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Growth Performance of Sheep Fed Natural Pasture Hay Supplemented with Enset (*Enset Eventricosum*) Leaf, Noug Seed Cake or Their Mixture

Kedir A* and Tesfaye F

College of Agriculture and Natural resources, Wolkite University, Ethiopia

***Corresponding author:** Kedir A, College of Agriculture and Natural resources, Wolkite University, Gubrie P.O. Box 07, Ethiopia

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ABSTRACT

This study was conducted to determine the effect of Enset Leaf (EL), Noug Seed Cake (NSC) or their mixtures on the growth performance of sheep fed natural pasture hay as a basal diet. Twenty-five yearling rams with a mean initial body weight of 16.72 ±0.08 kg were used in randomized complete block design arranged into five blocks of five animals. Five treatments were assigned randomly to each animal in a block. The five dietary treatments used were natural pasture hay fed ad libitum (T1), natural pasture hay ad libitum + 300 g NSC (T2), natural pasture hay ad libitum + 200 g DM NSC +100g DM EL (T3), natural pasture hay ad libitum + 100 g DM NSC + 200g DM EL (T4), and 300 g DM EL (T5) which are offered twice daily at 0800 and 1600 hours. The results of this study indicated that, supplementation of EL, NSC or their mixtures significantly increases the total dry matter (DM), organic matter (OM) and crude protein (CP) intake. Supplementation of NSC, EL, and their mixtures also significantly improved (p<0.001) the digestibility of DM, OM, CP, NDF and ADF. The digestibility of sole NSC supplemented sheep was significantly higher (p<0.001) than sole EL supplemented sheep. Significantly higher (p<0.001) final and daily weight gain in the range of 25.6-57.8g/head/day was observed for supplemented sheep, whereas 2.2g/head/day weight loss was recorded for non-supplemented sheep, which might be due to low CP intake and digestibility observed in natural pasture hay. Sheep supplemented with sole NSC (T2) significantly gained more weight (p<0.001). Generally, supplementation of NSC, EL or their mixtures to natural pasture hay significantly improved (p<0.001) total DM intake, CP intake, feed conversion efficiency, CP digestibility and daily weight gain. Thus, from biological point of view, to attain the required level of body weight at slaughter, sheep producers can use all the supplement types depending upon their availability.

Keywords: Enset Leaf; Noug Seed Cake; Digestibility; Weight Gain; Carcass

Abbreviations: DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; FBW: Final Body Weight; ADG: Average Daily Body Weight Gain; FCE: Feed Conversation Efficiency

Introduction

Ethiopia has the largest livestock inventory in Africa with extremely important as they serve a wide variety of functions in society from social to subsistence purposes (Kimball, et al. [1,2]) and a population of cattle 60,39 million, sheep 31.3million, goat 32.74 million, chicken 60.51 million, horses 2 million, donkey 8.85 million, mules 461,665, camels 1,42 million (CSA [3]). It contributes 19% of the total gross domestic product (GDP), and 16–19% of the foreign exchange earnings of the country and 30-35% of the total agricultural GDP (Halderman, et al. [4-6]). The sector creates livelihood for 65% of the rural population. In spite of the huge livestock resources in Ethiopia, the overall contribution of the sub-sector is very low, compared to its potential due to shortage several technical and nontechnical problems. Feed in terms of quality and quantity as one of the major constraints (FAO [7-9]). Although different reports showed some variation on the contribution of different feed resources, the major feed resources of the country include green fodder (grazing) (54.59%), crop residues (31.60%), hay (6.81%), industrial by products (1.53%), moreover; very small amount of improved forages (only 0.31%) was used as animal feed while other types of feed that accounted for about

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5.11% types of feed that accounted for about (CSA [3]). Consequently, meat production is highly affected as a result of this poor nutrition. Agro-industrial products which is considered as major important for meat production is mainly restricted to the urban and peri-urban. So using the locally available feed is increasingly demanding. To do so, observing the effect of this locally available feeds on meat production and recommending for the farmer should be encouraged. With this regard, Enset is the locally available feed resource, native to the highlands of south and southwestern Ethiopia including Gurage zone in which this study will be carried.

Enset leaves (high protein portion) are the major source of feed to the livestock. Reports done by Dereje [10] and Brandt, et al. [11] showed that the protein content and the total amount of protein are greater in the portion not eaten by humans. By comparison, the stems and any remaining leaves of cereals and other tuber crops that are left for animal feed are usually of low protein value and in some cases are unacceptable as animal feeds. The very low DM content of the pseudo-stem poses DM intake limitation on animals while it could be an advantage if drinking water is in short supply. The relatively high CP content of the leaf (about 15.1%) makes it a favorable feed resource in ruminant feeding as the protein content is comparable to that of many browse species (Adugna [12]).

The CP content of the pseudo-stem is usually less than 7%. Thus, unless properly supplemented with nitrogen sources, the low protein content could depress the feed intake and utilization of the corm and pseudo-stem when fed to ruminant animals. According to Dereje [10] the chemical composition and the rumen degradability suggests that the enset have a potential to be uses as feed for animals to an increasing extent. During dry season, the animal owners traditionally use enset leaf for supplemental feeding. Besides the enset leaf, they also make use of the pseudo-stem and the corm of the plant as a feed supplement on a severe feed scarce season (Dereje [13]). Enset leaf, as the plant is tolerant to environmental stress (Taye [14]), provides sustainable feed production which can be harvested when need arises. All fresh parts can be eaten by cattle (Dereje, et al. [10,15]) which made it a crop of sustainable feed resource. Therefore, the potential role small ruminants, mainly sheep, play for the sustainable intensification of the system is worth studying. So, this study was concerned to see the effect of enset leaf with or without noug seed cake on the performance of sheep so as to fulfill the need of animal protein by utilizing the locally available feed resources.

Objective

To investigate the effect of enset leaf, noug seed cake or their mixtures on the growth performance of sheep fed natural pasture hay as a basal diet.

Materials and Methods

Description of the Study Area

The experiment was conducted at Wolkite University found in Gurage zone, Southern Nations and Nationalities Region. The University is located at about 162 km south west of Addis Ababa. The site is located at an altitude ranging from 1,001 to 3,500 meters above sea level (m.a.s.l) between 7.80 - 8.50 North latitude and 37.50 - 38.70 East longitudes. The mean annual rainfall and temperature of the study area ranges 600-1600mm and 13-300c, respectively (GZADD, 2011).

Experimental Animals and their Management

Twenty five yearling male local sheep were purchased from local market-Emdibir/wolkite town. The initial body weight of the animals was recorded for each sheep before the commencement of the experiment. The sheep was quarantined (treated for different disease) for 15 days. There were 15 days of adaptation period and followed by 90 days of data collection. The animals were adapted to the experimental conditions and feeds for fifteen days followed by 90 days data collection period.

Experimental Design and Treatments

The experiment was arranged in a completely randomized block design. At the end of the quarantine period, the experimental animals were blocked in to five groups of five animals each based on initial body weight and placed in an individual pen randomly. Sheep within a block was randomly assigned to one of the five dietary treatments. The supplements were offered on DM basis and each animal received 300 g supplement per day except control as shown below. The enset leaf was chopped and dried prior to feeding and the supplement feeds was weighed and thoroughly mixed as stipulated in treatments. The common salt block lick and water were allowed to the experimental animals as ad libitum. The studies have five treatments as shown below (Table 1).

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Table 1.

Treatments	Natural Pasture hay	Enset leaf (g DM/d)	Noug seed cake (g DM/d)
T1	Ad libitum	0	0
T2	Ad libitum	0	300
T3	Ad libitum	100	200
T4	Ad libitum	200	100
T5	Ad libitum	300	0

Measurements and Laboratory Analysis

Feeding Trial and Body Weight Gain: At the end of the quarantine period, the animals were offered with natural pasture hay ad libtium alone or supplemented with dried enset leaf, noug seed cake and their mixtures according to the treatment for 15 days to adapt them to the treatment feeds prior to the beginning of the experiment followed by 90days of feeding trial. The supplements were offered at 0800 and 1600 hours in equal proportions, and mineral block and water were available all the time throughout the experiment. Feed offered and refused were collected and weighed daily for each animal corresponding to each treatment diet to determine daily feed intake throughout the experimental period. Daily feed intakes of individual sheep were determined as a difference between the feed offered and refused. Samples of hay and supplement feeds (enset leaf, noug seed cake and their mixtures) offered and refused were collected daily and pooled over experimental period for each feed and each treatment. The samples of feed offered and refused for each feed and each treatment was mixed thoroughly and 20% of the composite sub-sample was taken for chemical analysis separately. The DM content of feeds was determined after drying the sub-sample of feeds at 105 oC for 24 h in an oven to constant weight. Initial BW of the sheep was recorded on the first day of the experiment and thereafter the BW measurements was taken at ten days intervals individually after overnight fasting and before offering the daily ration. The results were recorded throughout the experimental period to determine body weight change. Average daily BW gain was calculated as a difference between final and initial body weight of the sheep divided by the number of feeding days. The feed conversion efficiency (FCE) of experimental animals was determined by dividing the daily body weight change to the quantity of dry matter consumed by the animal.

Digestibility Trial: Following the feeding trial, all animals were harnessed with fecal collecting bag to collect feces for feed digestibility determination. After acclimatization period of three days to the fecal carrying of collecting bags, feces were collected for seven consecutive days. Feeding and animal management during the digestibility trial was similar to that in the feeding trial. Each day's collected feces per animal were weighed and 20% of it was sub-sampled and stored frozen at -20 °C, and pooled over the collection period. At the end of the digestion trial, the collected fecal sample from each animal was thawed to room temperature, thoroughly mixed, and 20% of the composite sample from each animal feces was sub sampled, weighed and dried at 60 °C for 72 h while the partial dried samples were ground to pass 1mm sieve and stored in airtight polyethylene bag pending chemical analysis. The apparent digestibility percentage of DM, OM, CP, NDF and ADF was determined using the following formula;

$$Apparent\ digestibility\ percentage = \frac{(Nutrient\ intake - nutrient\ in\ feces)\ x100}{Nutrient\ intake}$$

Carcass Parameters: At the end of the digestibility trial, all the experimental sheep were kept without feed overnight and slaughtered for carcass evaluation. Animals were weighed immediately before slaughter. Thle sheep were slaughtered by severing the jugular vein and carotid arteries with a knife. The blood was drained in to a bucket and weighed. The head was detached from the body after blood flow ceased. After skinning and decapitation, main carcass characteristics was evaluated as slaughter weight (SW), empty body weight (EBW) and hot carcass weight (HCW). Dressing percentage was expressed as percent SW (DPS) and EBW (DPE). The carcass was divided into the five primal cuts, which was neck and shoulder, breast and shank, rack, loin and leg, respectively. Rib-eye muscle area between the 12th and the 13th ribs of the left and right half of the carcass was determined and the average value for rib-eye muscle area was taken based on the recommendation of Torell and Suverly [16]. The non-carcass components were partitioned into edible and non-edible offal. The total edible and non-edible offal components yield was determined separately. The edible offal components including blood, heart, liver, kidney, tongue, reticulo-rumen, omaso-abomasum, hind gut (small and large intestine), and internal fat depots and tail fat were recorded separately. Similarly, the non-edible offal components which include, head without tongue, skin, testicle, penis, legs below feet lock, gut content, spleen and lung with trachea were recorded separately. Empty body weight was calculated as slaughter weight less gut content. Hot carcass weight was estimated after removing weight of the head, skin, thoracic, abdominal and pelvic cavity contents. Dressing percentage was calculated as a ratio of hot carcass weight to slaughter weight or empty body weight.

Chemical Analysis

Chemical analyses of feeds offered and refused during digestibility and feeding trial as well as feces excreted in digestibility trial was subjected to laboratory analysis. The partially dried samples of

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feces and the air dried feed was ground using laboratory mill to pass through a 1mm sieve screen size and taken to laboratory for chemical analysis. The samples of feed offered, refused and feces were analyzed for DM, ash and nitrogen (N) according to the procedures of AOAC [17]. Crude protein was estimated as N x 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed by the method of Van Soest and Robertson [18].

Statistical Analysis

The analysis of variance of the data from feed intake, digestibility, body weight gain and carcass were conducted using the R software. Treatment means that are significantly different from each other were separated by Tukey test. The model used for data analysis was.

$$Yij = \mu + Ti + Bj + eij$$

Where: Yij = response variable

μ = overall mean

Ti = treatment effect

Bj = block effect

eij = random error

Results and Discussions

Chemical Composition of Experimental Feeds

The chemical composition of the feeds used in the present study is given in Table 2. The CP values of natural pasture hay (7.2%) obtained from this study was less than the minimum level (7.5% crude protein) required for proper rumen function (Van Soest [19]) However, the CP values of enset leaf and noug seed cake was higher than the minimum value (7.5%), required for optimum rumen microbial function that can support maintenance requirement of ruminants and optimize cell wall degradation. The noug seed cake has CP contents greater than 15%, a level that is usually required to support lactation and growth (Norton, 1982) but not in the case of enset leaf. Moreover, according to Singh and Oosting [20], roughage feeds with NDF contents of less than 45% categorized as high quality, 45 - 65% as medium quality and more than 65% as low quality. Based on this, the natural pasture hay used in current study was categorized as low quality, enset leaf as medium quality and noug seed cake as high quality. Furthermore, both enset leaf and natural pasture hay have high NDF values greater than the level (55% NDF) above which voluntary feed intake is limited. Van Soest [21] indicated that sole supplementation of these two feeds limited voluntary feed intake. In another words, there is a need to supply another nutrient when either of natural pasture hay or enset leaf is supplied solely. Thus, the enset leaf and noug seed cake mixtures at the current study either at the ratio of 1EL: 2NSC or 2EL: 1NSC have NDF values less than the level (55% NDF) above which voluntary feed intake is limited.

Table 2: Chemical Composition of Experimental Feeds

Feed	DM (%)	Chemical Composition				
		CP	Ash	NDF	ADF	ADL
Natural Pasture hay	92.1	7.02	8.4	71.03	39.87	6.68
Enset leaf	92.2	12.5	12.2	62.01	40.2	6.5
NSC	92.5	31.5	7.5	36.5	32	12.04
1EL:2NSC	92.4	25.17	9.07	45	34.73	10.19
2EL:1NSC	92.3	18.83	10.63	53.51	37.47	8.35

The DM, NDF and ADF content of natural pasture and enset leaf in the current study was similar to the value of 92.60%, 75.54% and 41.08%, and 92.40%, 61.06% and 39.18%, respectively for natural pasture hay and enset leaf reported by Dersha, et al. [22]. The value of enset leaf was also comparable to the value of 13.12%, 63.62% and 39.24% reported by Ajebu, et al. [23] for CP, NDF and ADF, respectively. Mohammed, et al. [24] also reported similar result of crude protein (12.41%) for enset leaf. Like crude protein, similar result of 62% was reported by Feleke, et al. [25] for NDF content of enset leaf. Similar results of noug seed cake chemical composition with the value of 92.18%, 32.0%, 36.89% and slightly lower value of 27.03% was reported by Amare [26] for DM, CP, NDF and ADF content, respectively. However, the crude protein content was slightly higher than the value of 6.34% and 9.34% reported by Dersha, et al. [22] for natural pasture and enset leaf, respectively. Lower crude protein (7.6 %) content of enset leaf was also reported by Feleke, et al. [25].

Dry Matter and Nutrient Intake

The mean DM and nutrient intake of sheep fed natural pasture hay alone or supplemented with enset leaf, noug seed cake or their mixtures are given in Table 3. Supplementation of enset leaf and noug seed cake significantly decrease the natural pasture hay intake but not total DM intake which was comparable to other studies such as Fentie [27] for noug seed cake (Guizotia abyssinica), wheat bran and their mixtures supplemented sheep, and Bimrew [28] for rice bran and noug seed (guizotia abissynica) cake mixtures supplemented sheep. The total DM intake was significantly higher (P<0.001) for sole noug seed cake and higher proportion of noug seed cake supplemented sheep than for un supplemented and sole enset leaf supplemented ones. This was probably due to the low fiber fraction and high CP in noug seed cake, which increased the basal diet intake and resulted in better total DMI. This indicated that, supplementation of natural pasture hay with noug seed cake and enset leaf significantly improved (P<0.001) total DMI. However, the total DMI in the current study decreases as the proportion of enset leaf in the total ration was increased.

Table 3: Daily dry matter and nutrient intakes of local sheep fed natural pasture hay alone or supplemented with enset leaf, noug seed cake or their mixtures.

Parameters	Treatments					
	T1	T2	T3	T4	T5	SEM
Hay DM intake (g/d)	550.0^{a}	370.0^{b}	360.0^{c}	350.0^{d}	340.2^{e}	1.047
Supplement DM intake (g/d)	-	300^{a}	270^{b}	260^{c}	255^{d}	0.583
Total DM intake (g/d)	550.0^{e}	670.0^{a}	630.0^{b}	610.0^{c}	595.2^{d}	1.267
DM intake (% BW)	3.26^{a}	3.06^{bc}	3.06^{bc}	3.00^{c}	3.14^{b}	0.031
OM intake (g/d)	503.8^{e}	616.4^{a}	575.3^{b}	553.0^{c}	535.5^{d}	1.161
CP intake (g/d)	38.62^{e}	120.46^{a}	93.24^{b}	73.52^{c}	55.74^{d}	0.158
NDF intake (g/ d)	390.7^{b}	372.3^{e}	377.2^{d}	387.7^{c}	399.8^{a}	0.814
ADF intake (g /d)	219.30^{c}	243.50^{a}	237.30^{b}	236.96^{b}	238.18^{b}	0.486

Note: ^{a,b,c,d,e} Means in the same row with different superscripts differ significantly (P<0.05); SEM: standard error of mean ; DM: dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fiber; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

This might be due to the increased NDF and ADF, and the decreased CP contents. The high NDF and ADF contents might be the major factors that contribute to a reduced intake of the natural pasture hay by reducing rate of passage. If the ingested feed is retained longer in the rumen, it is expected that the animal would consume less feed, because of the occupied space or gut fill (Grovum, et al. [29]). Contrary, dietary protein supplementation is known to improve intake by increasing the supply of nitrogen to the rumen microbes. This has positive effect on increasing rumen microbial population and efficiency, thus enabling them to increase the rate of breakdown of the digesta which in turn increases feed intake (Van Soest [19]). Even if total DM intake of sheep supplemented with enset leaf was lower than that of noug seed cake supplemented, enset leaf supplementation improved feed intake when compared with the control groups which was in constituent with Assefa, et al. [30]. In addition, total DM intake as percent of body weight (3.00 to 3.26%) in the current study was within the range of 2 to 4% recommended for tropical sheep or goats (Susan [31]). Similarly, it was also within the range of 2-6% recommended by ARC (1980), and between 2.05 to 3.86% and 2.8 to 3.8% reported by Feleke, et al. [25] and Bimrew [28], respectively.

Similar to total DM intake, OM and CP intake in the current study increased with the increment of noug seed cake proportion in total rations (Table 3). Thus, the significantly higher (P<0.001) OM and CP intake in sole noug seed cake supplemented sheep followed by high proportion of noug seed cake supplemented animal might be due to high OM and CP content of noug seed cake compared to enset leaf. However, significantly higher (P<0.001) NDF intake was for sole enset leaf supplemented sheep followed by sole natural pasture supplemented animal which might be due to high NDF content of these feeds. In contrast, significantly higher (P<0.001) ADF intake was found in sole noug seed cake (T2) supplemented sheep followed by other supplemented animals might be related to high total DM intake and ADF digestibility in T2 than other treatments. The total daily DM intake (550.4-670g/d) in the current study was within the range of 447.4 - 749.6 g/d reported by Bimrew [28] for Farta sheep supplemented with different levels of rice bran and noug seed cake mixtures; 540.5-788 g/d reported by Fentie [27] for Farta sheep fed on grass hay and supplemented with wheat bran, noug seed cake and their mixtures, and similar to the range of 393- 661.9 g/d reported by Almaz [32] for local sheep fed finger millet straw alone or supplemented with mixtures of atella and noug seed cake. However, it was slightly higher than the range 333-626 g/d DM intake reported by Feleke, et al. [25] for Adilo sheep supplemented with atella and enset leaf.

Dry Matter and Nutrients Digestibility

There was significantly higher (P<0.001) apparent digestibility coefficient of DM, OM, CP, NDF and ADF for the supplemented than non-supplemented sheep (Table 4). The relatively lower nutrient digestibility observed in the non-supplemented sheep might be due to the high level of NDF and ADF intake from the natural pasture hay than in supplemented sheep, since the primary chemical components of feed that determine the rate of digestion are NDF and ADF (MacDonald, et al. [33]). In addition, it might be due to the lower CP content of the natural pasture hay as compared to other supplements. Similarly, the DM, OM, CP, NDF and ADF digestibility of sole noug seed cake supplemented sheep (T2) was significantly higher (P<0.001) than the digestibility of sole enset leaf supplemented sheep (T5). Digestibility of DM and nutrients among mixtures of noug seed cake and enset leaf supplemented sheep was not significantly different (P>0.05) from each other except CP digestibility.

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Table 4: Apparent dry matter and nutrient digestibility coefficient of local sheep fed on natural pasture hay based diet and supplemented with enset leaf or noug seed cake and their mixtures.

Nutrients	Treatments					
	T1	T2	T3	T4	T5	SEM
DM	0.490^{c}	0.650^{a}	0.639^{a}	0.629^{a}	0.589^{b}	0.009
OM	0.520^{e}	0.689^{a}	0.660^{ab}	0.650^{bc}	0.620^{cd}	0.01
CP	0.460^{e}	0.799^{a}	0.739^{b}	0.669^{c}	0.640^{cd}	0.011
NDF	0.54^{d}	0.64^{a}	0.63^{a}	0.62^{ab}	0.59^{bc}	0.009
ADF	0.470^{c}	0.580^{a}	0.516^{b}	0.510^{b}	0.510^{b}	0.005

Note: ^{a,b,c,d,e}Means in the same row with different superscripts differ significantly (P<0.05); SEM: standard error of mean; DM: dry matter; CP: crude protein; OM: organic matter; NDF: neutral detergent fibre; ADF: acid detergent fiber; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

However, CP digestibility was significantly decreased (P<0.001) with the decreasing of noug seed cake proportion in the total mix or vice versa. The greater CP digestibility of sole noug seed cake or higher proportion of noug seed cake supplemented group could be due to higher intake of dietary protein, since CP digestibility is associated with higher CP intake (McDonald, et al. [33]) (Table 4). The DM, OM, NDF and ADF digestibility of enset leaf in the current study was lower than the value of 0.71, 0.76, 0.78 and 0.66 reported by Feleke, et al. [25]. However, the CP digestibility of enset leaf in the current study was similar to the value of 0.63 and 0.636 reported by Feleke, et al. [25]and Nurfeta, et al. [34], respectively. Similarly, the DM and ADF digestibility of sole enset leaf supplemented in the current study was similar to the value of 0.589 and 0.502 for DM and ADF digestibility, respectively (Nurfeta, et al. [34]). However, the OM and NDF digestibility was higher than the value of 0.594 and 0.412 reported by the same author for OM and NDF, respectively.

Body Weight Gain

The supplemented sheep achieved significantly higher (P<0.001) final body weight (FBW), average daily body weight gain (ADG) and feed conversation efficiency (FCE) than the non-supplemented sheep (Table 5). The increased in live weight gain and average daily gain in supplemented animals compared to the control group might be explained by the higher total DM and CP intake and better digestibility of the treatment diets. Similarly, sole noug seed cake supplemented sheep achieved significantly higher (P<0.001) FBW, ADG and FCE than the sole enset leaf supplemented sheep which was the function of DM and nutrient intake and its digestibility. However, there was no significance difference (P>0.05) between different proportion of enset leaf and noug seed cake mixtures supplemented sheep for final body weight and feed conversion efficiency. Unlike FBW and FCE, ADG was significantly increased (P<0.05) with the increment of noug seed cake or significantly decreased (P<0.05) with the decrement of enset leaf proportion in the total mix. Sheep fed natural pasture hay alone lost weight which could be due to low DM and CP intake in the control group, and the low CP content of the natural pasture hay used in the current study which was in line with the report of Van Soest [35] who reported that when the CP content of forage is less than 8%, the growth of animal will be retarded. Nitrogen deficiency below the requirement of rumen bacteria could impact animal performance (McDonald, et al. [33]), which may occur when the CP content of the forage is below 8% (Van Soest [32]). Because of low nitrogen, high cell wall and slow digestion, animals kept on sole hay or straw diet may not be able to maintain their nitrogen balance and growing animals could lose body weight (Kitho [36]).

Table 5: Body weight change of local sheep fed natural pasture hay alone or supplemented with enset leaf, noug seed cake or their mixtures.

Parameter	Treatments					
	T1	T2	T3	T4	T5	SEM
IBW (kg)	16.7	16.8	16.7	16.8	16.6	0.13
FBW (kg)	16.50^{d}	22.0^{a}	20.6^{b}	20.3^{b}	18.9^{c}	0.153
WC (kg)	-0.2^{e}	5.2^{a}	3.9^{b}	3.5^{c}	2.3^{d}	0.115
ADG (g)	-2.2^{e}	57.8^{a}	43.3^{b}	38.9^{c}	25.6^{d}	1.28
FCE (gain/feed)	-0.004^{d}	0.086^{a}	0.069^{b}	0.063^{b}	0.043^{c}	0.002

Note: ^{a,b,c,d,e}Means with different superscripts in the same row are significantly different (P<0.05); SEM: standard error of mean; IBW: initial body weight; FBW: final body weight; WC: weight change; ADG: average daily body weight gain; FCE: feed conversion efficiency; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

The average daily gain of supplemented sheep with the range of 25.6g-57.8g in the current study was similar to the range of 24.4g-47.8g reported by Feleke, et al. [25] in which similar weight gain of 25.6g versus 24.4g was found for sole enset leaf supplemented sheep. Ajebu, et al. [37] also found a weight gain of 17.4g/d and 29.8g/d, and a loss of 2.4g/day when enset leaf was supplemented to untreated wheat straw at the rate of 417g, 594gDM/d and 215g DM/day, respectively. Similarly, it was within the range of 5.6g -57.8g reported by Abebaw, et al. [38] in which the same weight gain of 57.8g/d was found for sole noug seed cake supplemented sheep. However, it was less than the value of 70.11g-82.44g/d reported by Fentie [27] for Farta sheep fed on grass hay and supplemented with wheat bran, noug seed cake and their mixtures. The loss of body weight (2.2g/d) for sole natural pasture hay supplemented sheep in the current study was less than the loss of 9.11g/d and 7.7g/d reported by Fentie

[27] and Jemberu [39], respectively. Contrarily, daily weight gain of 0.22g/d and 2.7g/d was reported by Abebaw, et al. [38] and Bimrew [28], respectively for sole natural pasture hay supplemented sheep. The feed conversation efficiency in the current study for the supplemented sheep was also within the range of 0.00-0.11 and 0.03 -0.10 reported by Bimrew [28], and Taye [40] in Farta sheep fed on natural pasture hay and supplemented with graded levels of noug seed cake and rice bran mixture, and Hararghe highland sheep fed natural pasture hay and supplemented with oat bran, noug seed cake and their mixtures, respectively. It also similar to the range of 0.041 -0.076 reported by Feleke, et al. [25] in Adilo sheep fed urea treated wheat straw supplemented with atella, enset leaf and their mixture.

Carcass Components

Carcass characteristics of the experimental sheep are given in Table 6. There was significant difference (P<0.001) in slaughter weight, empty body weight, hot carcass weight, dressing percentage on empty body weight basis and rib-eye area between treatments except between T3 and T4 (different proportion of enset leaf and noug seed cake mixtures supplemented group) in which there was no significance difference for slaughter weight, empty body weight and rib-eye area, and significance difference was achieved at (P<0.05) and (P<0.01) for dressing percentage on empty body weight basis and hot carcass weight, respectively. The carcass characteristics of sole noug seed cake supplemented group was significantly higher (P<0.001) than other treatments. In contrast to this, the carcass characteristics of sole enset leaf supplemented sheep was significantly lower (P<0.001) than other treatments except dressing percentage on slaughter weight basis. However, there was no significance difference (P>0.05) between T5 and other treatments for dressing percentage on slaughter weight basis except T2. The dressing percentage and rib-eye area of the sheep in the present study was equivalent to the dressing percentage of 34.4 –39.9% and rib-eye area of 6.6-9.5cm2 reported by Feleke, et al. [25]. In addition, the dressing percentage in the current study was slightly within the value of 34.2–51.6% and 35.8-45.0% reported by Taye [40] and Wondwosen, et al. [41], respectively. However, slightly lower rib-eye area of 5.3-7.7cm^2 and 3.6 -7.6cm^2 was reported by the same authors, respectively.

Table 6: Carcass characteristics of local sheep fed natural pasture alone or supplemented with enset leaf, noug seed cake or their mixtures.

Parameters	Treatments					
	T1	T2	T3	T4	T5	SEM
Slaughter weight (kg)	16.5^d	22.0^a	20.6^b	20.3^b	18.9^c	0.15
EBW (kg)	12.3^d	16.7^a	15.3^b	15.1^b	13.8^c	0.11
HCW (kg)	5.8^e	8.8^a	7.6^b	7.2^c	6.7^d	0.09
DPS (%)	35.1^b	40.0^a	36.7^b	35.6^b	35.5^b	0.57
DPE (%)	50.7^e	56.3^a	51.9^b	51.6^c	49.2^d	0.08
REA (cm2)	7.1^d	10.2^a	9.0^b	8.7^b	7.8^c	0.1

Note: ^{a,b,c,d,e} Means with different superscripts in rows are significantly different (P<0.001); SEM: standard error of mean;EBW: Empty body weight; HCW: Hot carcass weight; DPS: Dressing percentage on slaughter weight basis; DPE: Dressing percentage on empty body weight basis; REA: Rib-eye area; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

Non-Carcass Components

Edible Offal: Heart, lung, esophagus liver, kidney, empty gut, kidney knob and channel fat, omental fat and tongue were considered as edible offals. Sole noug seed cake supplemented sheep had significantly higher (P<0.001) edible offals than sole enset leaf and un-supplemented sheep except for reticulo-rumen and tongue in which T4 and T1 had significantly higher (P<0.001) reticulo-rumen and tongue, respectively might be due to its high CP content. Assefa, et al. [30] also reported the higher values of liver, kidney, SI, LI, Abdominal fat, Blood and TEO with increasing protein supplementation level. Lower edible offals were found in those sheep fed sole natural pasture hay and sole enset leaf. The total edible offals (TEO) of the supplemented sheep was greater (P<0.001) than non-supplemented ones which was in agreement with the studies reported by Assefa, et al. [30,42], Aschalew (2011). Similarly, the TEO of sole noug seed cake supplemented sheep was significantly higher (P<0.001) than sole enset leaf supplemented sheep. However, there was no significance difference (P>0.05) between different proportion of enset leaf and noug seed cake mixture supplemented sheep (Table 7).

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Table 7: Non-carcass components (edible offals) of local sheep fed natural pasture hay alone or supplemented with enset leaf, noug seed cake or their mixtures.

Edible offals	Treatments					
	T1	T2	T3	T4	T5	SEM
Heart (g)	99^{d}	108^{a}	106^{ab}	104^{bc}	96^{e}	0.93
Liver + gall bladder (g)	428^{e}	542^{a}	529^{c}	540^{b}	500^{d}	0.59
Kidney (g)	87^{d}	109^{a}	105^{b}	105^{b}	98^{c}	1.04
Reticulo-rumen (g)	534^{e}	592^{b}	589^{c}	605^{a}	561^{d}	0.51
Omaso-abomasum (g)	146^{b}	149^{a}	137^{c}	127^{d}	123^{e}	0.93
SI and LI (g)	593^{d}	658^{a}	635^{b}	612^{c}	576^{e}	1.07
Tongue (g)	106^{a}	100^{b}	87^{c}	84^{c}	79^{d}	1.09
Abdominal fat (g)	39^{d}	77^{a}	68^{b}	59^{c}	60^{c}	1.11
Blood (g)	1039^{e}	1152^{a}	1108^{c}	1137^{b}	1058^{d}	1.07
TEO (kg)	3.07^{d}	3.49^{a}	3.36^{b}	3.37^{b}	3.15^{c}	0.01

Note: ^{a,b,c,d,e} Means with different superscripts in rows are significantly different (P<0.05); Oma-Abom: omasum and abomasum; SI and LI: small intestine and large intestine; TEO: total edible offals; SEM: standard error of mean; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

Non-Edible Offal: Head, gut content, spleen, testicles and penis, skin, feet, lung and gall bladder were categorized as non-edible offals. Like edible offals, the non-edible offals of sole noug seed cake supplemented sheep was significantly higher (P<0.001) than non-supplemented and sole enset leaf supplemented sheep except for penis in which there was no significance difference (P>0.05) with that of un-supplemented one. Similarly, the sole enset leaf supplemented sheep was significantly higher (P<0.001) than control for skin, gut, spleen, lung and TNEO. Moreover, as far as different proportion of enset leaf and noug seed cake mixtures was concerned, the higher proportion of noug seed cake supplemented sheep (T3) was significantly higher (P<0.001) than lower proportion supplemented sheep (T4) for skin, fetlock, gut and spleen. In contrast to this, head, penis, bladder and lung was significantly higher (P<0.001) for T4 supplemented sheep than T3 supplemented sheep. Furthermore, significance difference was achieved for total non-edible offals between supplemented and non-supplemented group, and T2 and T4, T2 and T5, and T4 and T5 even if there was no significance difference (P>0.05) between different proportion of enset leaf and noug seed cake mixture supplemented sheep. In contrast to this study, non-significance of TNEO was reported by Taye [40], Amare (2007) and Hirut [43] (Table 8).

Table 8: Non-carcass components (non-edible offals) of local sheep fed natural pasture hay alone or supplemented with enset leaf, noug seed cake or their mixtures.

Parameters	Treatments					
	T1	T2	T3	T4	T5	SEM
Head (g)	1274^{b}	1291^{a}	1256^{c}	1276^{b}	1206^{d}	1.09
Skin (g)	2134^{e}	3225^{a}	3153^{b}	2678^{c}	2604^{d}	0.27
Testis (g)	172.7^{c}	185.6^{a}	173.5^{b}	173.8^{b}	162.7^{d}	0.19
Penis (g)	56.6^{a}	56.9^{a}	52.6^{c}	55.7^{b}	50.2^{d}	0.11
Fetlock (g)	271.2^{d}	325.2^{a}	283.8^{b}	278.6^{c}	270.4^{e}	0.2
Gut (g)	4800^{e}	5387^{a}	5234^{b}	5226^{c}	5081^{d}	0.46
Bladder (g)	40.3^{c}	47.5^{a}	44.9^{b}	47.7^{a}	40.5^{c}	0.16
Spleen (g)	65.2^{e}	111.7^{a}	105.4^{b}	99.6^{c}	91.8^{d}	0.18
Lung (g)	302.1^{e}	400.3^{a}	381.5^{c}	388.7^{b}	355.6^{d}	0.12
TNEO (kg)	9.1^{e}	11.0^{a}	10.7^{ab}	10.2^{bc}	9.9^{d}	0.14

Note: ^{a,b,c,d,e}Means with different superscripts in rows are significantly different (P<0.05); TNEO: total non-edible offals; SEM: standard error of mean; T1= Natural pasture hay; T2 = Natural pasture hay ad libitum + 300 g/d Noug seed cake; T3 = Natural pasture hay ad libitum + 200 g/d Noug seed cake + 100 g/d enset leaf; T4 = Natural pasture hay ad libitum + 100 g/d Noug seed cake + 200 g/d enset leaf; T5 = Natural pasture hay ad libitum + 300 g/d enset leaf.

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Conclusions and Recommendations

This study was conducted to evaluate the effect of supplementing enset leaf, noug seed cake or their mixtures to natural pasture hay based diet on feed intake, digestibility, body weight gain and carcass characteristics of sheep. The results of this study indicated that supplementation of enset leaf, noug seed cake and their mixtures to natural pasture hay based diet have a positive effect on total DM intake, CP intake, feed conversion efficiency, CP digestibility, weight gain and carcass characteristics of local sheep. But, more responses were recorded for sheep supplemented noug seed cake than enset leaf or their mixtures which might be come from its higher CP content and digestibility. Thus, depending on its availability, the two supplements can be used to improve the performance of animals in roughage based diets. However, there is a need of partial budget analysis to recommend the exact proportion of enset leaf and noug seed cake mixtures that is economically and biologically feasible since the current study lack partial budget analysis. If using of 1EL:2NSC (T3) and 2EL:1NSC (T4) are the same based up on the economic point of view, using of T3 will be recommended since it also biologically more feasible [44-52].

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