region in northern Ethiopia. Twenty intact yearling male highland sheep weighing16.9±1.62 kg were used in a randomized complete block design and included the following four treatments: T1 (control, wheat straw ad libitum+200 g noug seed cake (NSC)+150 g wheat bran (WB)); T2 (wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala* (DLL)+150 g WB); T3 (wheat straw ad libitum+140 g NSC+87.3 g DLL+150 g WB); and T4 (wheat straw ad libitum+110 g NSC+130.2 g DLL+150 g WB). Sheep fed on T4 diet consumed higher total dry matter (658 g/head/day) and recorded the highest average daily weight gain (59 g/head/day). Sheep fed on T4 diet had higher dry matter (61 %), organic matter (63 %), and crude protein (75 %) digestibility values than the other treatments. Sheep fed on T3 diet demonstrated higher feed conversion ratio (11.93) than sheep kept on the other treatments. All sheep exhibited positive nitrogen balance, with the highest nitrogen retention being measured in T4 (12 g/head/day). It is concluded that partially replacing NSC by DLL can improve total dry matter intake, digestibility of nutrients, and body weight gain in highland sheep fed on wheat straw as the basal diet.

T. Tesfay
Tigray Agricultural Research Institute,
Alamata Agricultural Research Center,
P.O. Box 56, Tigray, Ethiopia

Y. Tesfay (✉)
Department of Animal, Rangeland and Wildlife Sciences,
Mekelle University,
P.O. Box 231, Tigray, Ethiopia
e-mail: yayneshet_tesfay@yahoo.com

Keywords Body weight · Digestibility · Dry matter intake · Feed conversion · Legumes

Abbreviations

ADF	Acid detergent fiber
ADL	Acid detergent lignin
BW	Body weight
CP	Crude protein
DM	Dry matter
NDF	Neutral detergent fiber
NSC	Noug seed cake
OM	Organic matter
WB	Wheat bran

Introduction

The major available feed resources in sub-Saharan African countries such as Ethiopia are natural pasture, crop residues, and aftermath, which are usually not capable of supporting reasonable animal productivity due to low (<7 %) crude protein (CP) content, poor (<50 %) digestibility, and high (>55 %) neutral detergent fiber (NDF) (Bogale et al. 2008; Abate and Melaku 2009). Various techniques to improve utilization of low-quality forages have been tested but not adopted by farmers in tropical countries for various reasons including economic constraints (Ben Salem and Smith 2008). Chemical treatments are effective methods to improve crop residues but cost implications and their difficulty to apply are basic challenges. Supplementation using agro-industrial by-products such as noug (*Guizotia abyssinica*) (L.f.) Cass. seed cake, commercial concentrates, and green leguminous multipurpose trees and shrubs are among the common strategies used by farmers. The use of agro-industrial by-products such as noug seed cake is expensive and at times inaccessible for remotely residing smallholder farmers.

Alternatively, leguminous supplements such as *Leucaena leucocephala* (Lam.) de Wit could be used to partially replace the more expensive and inaccessible agro-industrial by-products (Yayneshet et al. 2008; Mekoya et al. 2009). *L. leucocephala* as a tree legume is noted for its highly nutritive value for ruminant production (Babayemi and Bamikole 2006; Osakwe 2006). The plant has proved to be a valuable multipurpose tree and the dried leaves have shown to have reduced mimosine content (Mero and Udén 1990). Supplementation with *L. leucocephala* leaves resulted in positive live weight gain, dry matter (DM) intake, feed digestibility, N balance, and improved rumen function in different species of animals (Reed et al. 1990; Abdulrazak et al. 1997). *L. leucocephala* is now being grown in all agro-ecological zones and well adapted to Tigray Region in northern Ethiopia. However, farmers still have low perception about the use of *L. leucocephala* as animal feed. The objective of this study was to evaluate the effect of partial replacement of noug seed cake by dried *L. leucocephala* leaves on feed intake, live weight gain, digestibility, and nitrogen balance of highland sheep fed on wheat straw in Tigray Region of northern Ethiopia.

Materials and methods

Description of study area

The study was carried out at Small Ruminant Research Unit of Mekelle University, Mekelle, Ethiopia located at 13°27 N and 039°01 E. Altitude ranges from 2,000–2,200 m above sea level and climate of the region is semiarid with annual rainfall ranging between 500 and 700 mm and with relative humidity of 50 %. Annual average maximum and minimum temperatures are 40 and 20 °C, respectively. The dominant soil types are classified to into four classes: sandy loam, silty loam, clay loam, and clay soils. The principal land use in the study area is rain-fed mixed crop-livestock agriculture. The area is sparsely vegetated as a result of excessive deforestation mainly for agricultural land.

Experimental animals and their management

Twenty non-castrated yearling male highland sheep weighing 16.9±1.62 kg were purchased from different farmers in Enba-Alaja District main market place in northern Tigray. The experimental sheep were purchased from similar agro-ecological zone and housed in individual pens equipped with feeding and watering troughs. All sheep were drenched with a broad spectrum anthelminthic (Albendazol) drug against internal parasites, sprayed with an acaricide (Ectoparasite 30) against external parasites, and vaccinated against anthrax and ovine pasteurollosis.

Experimental design and treatments

The experiment design was a randomized complete block with four treatments and five blocks. Blocking was done on the basis of five arbitrarily chosen initial body weight ranges (weight group 1—14.5–15 kg; weight group 2—15.1–16 kg; weight group 3—16.1–17 kg; weight group 4—17.1–18 kg; and weight group 5—18.1–19.5 kg). These five blocks served as replications, and in each block one sheep was assigned per treatment. Dried *L. leucocephala* leaf was included in the diet of the yearling sheep to partially replace noug seed cake at 15, 30, and 45 % on dry matter basis. The following four treatments were formulated by first subtracting the above percentages of NSC and replacing them by equivalent amounts of dried *L. leucocephala* leaf: T1 (control)—wheat straw ad libitum+200 g noug seed cake (NSC)+150 g wheat bran (WB); T2 (15 %)—wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala* (DLL)+150 g WB; T3 (30 %)—wheat straw ad libitum+140 g NSC+87.3 g DLL+150 g WB; T4 (45 %)—wheat straw ad libitum+110 g NSC+130.2 g DLL+150 g WB.

The *L. leucocephala* leaves were harvested from the premises of Mekelle Agricultural Research Centre in northern Ethiopia and dried under a naturally ventilated open shade. Wheat straw, noug seed cake, and wheat bran were purchased from the market in Mekelle.

Feed intake and body weight

Daily feed offered and refused were collected over a 90-day period, weighed, pooled for each treatment, and about 20 % subsampled for chemical analysis. Daily feed intake of individual sheep was calculated as a difference between feed offered and refused and expressed on metabolic body weight ($W^{0.75}$) basis. Feed conversion ratio was calculated as the proportion of daily feed intake to daily live weight gain. Live weight of each animal was recorded at weekly interval after overnight fasting. Average daily live weight gain was computed as the difference between final live weight and initial live weight divided by 90 days feeding period.

Digestibility trial

The digestibility trial was conducted for 7 days following the feeding trial and after 3 days of adaptation period for carrying canvas fecal bags. Feces were collected and weighed every morning for each sheep before feed offer. The collected feces were mixed thoroughly, and 10 % subsampled and kept in air tight plastic containers and stored at −20 °C until the end of the digestibility trial. Urine was collected over 24 h using collection plastic (2 l) containing 100 ml 10 % sulfuric acid. From the total urine collected, 10 % of the urine voided daily per animal was sampled and

pooled over the collection period and stored at −20 °C until analysis.

Nitrogen retention was calculated as a difference between the nitrogen intake and nitrogen excretions in fecal and urine during the 7 days of collection. Apparent digestibility of DM, organic matter (OM), CP, NDF, and acid detergent fiber (ADF) were estimated using the formula of McDonald et al. (2002).

Chemical analysis

Dry matter, OM, and nitrogen contents of feed offered and feces were determined following the procedures of AOAC (2000). The NDF, ADF, and sulfuric acid solubilized acid detergent lignin (ADL) were determined according to Robertson and Van Soest (1981).

Statistical analysis

The data collected from the experiment were subjected to analysis of variance using the general linear model procedure of SAS (SAS 1998). Significant treatment means were separated using Tukey HSD. The following statistical model was used to analyze the data:

$$Y_{ijk} = \mu + a_i + b_j + e_{ijk}$$

where:

Y_{ijk} = response variable;
μ = overall mean;
a_i = ith treatment effect (i = 1–4; treatment 1, treatment 2, treatment 3, and treatment 4);
b_j = jth block effect (j=1–5; weight group 1 (14.5–15 kg), weight group 2 (15.1–16 kg), weight group 3 (16.1–17 kg), weight group 4 (17.1–18 kg), weight group 5 (18.1–19.5 kg));
e_{ijk} = Normally and independently distributed random error.

Results

Chemical composition

The chemical composition of the experimental feeds and treatments are provided in Table 1. The crude protein content of NSC and WB ranked first and second. The CP content of WS was below the maintenance requirement of sheep while DLL contained more than ten times (25 vs 265 g/kg DM) crude protein. Wheat straw contained the highest concentration of NDF, ADF, and ADL. The lowest NDF and ADF values were measured in NSC and WB, respectively. The DM, CP, ADF, and ADL contents of T4 diets were higher than T1, T2, and T3. However, T4 diets had lower OM and NDF contents than T1, T2, and T3.

Dry matter and nutrient intake

Sheep fed on T4 diet had the highest total DM and nutrient intake (Table 2). Dry matter consumption expressed on metabolic body weight ($W^{0.75}$) basis was the highest in sheep fed on T4 and T3. Sheep fed on T4 consumed the highest OM (594 g/head/day). The consumption of NDF was comparable in sheep fed on T3 and T4 treatments (358.6 vs 360.3 g/head/day).

Body weight gain and feed conversion

Sheep fed on T4 diet had higher average daily body weight gain than sheep fed on T1, T2, and T3 diets (Table 3). The highest average daily body weight gain was measured on sheep fed on T4 (58.88 g/head/day). Feed conversion ratio

Table 1 Chemical composition of the experimental diets and treatments

Composition (g/kg DM)	Feeds				Treatments			
	WS	WB	NSC	DLL	T1	T2	T3	T4
DM	907	951	910	925	900	898	896	902
OM	887	886	907	895	926	927	929	918
CP	25	151	353	265	27	259	252	299
NDF	720	460	339	453	391	403	413	388
ADF	384	154	287	326	230	237	243	278
ADL	107	33	61	87	49	53	56	64

ADF acid detergent fiber, *ADL* acid detergent lignin, *CP* crude protein, *DM* dry matter, *NDF* neutral detergent fiber, *NSC* noug seed cake, *OM* organic matter, *WS* wheat straw, *WB* wheat bran, *DLL* dried *L. leucocephala*, *T1* control (wheat straw ad libitum+200 g NSC+150 g WB), *T2* wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala*+150 g WB, *T3* wheat straw ad libitum+140 g NSC+87.3 g dried *L. leucocephala*+150 g WB, *T4* wheat straw ad libitum+110 g NSC+130.2 g dried *L. leucocephala*+150 g WB

Table 2 Dry matter and nutrient intake of highland sheep fed different level of dried *L. leucocephala* as a partial replacement for noug seed cake

Intake	Treatments				SEM	*P* value
	T1	T2	T3	T4		
Total DM (g/day)	593.62 d	609.86 c	635.43 b	657.64 a	4.211	<0.001
Total DM (g/kg $W^{0.75}$)	59.57 c	60.86 c	62.91 b	65.35 a	0.420	<0.001
Nutrient intake (g/day)						
OM	538.27 d	553.20 c	577.03 b	593.95 a	3.834	<0.001
CP	88.153 b	86.77 b	89.269 b	110.05 a	0.893	<0.001
NDF	327.585 c	342.26 b	358.63 a	360.3 a	2.267	<0.001

Means with different letters in a row are significantly different ($P<0.05$)

CP crude protein, *DM* dry matter, *NDF* neutral detergent fiber, *OM* organic matter, *SEM* standard error of mean, *T1* control (wheat straw ad libitum +200 g NSC+150 g WB), *T2* wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala*+150 g WB, *T3* wheat straw ad libitum+140 g NSC+87.3 g dried *L. leucocephala*+150 g WB, *T4* wheat straw ad libitum+110 g NSC+130.2 g dried *L. leucocephala*+150 g WB

was higher in sheep that consumed T3 (11.9 %) and T2 (11.4 %) diets than sheep fed on T4 (11.2 %) and T1 (11.1 %) diets.

Nutrient digestibility and nitrogen balance

Nutrient digestibility data are presented in Table 4. The highest CP digestibility was recorded in sheep fed on T4 diet (74.96 %). However, there was no significant difference among treatments on NDF ($P=0.438$) digestibility and digestibility of ADF tended to be significant ($P=0.076$) among the treatments.

Total nitrogen consumed and excreted is presented in Table 5. All sheep had positive nitrogen balance, with the highest value measured in sheep fed on T4. Sheep placed on T1 and T3 diets had higher fecal nitrogen excretion than sheep on T2 and T4 diets. Sheep offered T4 diet had higher nitrogen retention than sheep fed on T1, T2, and T3 diets.

Discussion

Wheat straw had low CP content and high value of NDF and ADF, which suggests its inability to keep sheep at maintenance level and a positive response to supplementation. High values of NDF and ADF are likely to depress intake and digestibility of roughage-based diets (Van Soest 1994). Thus, the CP and NDF values of WS in the current study are lower than the value reported by Gebremeskel and Kefelegn (2011). The crude protein content of DLL leaves, NSC and WB can satisfy the maintenance and production requirements of sheep. The CP and NDF values of DLL in the current study are higher than the 405 g/kg DM reported by Fasae et al. (2011), while the NDF value is lower than the 632 g/kg DM reported by others (Eniolorunda 2011; Jetana et al. 2011). However, the CP value of DLL in the current study is lower than 288 g/kg DM (Asaolu et al. 2011). The NDF, ADF, and ADL values of NSC in the current study were lower than the value reported by Kebede et al. (2011) and Gebremeskel and Kefelegn (2011). The CP and NDF values of wheat bran in the current study were lower than the values reported by Kebede et al. (2011). Chemical composition values variation could be attributed to different environmental conditions in which the crops were grown and methods employed to process the grain, additives used, and quantity of fat extracted (McDonald et al. 2002).

Wheat straw intake and total DM intake were increased with a progressive substitution of NSC by DLL. Total DM intake observed with increasing level of dried *L. leucocephala*

Table 3 Body weight change of highland sheep fed on different levels of *L. leucocephala* as partial replacements for noug seed cake

Parameter	Treatments				SEM	*P* value
	T1	T2	T3	T4		
Final body weight (kg)	21.5 b	21.7 b	21.9 a, b	22.3 a	0.137	0.009
Average weight gain (g/head/day)	53.33 b	53.33 b	53.33 b	58.88 a	0.878	0.001
FCR (%)	11.1 b	11.4 a, b	11.9 a	11.2 b	0.16	0.017

Means with different letters in a row are significantly different ($P<0.05$)

SEM standard error of mean, *T1* control (wheat straw ad libitum+200 g NSC+150 g WB), *T2* wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala*+150 g WB, *T3* wheat straw ad libitum+140 g NSC+87.3 g dried *L. leucocephala*+150 g WB, *T4* wheat straw ad libitum+110 g NSC+130.2 g dried *L. leucocephala*+150 g WB, *FCR* feed conversion ratio

Table 4 Apparent nutrient digestibility of highland sheep fed on different levels of *L. leucocephala* as partial replacements for noug seed cake

Digestibility (%)	Treatments				SEM	*P* value
	T1	T2	T3	T4		
DM	57.31 a	60.61 a	59.93 a	61.01 a	1.524	0.371
OM	59.72 a	62.9 a	62.3 a	63.15 a	1.437	0.321
CP	68.4 b	69.9 b	69.33 b	74.96 a	1.168	0.017
NDF	51.78 a	55.74 a	55.17 a	55.41 a	1.834	0.438
ADF	35.83 a	42.04 a	41.65 a	45.80 a	2.247	0.076

Means with different letters in a row are significantly different ($P<0.05$)

SEM standard error of mean, *T1* control (wheat straw ad libitum+200 g NSC+150 g WB), *T2* wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala*+150 g WB, *T3* wheat straw ad libitum+140 g NSC+87.3 g dried *L. leucocephala*+150 g WB, *T4* wheat straw ad libitum+110 g NSC+130.2 g dried *L. leucocephala*+150 g WB

supplementation might suggest the reduced depressing effect of condensed tannin in DLL leaves. The level of DM intake recorded in the current study when DLL is included at the highest (130 g DM/day) is more than the intake measured when DLL leaf is included at 150 g DM/day (Masama et al. 1997), which can be attributed to the drying effect of the DLL as well as to the other supplements. Such trends were also noted by Ndemanisho et al. (1998) when cotton seed cake was replaced by dried *L. leucocephala.* Mtenga and Shoo (1990) reported an increase in DM intake in goats with increased level of supplementation of dried *L. leucocephala.* The high CP intake observed in sheep fed on T4 diet was due to increased total DM intake and higher CP content of the feeds. The DM, OM, NDF, and ADF intakes increased with a progressive replacement of NSC by DLL. The improved feed intake for *Leucaena*-supplemented diets could have resulted due to faster rumen outflow rate and the provision of more degradable organic matter (Yousuf et al. 2007). Indeed, McDonald et al. (2002) identified that feeds rich in protein promote number and variety of rumen microbial population, which in turn facilitates rumen fermentation.

Due to high CP intake, sheep fed with T4 diet had higher live weight gain. Sheep fed on T4 diets had 58.8 g/head/day average daily body weight gain. Maasdorp et al. (1999) noted that when DLL and CSC are provided in mixture, a synergetic effect in the form of protecting protein from rumen degradation is likely to happen and this might have reduced nitrogen wastage. The results of daily body weight gain of the supplemented treatments of this study were comparable to those reported by Nega and Melaku (2009), which were in the ranges of 5.5 to 57.8 g/day. This range is higher than the value reported by Fasae et al. (2011) on sheep fed with maize residues and supplemented with DLL but lower than the 64–134 g/day reported by Eniolorunda (2011) and Gebremeskel and Kefelegn (2011). The higher body weight gains achieved in sheep fed on T4 is a reflection of higher CP intake and digestibility.

Sheep fed with T4 diets had higher CP digestibility than sheep fed on T3, T2, and T1 diets. The digestibility of N in T4 was higher than other treatments, which could be due to the higher N supply in these diets. Preston and Leng (1984) reported that any increase in protein intake will lead to increase in digestibility of crude protein. Similarly, Melaku

Table 5 Nitrogen intake, excretion and retention in highland sheep fed on different levels of *L. leucocephala* as partial replacements for noug seed cake

Parameter(g/head/day)	Treatment				SEM	*P* value
	T1	T2	T3	T4		
Total nitrogen consumed	15.15 d	15.45 c	15.55 b	18.64 a	0.019	<0.001
Total nitrogen excreted in urine	2.4 b	2.55 a	2.3 b	2.28 b	0.038	0.004
Total nitrogen excreted in feces	4.74 a	4.64 a	4.77 a	4.49 a	0.226	0.808
Total nitrogen excreted	7.1 a	7.2 a	7.08 a	6.78 a	0.246	0.808
Total nitrogen retained	7.99 b	8.25 b	8.47 b	11.86 a	0.244	<0.001

Means with different letters in a row are significantly different ($P<0.05$)

SEM standard error of mean, *T1* control (wheat straw ad libitum+200 g NSC+150 g WB), *T2* wheat straw ad libitum+170 g NSC+44.3 g dried *L. leucocephala*+150 g WB, *T3* wheat straw ad libitum+140 g NSC+87.3 g dried *L. leucocephala*+150 g WB, *T4* wheat straw ad libitum+110 g NSC+130.2 g dried *L. leucocephala*+150 g WB

et al. (2004) observed that mixtures of multipurpose trees fed to Menz sheep fed on tef straw improved CP digestibility. The CP digestibility value in the current study is comparable with the values reported by Eniolorunda (2011) and Gebremeskel and Kefelegn (2011). Aregheore and Perera (2004) reported that an enhancement of nutrient digestibility could probably be due to an effect of improved microbial growth in the rumen and enhanced fermentation inside the rumen. The higher N retention observed for T4 diet was probably due to the higher N digestibility and high N intake in these treatments. The N retention measured in this study is more than the value reported by Asaolu et al. (2011) when sheep was fed with *Moringa oleifra* and *L. leucocephala* in equal proportions. Treatment diets significantly affected only urine nitrogen excretion but not fecal nitrogen excretion. A similar pattern was observed in other reports (Asaolu et al. 2011; Fadiyimu et al. 2010). Kaswari et al. (2007) suggested that losses of N in urine are mainly caused by an oversupply of crude protein and/or an imbalance in the supply of amino acids. Similarly, Ndemanisho et al. (1998) reported significant effect on urinary nitrogen excretion in goats when cotton seed cake was refed by dried *L. leucocephala*.

Conclusions

The current practice of supplementing expensive protein sources such as noug seed cake for highland sheep can be partially replaced with less expensive and locally available green leguminous multipurpose browse species such as *L. leucocephala*. It is concluded that partially replacing noug seed cake by dried *L. leucocephala* leaves can improve total DM intake, digestibility of nutrients, and body weight gain in highland sheep fed on wheat straw.

Acknowledgments The first author (TT) is very grateful to the Rural Capacity Building Project and the Tigray Agricultural Research Institute for their financial support.

Conflict of interest We, the authors of this work, declare that we had no any conflict of interest regarding this research work.

References

Abate, D., Melaku, S., 2009. Effect of supplementing urea-treated barley straw with lucerne or vetch hays on feed intake, digestibility and growth of Arsi Bale sheep, Tropical Animal Health and Production, 41, 579–586.

Abdulrazak, S.A., Muinga, R.W., Thorpe, W., Ørskov, E.R., 1997. Supplementation with *Gliricidia sepium* and *Leucaena leucocephala* on voluntary food intake, digestibility, rumen fermentation and live weight of crossbred steers offered *Zea mays* stover, Livestock Production Science, 49, 55–64.

AOAC, 2000. Official methods of analysis, (Association of Official Analytical Chemists, Gaithersburg, MD).

Aregheore, E. M., Perera, D., 2004. Effects of *Erythrina variegata*, *Gliricidia sepium* and *Leucaena leucocephala* on dry matter intake and nutrient digestibility of maize stover before and after spraying with molasses, Animal Feed Science and Technology, 111, 191–201.

Asaolu,V.O., Binuomote, R.T., Akinlade, J.A., Oyelami O.S., Kolapo, K.O., 2011. Utilization of *Moringa oleifera* fodder combinations with *Leucaena leucocephala* and *Gliricidia sepium* fodders by West African Dwarf Goats. International Journal of Agricultural Research, 6, 607–619.

Babayemi, O.J. Bamikole, M.A., 2006. Supplementary value of *Tephrosia bracteolate*, *Leucaena leucocephala*, and *Gliricidia sepium* hay for West African Dwarf goats kept on range, Journal of Central European Agriculture, 7, 323–328.

Ben Salem, H., Smith, T., 2008. Feeding strategies to increase small ruminant production in dry environments, Small Ruminant Research, 77, 174–194.

Bogale, S., Melaku, S., Yami, A., 2008. Potential use of crop residues as livestock feed resources under smallholder farmers conditions in Bale highlands of Ethiopia, Tropical and Sub-Tropical Agro-Ecosystems, 8, 107–114.

Eniolorunda, O. O., 2011. Evaluation of biscuit waste meal and *Leucaena leucocephala* leaf hay as sources of protein and energy for fattening Yankassa rams. African Journal of Food Science, 5, 57–62.

Fadiyimu, A.A., Alokan, J.A., Fajemisin, A.N., 2010. Digestibility, nitrogen balance and haematological profile of West African Dwarf sheep fed dietary levels of *Moringa oleifera* as supplement to *Panicum maximum*. Journal of Animal Sciences, 6, 634–643.

Fasae, O.A., Adesope, A.I., Ojo, V.O.A., 2011. The effect of *Leucaena* leaf supplementation to maize residues on village goat performance. Journal of Animal and Plant Sciences, 10, 1276- 1282.

Gebremeskel, G., Kefelegn, K., 2011. Feed utilization, digestibility and carcass parameters of Tigray highland sheep fed urea treated wheat straw supplemented with mixtures of wheat bran and noug seed cake in Southern Tigray, Ethiopia. Livestock Research for Rural Development, 23. Article# 184 Retrieved May 30, 2012, from http://www.lrrd.org/lrrd23/9/gebr23184.htm

Jetana, T., Vongpipatana, C., Usawang, S., Thongruay, S., 2011. The use of tropical protein-rich leaves as supplements to Thai swamp buffalo receiving a basal diet of rice straw and treated leucaena (*Leucaena leucocephala*). Tropical Animal Health and Production, 43, 57–67.

Kaswari, T., Lebzien, P., Flachowsky, G., Meulen, U.T., 2007. Studies on the relationship between the synchronization index and the microbial protein synthesis in the rumen of dairy cows, Animal Feed Science and Technology, 139, 1–22.

Kebede, T., Gutu, T., Tadesse, E.,2011. Performance and economic efficiency of browsing Arsi-Bale goats supplemented with sweet potato (*Ipomoea batatas L.*) vines as replacement for concentrate. International Journal of Livestock Production, 7, 92–99.

Maasdorp, B.V., Muchenje, V., Titterton, M. 1999. Palatability and effect on dairy cow milk yield of dried fodder from the forage trees *Acacia boliviana*, *Calliandra calothyrsus* and *Leucaena leucocephala*, Animal Feed Science and Technology, 77, 49–59.

Masama, E., Topps J.H., Ngongoni N.T., Maasdorp, B.V., 1997. Effects of supplementation with foliage from the tree legumes *Acacia angustissima*, *Cajanas cajan*, *Calliandra calothyrsus* and *Leucaena leucocephala* on feed intake, digestibility and nitrogen metabolism of sheep given maize stover ad libitum, Animal Feed Science and Technology, 69, 233–240.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., 2002. Animal nutrition, (Prentice Hall, London).

Mekoya, A., Oosting, S.J., Fernandez-Rivera, S., Tamminga, S., Tegegne, A., Van der Zijpp, A.J., 2009. Effect of supplementation

of Sesbania sesban on post-weaning growth performance and sexual development of Menz sheep (Ethiopia), Livestock Production Science, 121, 108–116.

Melaku,S., Peters K.J. Azage T., 2004. Effect of supplementation with foliage of selected multipurpose trees and their mixtures or wheat bran on feed intake, plasma enzyme activities, live weight and scrotal circumference gain in Menz Sheep, Livestock Production Science, 89, 253–264.

Mero, R.N., Udén, P., 1990. Effect of supplementing mature grass hay with dried *Leucaena* leaves on organic matter digestibility and voluntary intake by sheep, Animal Feed Science and Technology, 31: 1–8.

Mtenga, L.A., Shoo, R.A., 1990. Growth rate, feed intake and feed utilization of small East African goats supplemented with *Leucaena leucocephala*. Small Ruminants Research, 3, 9–10.

Ndemanisho, E.E., Mtenga, L.A., Kimbi, E.F.C., Kimambo, A.E., Mtengeti, E.J., 1998. Substitution of dried *Leucaena leucocephala* (DLL) leaves for cotton seed cake (CSC) as a protein supplement to urea treated maize stover fed to dairy weaner goats, Animal Feed Science and Technology, 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 noug seed (*Guizotia abyssinica*) meal, Tropical Animal Health and Production, 41, 507–515.

Osakwe, I.I., 2006. Effects of *Leucaena leucocephala* supplementation to basal hay on energy and protein metabolism in West African Dwarf sheep, Nigerian Journal Animal Production, 33, 94–101.

Preston, T., Leng, R.A., 1984. Supplementation of diets based on fibrous residue and by-products. In: F. Sundstøl and E. Own (eds), Straw and other fibrous by-products as feed. (Elsevier, Amsterdam), 373–413.

Reed, J.D., Soller, H., Woodward, A., 1990. Fodder tree and stover diets for sheep: intake, growth, digestibility and effects of phenolics on nitrogen utilization, Animal Feed Science and Technololgy, 30, 39–50.

Robertson, J.B. Van Soest, P.J., 1981. The detergent system of analysis. In: W.P.T. James and O. Theander (eds), The analysis of dietary fibre in food. (Marcel Dekker, New York), 123–158.

SAS (Statistical Analysis System), 1998. SAS/STAT Guide to personal computers, Version 7, (Statistical Analysis System Institute. Inc., North Carolina).

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant, (Cornell University Press, New York).

Yayneshet, T., Eik, L.O., Moe, S.R., 2008. Feeding *Acacia etbaica* and *Dichrostachys cinerea* fruits to smallholder goats in northern Ethiopia improves their performance during the dry season, Livestock Science, 119, 31–41.

Yousuf, M. B. Belewu, M A., Gbadamosi, H. A., Ogudun, N. I., 2007. Replacing Cotton Seed Cake with Cassava Leaf Meal in Corn Bran Based Diet Fed to the Goat. Bulgarian Journal of Agricultural Science, 13, 231–236.