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Digestibility and Feed Intake of Menz Sheep Fed Natural Pasture Hay Supplemented with Ameja (Hypericum quartinanum) Leaf and Noug (Guizotia abyssinica) Seed Cake

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Abstract
The experiment was conducted to evaluate the effect of supplementation of different proportion of Ameja (Hypericum quartinanum) leaf (AL) and Noug (Guizotia abyssinica) seed cake (NSC) on digestibility and feed intake of Menz sheep. Twenty five yearling male Menz lambs were divided based on their initial body weight (BW) and randomly assigned to treatments. Treatments were natural pasture hay (NPH) ad libitum + 150 g/day oats grain alone (T1) or with 344 g/day AL (T2), 230 g/day AL + 50 g/day NSC (T3), 112 g/day AL + 100 g/day NSC (T4) and 150 g/day NSC (T5). The supplements from AL and NSC were on iso-nitrogenous basis. The crude protein (CP) content of NPH, NSC, AL and oat grain was 6.5, 35.6, 15.1 and 9.8%, respectively. Total dry matter (DM) intake was greater for T3, T4, and T5 as compared to T1. There was significant difference among treatments in CP intake and its digestibility differed ($P < 0.001$) among the treatments but not for DM and other nutrients. Thus it is advisable to use Noug seed cake alone or Ameja/Noug seed cake combination at 67:33 proportion as protein supplement, whenever Noug seed cake is available. However, when Noug seed cake is unavailable or expensive, Ameja leaf can be used as a sole protein supplement.
Keywords: Menz Sheep, Intake, Digestibility, Ameja, Noug, Crud protein.

INTRODUCTION

Sheep, comparing with other farm livestock are more dependent on natural pasture for maintenance and production (Ranjhan, 1997). However, the yield and quality of the natural pasture in the Ethiopian highlands has declined through the years due to overgrazing and lack of proper management. As a result, the natural pasture hay is generally characterized by relatively low crude protein and high fiber content and it can supply only sub-maintenance requirement of animals when fed alone (Seyoum *et al*., 1998). The digestion of cellulose/hemicelluloses, the major sources of energy in forage-based ruminant diets, depends on the activities of the microflora (Annison, *et al.,* 2002). Hence, the maintenance of a healthy rumen ecosystem is a prerequisite of ruminant nutrition. Active microbial protein synthesis can only occur if adequate amounts of rumen degradable protein and readily available energy are simultaneously present in the feed (McDonald *et al*., 2002). Depression in feed intake is apparent mainly due to low nitrogen and high neutral detergent fiber (NDF) content (McDowell, 1985; Van Soest, 1994; Forbes, 2007). Hence, supplementation with protein and energy supplements is crucial to improve the digestibility and enhance feed intake of natural pasture. Currently, protein supplements are unavailable in the vicinity of small-holder farmer and if available, it is non affordable. Therefore, it is utmost important to look for alternative protein supplements.

Ameja (Hypericum quartinanum) is one indigenous shrub that stays green throughout the year and is directly browsed by sheep and goats (Likawent et al., 2008). It has got a crude protein content of 12.73% and 16.94% during dry and wet season, respectively (Likawent et al., 2008). It can thus be a potential supplement to partially fill the gap of protein deficit in low quality feeds. Noug or Niger seed (Guizotia abyssinica), is one of the oil seeds, and which is an annual herbaceous plant widely cultivated in the highlands of Ethiopia for edible oil (Butterworth and Mosi, 1986).

So far, no study has been conducted on the feeding value of this indigenous plant, hence, this study was initiated to evaluate the potential of Ameja for supplementing highland sheep with the objective of evaluating the effect of supplementation of different proportions of Ameja (*Hypericum quartinanum*) leaf and Noug seed (*Guizotia abyssinica*) cake on digestibility and intake of Menz sheep fed natural pasture hay basal diet.

MATERIAL AND METHODS

Description of the Study Area

The experiment was conduct at Debre-Birehan Agricultural Research Center. The study area is located in central highlands of Ethiopia at about 120 km North East of Addis Ababa, at an altitude of 2800 meter above sea level. The geographical location of Debre-Birehan is 09º 35' 45" to 09º 36' 45" north latitude and from 39º 29' 40" to 39º 31' 30" east longitude (NSRC, 2006). According to the climatic data records from 1954 to 2005, the mean annual rainfall at Debre-Birehan is 897.8 mm, mean annual maximum temperature is 19.9^{o}C and monthly values range between 18.7^{o}C in August and 22.0^{o}C in June. The mean annual minimum temperature is 6.5^{o}C and monthly values range between 3.2^{o}C in November and 8.5^{o}C in June (NSRC, 2006). The coldest month occurs in November while the hottest months are May and June. The area is characterized by mixed crop livestock production system. Barley, wheat, and faba bean are the major crops grown in the area. Among livestock, cattle and sheep are the dominant species.

Feed Preparation and Feeding Procedure

Natural pasture hay was used as a basal diet and harvested from Debre-Birhan Agricultural Research Center, cured, baled and kept under shade. The Ameja (*Hypericum quartinanum*) leaves were harvested from natural established vegetation, from Dargegn kebele, Geramider Woreda, North Shewa zone of Amhara region. Harvesting was done during the month of October, when the plant started flowering. The leaf with the branch part was sun cured and after drying, the leaf part was separated from branch and kept in sacks and transported to Debre-Birhan Agricultural Research Center where the experiment was conducted. Noug (*Guizotia abyssinica*) seed cake (NSC) was purchased from the food oil manufacturers at Ginchi town, West Shewa Zone of Oromia region. Oats grains were purchased from the local market at Debre-Birhan town.

All experimental animals received the basal diet natural pasture hay *ad libtum* (at 20% refusal). The basal diet was offered at 0830 hour daily. Animals in the supplemented groups were fed the supplements in two equal halves at 0830 and 1600 hours daily. Water and salt block were available to all animals free of choice. For animals that received mixture of the two supplements, the supplements were thoroughly mixed after separate weighing of each component.

All animals received 150 gm coarsely ground oats grain as an energy supplement. Noug seed cake was offered at 150 gm per animal for the treatment that received 100% of the protein supplement. The amount of Ameja substituting noug seed cake was calculated based on the crude protein content of the two diets so as to make the supplements iso-nitrogenous.

Experimental Animal

Twenty five nearly yearling intact male Menz sheep were purchased from the local market. The age was determined based on the dentition and information obtained from the owner. Immediately after purchase, animals were kept in quarantine for 30 days and vaccinated for sheep pox and pasteurolosis. The experimental animals were drenched with Albendazole and Fasinex for endoparasites and sprayed with diazinol for ectoparasites before the commencement of the experiment.

Experimental Design and Treatment

Completely Randomized Design (CRD) was used for this experiment. The experimental sheep were divided into five blocks of five animals each based on their initial body weight and animals within each block were randomly assigned into the five treatments (Table 1). The initial body weight was the average of two consecutive body weight measurements and the average body weight was 16.56 ±1.54kg (Mean ±SE)

Digestibility Trial

Digestibility trial was conducted before the feeding trail on all sheep to be used for the study. The experimental animals were acclimatized to experimental feed and managed for 15 days before the commencement of data collection and measurements were continued for 7 days. Total collection of feces for digestibility measure was made for seven consecutive days using fecal bags after three days of acclimatizing the sheep to fecal bags. Fecal bags were emptied each day just after the morning meal, and the daily fecal output was weighed and recorded for each animal. Afterwards, the fecal output of each animal was thoroughly mixed and 20% of the feces voided were sampled to make a composite of fecal samples for each animal over the collection period. The fecal samples were stored frozen at -20 ^{0}C pending chemical analysis. The sheep were weighed at the beginning and end of the digestibility trial. The digestibility co-efficient (DC) of nutrients was calculated using the equation,

$$DC = \frac{\text{Total amount of nutrient in feed} - \text{total amount of nutrient in feces}}{\text{Total amount of nutrient in feed}}$$

Feeding Trial

The feeding trial lasted for 98 days following the digestibility trial. The sheep were penned individually and each sheep was fed according to the treatments. During the feeding trial, feed offered and refusals were recorded daily and feed intake was determined. Grab samples from the four feeds (natural pasture hay, oat, Ameja leaf and Noug seed cake) were taken in the middle of each week and a composite sample one for each feed type was formed for the entire feeding trial. Feed refusal was sampled for each animal at the middle of each week, by taking grab of samples and compositing the samples for each animal. Refusal samples were pooled per treatment.

Chemical Analysis

Sample of feed offered, refusals and feces were dried at 65°C in forced draft oven for about 72 hours and ground to pass 1mm mesh screen size. The ground samples were stored in airtight plastic containers pending chemical analysis. Dry matter (DM), ash, crude protein (CP) were analyzed according to AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the procedures of Van Soest and Robertson (1985). ADL was done for feed samples. The metabolize energy (ME; MJ/kg DM) intake of experimental animals was estimated from in vivo digestible organic matter intake (DOMI) values by using the equation of Agricultural Food and Research Council (1993) as ME (MJ/kg DM) = 0.0157*DOMI g/kg DM, where DOMI = digestible organic matter intake. The DOMI was calculated based on the digestibility of organic matter in digestibility trial and organic matter (OM) intake in the feeding trial.

Statistical Analysis

Data was analyzed using the General Linear Model procedure of SAS (SAS, 2001). When treatment effect was significant, means were separated by least significant difference (LSD).

RESULTS

The chemical composition of experimental feeds is presented in Table 2. The hay refusals in all treatments had lower CP and higher NDF, ADF and ADL as compared to the hay offered. As a protein supplement, NSC is obviously rich in CP which was about 36% in the present study. Besides, the fiber content of NSC was relatively low.

The DM and nutrient intake of the experimental animals is presented in Table 3. The DM intake of hay was not affected by treatments ($P > 0.05$), however, there was a significant ($P < 0.001$) difference among treatment groups in supplement intake. Lower supplement intake was observed in T2 and T5 compared to T3 and T4. Also there was a significant ($P < 0.05$) difference among treatments in total DM intake which was greater for T3, T4, and T5 as compared to T1. There was 13.69, 18.29, 31.01, and 22.49% increase in the DM intake in T2, T3, T4 and T5, respectively compared to the control group.

Difference in CP intake among treatments was significant ($P < 0.001$). Intake of CP ranked as T5 = T4 > T3 > T2 > T1. Intake of NDF was unaffected by treatment ($P > 0.05$), while that of ADF intake showed similar trend as that of total DM intake ($P < 0.05$). The estimated ME intake was significantly variable ($P<0.05$) among treatment groups. Greater values were obtained for T4 and T5 as compared to T1 and T2 ($P < 0.05$), and values for T3 were similar with other treatments (Table 3).

The apparent dry mater and nutrient digestibility coefficient of different treatment feeds is presented in Table 4. Apparent digestibility of DM, OM, ADF and NDF did not differ significantly ($P > 0.05$) among the treatment groups. However, there was significant difference ($P < 0.001$) between the treatment groups in CP digestibility. Protein supplemented groups had significantly greater difference ($P < 0.001$) in crude protein digestibility over the control. Further, there was no significant difference ($P > 0.05$) in CP digestibility between T2 and T3 and between T4 and T5.

DISCUSSION

The CP content of the hay used in this study was slightly below the 7% required to meet the maintenance requirement of ruminants (Forbes, 2007), whereas the NDF and ADF content appeared to be at a level that may limit the voluntary intake of animals (Van Soest, 1994). The chemical analysis values including CP, NDF, ADF, ADL and ash content of hay used in this study were within the range of values reported by Seyoum *et al.(*2007). The lower CP and higher NDF, ADF and ADL in hay refusal compared to the hay offered, was an indication for the selectivity of animals for the better nutritious parts of the plant.

The CP value for NSC recorded in this study was comparable to that reported by Seyoum *et al.* (2007). In the present study NSC was rich in CP and the fiber content was relatively low, indicating its good supplemental value. The ADL and ash content of NSC was within the range of values noted by Seyoum *et al.* (2007).

The CP content of Ameja leaf recorded in this study was similar with that reported by Likawent *et al.* (2008) for Ameja branch. According to Likawent *et al.* (2008), the CP content of Ameja branch ranges from 12.7-17% DM, and the value in the current study was within this range. Protein supplements are feeds of animal or plant origin that need to contain more than 15% CP to serve as a protein supplement (Susan, 2003). Hence, Ameja leaf which contained slightly more than 15% CP in the present study, could be considered as a protein supplement. The NDF, ADF and ADL contents of Ameja leaf were lower in this study as compared to the values reported by Likawent *et al.* (2008). The reason for this discrepancy might be due to the fact that in the previous study the branch was sampled together with the leaf while in the present study, leaf part along with only very succulent branch was collected and used.

The CP, NDF and ash content of oats grain in the current study was slightly higher than that reported by Seyoum *et al*. (2007), however, values for ADF and ADL were lower in this study. Generally, chemical composition of plants and their by-products between or within species differ to a greater extent (Ranjhan, 1997), as the chemical composition of the plants is affected by different factors such as soil composition, fertilizer application, irrigation, seasonal variation, stage of growth, frequency of cutting and variety of the plant .

In previous study, treatments with no supplementation appeared to consume more hay (Abebe, 2006) as opposed to the results of this study. However, in line with this study hay intake of rams was not significantly affected by protein supplementation (Gebregziabher *et al.*, 2003). Similarly, Kaitho *et al*. (1998) reported a significant increase in total DM intake with supplementation of browse species to Ethiopian Highland sheep despite lack of change in the basal feed (*Eragrostis teff*) straw DM intake. Takele and Getachew (2011) also noted that intake of the basal diet DM was not affected by supplementation of sole wheat bran, *Acacia albida* or their mixture. According to Romney and Gill (2000), supplementation tends to have a positive effect on overall DM intake, but may have positive or negative effects on intake of the basal forage, and the latter may be partly due to the substitution effect. In the present study, all sheep including the control received 150 gram oat grain, which might have enriched the nutrient intake of animals and relatively reduced the hay intake.

The difference in supplement intake was associated with differences in the amount of the supplement offered to different treatments to make the supplements iso-nitrogenous for the supplemented animals. However, the lower DM intake from the supplement for T2 than T3 and T4 despite the greater amount of supplemental DM to T2 suggests that the intake of Ameja leaf is limited probably due to the high level of tannin in the Ameja leaf.

According to Likawent *et al.* (2008), the condensed tannin content of Ameja branch ranges between 174.76 and 187.89 abs/gm in wet and dry season respectively, which relatively is higher compared to other indigenous feeds in the area (the condensed tannin content for other indigenous feed ranged between 4.82 – 181.67 abs/gm). Tannins are mildly toxic and at higher concentration often results to a reduction in feed intake (Forbes, 2007).

Minson (1990) suggested that for feeds with a crude protein (CP) content of less than 62 g CP kg^{-1} DM, fiber digestion is inhibited and the author cited a number of trials in which intake of forages have increased by 14–77% following provision of supplementary protein, which is in line with the results of the present study. The total DM intake values of the current study were within the range of values reported by Umunna *et al*. (1995) who noted that DM intake of Menz sheep fed oat hay supplemented with forage legume range between 650 and 815 grams per day.

The DM consumption of animals in this study was 3.4 to 4.0% of their body weight and was similar among treatments ($P > 0.05$). Values ranging 1.3 to 4.6% of BW DM intake has been reported by other workers (Gillespie, 1987; Susan, 2003; Abebe, 2006; Yeshambel *et al.,* 2012). The total DM intake per metabolic body weight and OM intake varied significantly ($P < 0.05$) and followed a similar trend like that of total DM intake. The DM intake per metabolic body weight in this study was slightly higher as compared to that noted by Ranjhan (1997).

According to Ranjhan (1977), the ME requirement for sheep weighing 20-30 kg ranged between 5.86 to 8.37 MJ and in the current study, except the control group, all the other treatments satisfied the ME requirements.

In agreement to this, Abebe (2006) reported that supplementation of linseed cake, wheat bran and their mixture did not have significant difference in DM, OM, NDF and ADF digestibility, but improved CP digestibility compared to the unsupplemented group. Similarly, according to Takele and Getachew (2011) supplementation of sole wheat bran, *Accacia albida* leaf meal or their mixture did not impact DM, NDF and ADF digestibility, but significant increased organic matter and CP digestibility. In the present study, the provision of 150 g of oat grain might have created a favorable ruminal environment for similar digestion of DM and fiber.

Supplementation of NSC alone or with Ameja (67:33), increased CP digestibility. Digestibility of CP in T2, T3, T4 and T5 was improved by 14.6%, 16.7, 37.5 and 50% as compared to the control, respectively. Hence, it is advisable to supplement natural pasture hay with NSC when it is available at a reasonable price. When NSC is not affordable or not easily available, Ameja leaf can be used to supplement sheep to improve CP digestibility and as a source of protein supply to the animal.

Conclusion

Whenever Noug seed cake is available, it is advisable to use it alone or Ameja/Noug seed cake combination at 67: 33 proportion as protein supplement. However, when Noug seed cake is unavailable or expensive, Ameja can be used as a sole protein supplement..

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Table 1. Experimental treatments

Treatments	Ameja in gm	Noug cake in gm	Oats grain gm
T_1: Basal diet *ad libtum*	-	-	150
T2: Basal diet *ad libtum* + 100% of dried Ameja leaf + 0% of NSC	344	0	150
T_3: Basal diet *ad libtum* + 67% of dried Ameja leaf + 33% of NSC	230	50	150
T_4: Basal diet *ad libtum* + 33% of dried Ameja leaf + 67% of NSC	112	100	150
T_5: Basal diet *ad libtum* + 0% of dried Ameja leaf + 100% of NSC	0	150	150

Table 2. Chemical composition of the experimental feeds

Experimental	Chemical composition (%)					
feed	DM	CP	NDF	ADF	ADL	Ash
Feed offered						
Hay	89.2	6.5	75.1	35.4	8.9	8.4
Noug cake	92.4	35.6	33.8	26.7	16.7	12.3
Ameja	90.2	15.1	43.7	25.8	17.8	4.6
Oats	89.5	9.8	43.8	16.3	1.1	5.6
Feed Refusals						
Hay T1	88.6	3.8	90.6	43.8	11.1	7.3
Hay T2	89.0	4.5	88.1	43.5	8.9	8.3
Hay T3	88.7	3.8	87.8	41.7	8.9	8.3
Hay T4	88.8	4.1	90.2	42.7	8.9	7.6
Hay T5	88.8	4.0	93.5	35.4	7.8	6.8

DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL= acid detergent lignin

Table 3. DM and nutrient intake of Menz sheep fed natural pasture hay supplemented with Ameja leaf and Noug seed cake.

Parameter	**Treatments**						
	T_1	T_2	T_3	T_4	T_5	SEM	LS
Hay DM (gm)	473.9	413.9	404.1	507.2	523.4	87.4	ns
Supplement DM (gm)	134.3^{c}	277.9^{b}	330.7^{a}	328.8^{a}	272.8^{b}	26.3	***
Total DM (gm)	608.2^{c}	691.5^{bc}	734.7^{ab}	836.0^{a}	796.2^{ab}	94.0	*
CP (gm)	51.5^{d}	70.0^{c}	82.2^{b}	96.8^{a}	98.9^{a}	7.2	***
OM (gm)	558.9^{c}	640.9^{bc}	680.0^{ab}	767.8^{a}	725.0^{ab}	86.2	*
NDF (gm)	402.1	409.7	431.7	501.5	482.5	67.0	ns
ADF (gm)	183.1^{b}	180.4^{b}	207.1^{ab}	245.8^{a}	244.3^{a}	33.2	*
ME (MJ)	5.7^{b}	6.9^{ab}	7.1^{ab}	8.4^{a}	8.0^{a}	1.2	*
TDM (%BW)	3.5	3.7	3.8	4.0	3.8	0.3	ns
DM (g/kgBW^{075})	70.9^{c}	76.2^{bc}	79.6^{ab}	84.7^{a}	81.1^{ab}	6.0	*

^{a,b,c} *means within a row not bearing a common superscript are significantly different; SEM = standard error of mean; *** = (P < 0.001); * = (P < 0.05); ns = not significant; TDM= total dry matter; OM= organic matter; CP = crude protein; ADF = acid detergent fiber; NDF =neutral detergent fiber; SL = significance level; BW= Body weight.*

Table 4. Dry mater and apparent nutrient digestibility coefficient in Menz sheep fed natural pasture hay supplemented with Ameja leaf and Noug seed cake.

Parameter	**Treatments**						
	T_1	T_2	T_3	T_4	T_5	SEM	LS
DM	0.61	0.64	0.64	0.67	0.66	0.071	ns
OM	0.64	0.68	0.66	0.70	0.70	0.066	ns
CP	0.48^{d}	0.58^{bc}	0.56^{cd}	0.66^{ab}	0.72^{a}	0.068	***
NDF	0.62	0.56	0.57	0.64	0.67	0.097	ns
ADF	0.61	0.56	0.55	0.61	0.64	0.088	ns

^{a,b,c}*means within a row not bearing a common superscript are significantly different; *** = (P < 0.001); ns = not significant; DM = dry matter; OM = Organic matter; CP = crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; LS = Level of significance; SEM= Standard error of mean.*