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Effect of Different Levels of Lentil (*Lens culinaries*) Hull and Noug Seed (*Guizotia abyssinica*) Cake Mixture Supplementation on Feed Intake, Digestibility and Body Weight Change of Farta Sheep Fed Hay as Basal Diet

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The objective of this experiment was to evaluate the effect of supplementation with different levels of lentil hull (LH) and Noug seed cake (NSC) mixture on feed intake, digestibility and body weight change of Farta sheep and to assess the economic benefit of the feeding regime. Twenty four intact male yearling Farta sheep with an initial average body weight of 18.05±1.09 kg (Mean±SD) were used in randomized complete block design (RCBD). The experiment consisted of 90 days of feeding trials followed by 7 days digestibility trials. The experimental animals were blocked into six blocks of four animals based on their initial body weight. The treatments were ad libitum feeding of natural grass hay and supplemented with 0, 200, 300 and 400 g/day/head of LH and NSC mixture at a proportion of 2:1 for T1, T2, T3 and T4, respectively on DM basis. All sheep were offered 50 g NSC to fulfill their maintenance requirement for the control group. The CP content of grass hay, LH, NSC and the mixture of LH and NSC were 7.13%, 22.3%, 34.65% and 26.37%, respectively. The hay DM intake was significantly (P<0.001) higher in control group (586.2 g/d) compared to the supplemented groups. However, the total DM intake was significantly higher (P<0.001) for supplemented groups compared to the control group. Intake of CP increased with increasing level of the supplements (59.1, 106.8, 130.5 and 153.8 g/day) for T1, T2, T3 and T4, respectively. Digestibility of DM, OM, CP, NDF and ADF were improved by supplementation. Average daily body weight gain (ADG), final BW and FCE were significantly higher (p<0.001) for supplemented groups as compared to control group. The partial budget analysis showed that T4 had highest economical gain. Generally, this study indicated that the current supplementary feeds improved the performance of Farta sheep and T4 is recommended on both biologically and economically efficient supplementary regime for this sheep breed.

Key Words: Farta Sheep, Lentil hull, Intake, Digestibility, Body weight change

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INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa with estimated number of 60.34 million cattle, 31.30 million sheep, 32.74 million goats,1.42 million Camels, 56.06 million poultry, 2.01 million horses, 0.46 million mules and 8.85 million donkeys (CSA, 2018). Sheep are one of the important components of the livestock sub-sector in Ethiopia and serves as sources of cash income, meat, wool, manure and saving for smallholders in different farming systems and agroecological zones of th e country (Thiruvenkadan *et al.,* 2009).

However, shortage of feed supply in terms of quality and quantity especially during the dry season are considered to be the major limitations for increasing production and productivity of sheep in most of the agro-ecological zones of the country (Yaynesh et al, 2010). These problems are the potential reasons for lack of consistent supply of sheep at the required body weight and have remained a major challenge for mutton and live sheep exporters (Solomon *et al.,* 2010). Livestock in general and sheep in particular are kept mostly on natural pastures, crop residues and stubble grazing in which the quality and quantity are subjected to great seasonal variation (Malede and Takele, 2014; Samual, 2014; Solomon *et al.,* 2014).

In the current study area, sheep mostly depends on high roughage and low crude protein (CP) content feeds which are not sufficient even to meet the maintenance requirements (EDAO, 2017). Most dry forages and roughages fed to sheep in the country have a CP content of less than 7% which are below the level to satisfy the requirements of rumen microorganisms (Van Soest, 1994). Feeds with low CP digestibility such as mature dry native grasses require supplementation with nitrogenous feed sources (McDonald et al., 2010).

One of the feasible methods of improving the nutritive value of roughage feeds for sheep is through supplementation with energy or protein rich feed sources, which can increase digestibility and nutrient intake

(Ajebu, 2010). In this regard, feed resources like lentil hull and noug seed cake are considered to be the promising supplementary feeds in reverting the current poor feeding situation. The seeds of lentil and noug are used for human consumption and their by-products are used for animal feed that could not compete with human food and improve the feeding values of low quality roughages. Lentil hull has 16% CP, 49.4% NDF and 48.6% ADF contents and it provides the gross energy of 17 MJ/Kg on DM basis (Yoseph *et al.,* 2002). The chemical composition of NSC as reported by Desta *et al.* (2017) is 94.5% DM, 91.7% OM, 33.4% CP, 36.5% NDF, 26.2% ADF and 10.4% ADL. Thus, LH and NSC are considered as an important source of feed for animals.

Despite of these importances, farmers in the current study area did not well utilize these feed resources for their animals. In addition, there is information gap as to the proportion of lentil hull and noug seed cake mixture to be used as a supplement ration for sheep. Therefore, the current study was designed to evaluate the effect of lentil hull and noug seed cake mixture supplementation on feed intake, digestibility and body weight change of Farta sheep with assessing its economic feasibility.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Amhara National Regional State, Estie District specifically at Wulkfit local name, which is located at 11° 39' of North latitude and 37° 40' East longitudes and far at 685 km Northeast of Addis Ababa and 120 km from Bahir Dar (capital of the region). The site is situated at an altitude of 2431-2560 meter above sea level. The annual rainfalls of the area ranged from 1307.7 mm to 1500 mm and the mean minimum and maximum temperatures are 8.3°C and 25°C, respectively (EDAO, 2017).

Experimental Animals and Their Management

Twenty-four yearling intact male Farta sheep with an initial body weight of 18.05±1.09 kg (Mean±SD) were purchased from Lewaye local markets. Age of the animals was determined by dentition (Vatta *et al*., 2006) and information obtained from the owners. The animals were quarantined for 21 days in order to observe their health condition and there were 15 days of acclimatization period of the experimental feed prior to the beginning of the actual data collection. All animals were sprayed against external parasites (tick, mange mites) by using Diazinon and dewormed against internal parasites using Ivermectin based on the recommendation of veterinarian. They were vaccinated against common diseases of the area (pasteurelosis, sheep pox and Anthrax). All animals were neck-tagged for identification purpose.

After the end of the quarantine period, the animals were moved to the experimental house where they were randomly assigned to individual pens furnished with watering and feeding troughs. The experimental sheep were offered natural grass hay *ad libitum* and the supplements (LH and NSC mixture) with incremental levels. The hay and the supplement were provided in separate containers. The supplements were offered twice daily at 0800 and 1600 hours by dividing it into two equal proportions. Common salt and water were made available to the animals at all times throughout the experimental period.

Feeds and Feed Preparation

The basal diet (natural grass hay) was purchased from the surrounding farmers and it was chopped (4-6 cm size) and stored under shed to maintain its quality. Noug seed cake was purchased from local oil processing factories which are available in Estie District. The lentil hull, processed with grain milling machine, was also purchased from Estie District. The supplement feeds were LH and NSC mixtures at the ratio of 67% to 33%, respectively.

Experimental Design and Treatments

The design of the experiment was randomized complete block design (RCBD) consisting of four dietary treatments and six replications, which were used to conduct both feeding and digestibility trials. At the end of the 21 days quarantine period, the animals were blocked into six blocks of four animals per block based on their initial body weight. The initial BW of the experimental animals was determined by taking the means of two consecutive weighing after overnight fasting. The animals in a block were randomly assigned to one of the four treatment diets. The dietary treatments in the current study consisted of natural grass hay alone (T1) and natural grass hay plus a mixture of LH and NSC at the level of 200 g (T2), 300 g (T3) and 400 g (T4) per head/day on DM basis. All the experimental animals were provided with 50 g NSC to meet the maintenance requirement of the control group and natural grass hay was provided *ad libitum.*

Feeding Trial

Feed intake measurement

The feeding trial was conducted for 90 days after 15 days of acclimatization period. The daily feed offered and the corresponding refusals of each animal was measured and recorded during the experimental period. Daily feed intake was determined as the difference between the amount of feeds offered and refused for each animal on DM basis.

Body weight measurement

Body weight of each animal was measured at the beginning of the feeding trial and every 10 days interval after wards. Animals were fasted overnight and weighed before the morning meal. Body weight change was calculated as the difference between final body weight and initial body weight. Average daily body weight gain was computed as body weight change divided by the number of experimental days. Feed conversion efficiency (FCE) of experimental animals was determined by dividing the daily average weight gain to the amount of daily feed consumed by the animal (Taylor and Field, 2001).

Substitution rate was calculated as the difference between basal diet intake of the control and supplemented treatments divided by the amount of supplement offered (Ponnampalam et al., 2004). The metabolize energy MJ/day intake was estimated from digestible organic matter intake (DOMI) values by using the equation of AFRC (1993) as ME (MJ/d) = 0.0157*DOMI g/kg DM.

Digestibility Trial

The digestibility trial was conducted after the feeding trial with the same animals of the feeding trial. All animals were harnessed with fecal collection bags for the determination of digestibility. The actual digestibility trial took a total of 7 days after 3 days of acclimatization of carrying the fecal bags. Out of the daily total fecal output, 20% was sub-sampled to form a weekly fecal composite sample for each animal and stored in deep freezer at a temperature of $-20^{o}C$.

Fecal samples were then thawed, thoroughly mixed, sub-sampled, dried at $60^{o}C$ for 72 hours and ground to pass through a 1 mm sieve screen and stored pending chemical analysis. Feed samples from each feed and refusals from each animal were collected each day to make a weekly composite feed sample for each feed and refusal for each animal. The apparent digestibility (AD) coefficient of DM and nutrients were calculated using the following formula (McDonald *et al*., 2002).

$$AD\ (\%) = \frac{\text{DM or nutrient intake - Fecal excreted}}{\text{DM or nutrient intake}} \times 100$$

Partial Budget Analysis

The partial budget analysis was done to evaluate the economic profitability of supplementation of LH and NSC mixture according to the procedure of Upton (1979). The purchasing and selling prices of experimental sheep and the total quantity of basal and supplement feed and its purchasing prices were recorded. The analysis involved the calculation of the variable costs of experimental sheep, feeds and benefits gained from the result. The total return (TR) was determined by calculating the difference between selling and purchasing price of experimental sheep. At the end of the experiment, the selling price of experimental sheep was estimated by experienced merchants. The cost of feeds was computed by multiplying the actual DM intake for the whole feeding period with the prevailing prices. Net return (NR) was calculated as the difference between TR and total variable costs (TVC) while change in net return (ΔNR) was calculated as difference between change in total return (ΔTR) and change in total variable costs (ΔTVC).The marginal rate of return (MRR) measures the increase in net income (ΔNR) associated with each additional unit of expenditure (ΔTVC). This is expressed in percentage as:

$$MRR\% = (\Delta NR/\Delta TVC) \times 100\%$$

Chemical Analysis

The chemical analysis of the experimental feeds, refusals and feces were carried out after taking representative samples. These representative samples were milled to pass through a 1 mm sieve screen. The determination of dry matter (DM), crude protein (CP) and ash were done according to the procedures of AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the methods of Van Soest and Robertson (1985). Organic matter (OM) was calculated as ash subtracted from hundred.

Statistical Analysis

Data on feeding trial, body weight change and digestion trial were subjected to the analysis of variance (ANOVA) using General Linear Model Procedures of SAS (2008). The significant treatment means were separated using Tukey's studentized range (HSD) test. The model used for data analysis was:

$$Y_{ij}=\mu + T_i + B_j + E_{ij}$$

Where,

Y_{ij}= observation in the i^{th} treatment and j^{th} block
μ= the overall mean
T_i= the i^{th} treatment effect
B_j= the j^{th} block effect
E_{ij}= the random error

RESULTS AND DISCUSION

Chemical Composition of Treatment Feeds

The chemical compositions of experimental feeds used in the current study are presented in Table 1. The CP value recorded for hay used in the current study was found to be within the maintenance requirement (7-7.5% CP) of sheep for microbial function (Van Soest, 1994), indicating the hay used in the current study had a relatively better quality. The CP content of hay refusals was relatively similar among the four treatment feeds. However, the hay offered had higher CP but lower NDF, ADF and ADL values than the hay refusals. This may be due to the fact that experimental sheep selected more edible portions of the basal diet and left the more fibrous parts (such as stems) of the grass which has higher fiber (NDF, ADF and ADL) fractions. McDonald *et al.* (2010) also indicated a reciprocal relationship between the protein and fiber content.

The CP values of hay 7.01%, 7.2% and 7.2% reported by Berhanu *et al.* (2014), Desta *et al.* (2017) and Lemma *et al.* (2018), respectively are in line with the CP content of hay recorded in the current study. However, it was higher than the values 3.56%, 3.73% and 6.04% and documented by Fentie (2007), Berhan and Asnakew (2015) and Michael *et al.* (2017), respectively and lower than the CP contents of 8%, 9.89% and 9.81% reported by Awoke (2011), Melese (2011) and Gebregiorgis *et al.* (2017), respectively. The differences in CP content of hay among the various studies are attributable to species composition of the hay, environmental factors in which the hay was grown, curing process during harvesting time, and stage of maturity at which the hay was harvested (Chrenkova *et al*., 2006; Dereje, 2015).

The NDF, ADF and ADL components of hay offer in the current study were 58.68%, 47.92% and 10.3%, respectively. Ruminants require sufficient NDF in their diets to maintain rumen function and maximize production. The NDF content of forage however varies widely, depending on species, maturity, and growing environment (Mahyuddin, 2007). The NDF component of hay used in the current study was comparable to the value 55.88% reported by Lemma *et al.* (2018) and lower than 73%, 73.48% and 79.4% reported by Girma *et al.* (2014), Amde (2015) and Shashie *et al.* (2017), respectively.

The CP value of LH (22.3%) in the current study was comparable with the CP content of LH (24.9%) reported by Habte and Yayneshet (2016). However, it was higher than the CP value 16% of LH reported by Yoseph *et al.* (2002). The CP content of LH in the current study showed that this feed resource could be used as protein supplement for small ruminants under poor quality roughages by smallholder farmers who have no access to conventional protein supplement feed sources. The OM value of LH in the current study was higher than the value 91.78% reported by Habte and Yayneshet (2016). But the NDF and ADF contents were relatively lower than the values 49.4% and 48.6%, respectively reported by Yoseph *et al.* (2002).These variations may be due to differences in the varity of lentil and the efficiency of processing methods which may or may not allow inclusion of broken and discarded lentil. These differences may be also happened due to differences in climatic conditions such as temperature, rainfall and the

Table 1. Chemical composition of treatment diets and hay refusals

	Chemical composition (% for DM and % for others on DM basis)					
Feed samples	DM	OM	CP	NDF	ADF	ADL
Hay	91.6	89.47	7.13	58.68	47.92	10.30
LH	90	94.44	22.30	42.22	31.11	5.55
NSC	92	89.13	34.65	40.78	30.78	6.28
LH+NSC(67:33)	90.6	92.66	26.37	41.74	31.00	5.79
Hay refusals						
T1	93	91.4	4.84	73.19	51.61	13.67
T2	90	93.48	5.41	71.11	60.00	17.77
T3	92	92.39	5.39	66.43	54.35	13.73
T4	91	91.32	5.32	67.98	54.95	14.57

DM= dry matter; OM= organic matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin; LH= lentil hull; NSC= noug seed cake; T1= grass hay *ad libitum* +50g NSC; T2= grass hay *ad libitum* + 50g NSC + 200g LH and NSC mixture; T3= grass hay *ad libitum* + 50g NSC + 300g LH and NSC mixture; T4= grass hay *ad libitum* + 50g NSC + 400g LH and NSC mixture; Supplement= LH and NSC mixture (67:33 ratio)

soil type where the plants are grown.

The CP content of NSC used in the current study was comparable with the values 34.27% and 33.4% reported by Lidetu (2011) and Desta *et al.* (2017), respectively but higher than the values 28.2% and 30.57% reported by Gezu *et al.* (2017) and Lemma *et al.* (2018), respectively and lower than the report of Shashie *et al.* (2017) who reported 36.2% CP. The variation in the CP content of NSC could be due to the difference in variety of noug seed used, soil and the agro-ecology where the crop is grown and the efficiency of the oil extraction methods. The NDF content of NSC in the current study was nearly equal to 41.3% reported by Worknesh and Getachew (2018).

Dry Matter and Nutrient Intake

Daily DM and nutrient intake of Farta sheep is presented in Table 2. The result showed that hay DM intake in the control group was significantly higher (P<0.001) than the supplemented groups. The hay DM intake also showed a significant (p<0.001) difference among the supplemented groups. The higher basal diet DM intake by sheep in the control group compared to supplemented ones might be due to the low CP content of hay used as a result of which the animals try to consume more hay to meet their nutrient requirement. While, lower basal DM intake in supplemented group compared to T1 could be due to the higher CP content of the mixture (LH and NSC) supplements, which might have satisfied the nutrient requirement of the experimental sheep.

On the other side, low hay DM intake in supplemented group might be due to the higher substitution rate of the supplement for the hay. This is clearly seen by depression of hay DM intake in the current study as the level of the supplement increased from 200 g to 400 g on DM basis. Therefore, supplementation of basal diet with LH and NSC mixture significantly (P<0.001) increased total DM intake but depressed the basal diet as the level of supplement increased. The result of the current study was similar to Fentie (2007), Aschalew (2011) and Lemma *et al.* (2018) who reported higher hay DM intake in the control group compared to supplemented ones for Farta sheep. Similar reports were also documented by Mesganaw (2014), Amde (2015) and Gezu *et al*. (2017) who reported higher DM intake of hay in the control than supplemented groups for Washera, Horro and Menz sheep, respectively.

In the current study, the total DM intake between experimental animals showed highly significant difference (p<0.001) and it was lowest (P<0.001) for non-supplemented sheep as compared to the supplemented groups. In this study, total daily DM intake was increased with increased level of supplementation. This trend is similar with the report of Melese (2011), Meaza (2012), Gezu *et al.* (2017) and Girma *et al.* (2017) who reported that the total DM intake of animals was increased with increased level of supplementation. Higher total DM intake in the supplemented groups is related to the favorable rumen environment, such as enhanced microbial growth, created by supplementation, which could have been resulted in enhanced fermentation, rate of break down and rate of digestion of the feed, which in turn results in a greater DM intake (McDonald *et al.,* 2010).

Table 2. Daily DM and nutrient intakes of Farta sheep fed natural grass hay basal diet and supplemented with different levels of lentil hull and noug seed cake mixture

Intake (g/day/head)	Treatments				SEM	SL
	T1	T2	T3	T4		
Hay DM	586.2^{a}	499.8^{b}	452.9^{c}	402.4^{d}	26.88	***
LH+NSC DM (67:33)	-	200	300	400	-	-
NSC DM	50	50	50	50	-	-
Total DM	636.3^{d}	749.8^{c}	802.9^{b}	851.9^{a}	26.98	***
Total DM (as %BW)	3.1^{b}	3.5^{ab}	3.58^{ab}	3.61^{a}	0.31	*
Total DM (g/kg BW$^{0.75}$)	70.9^{b}	76.8^{ab}	77.1^{ab}	80.6^{a}	5.79	*
Nutrient Intake (g/day)						
OM	569.8^{d}	674.4^{c}	723.6^{b}	769.8^{a}	24.04	***
CP	59.1^{d}	106.8^{c}	130.5^{b}	153.8^{a}	1.92	***
NDF	366.9^{c}	407.8^{b}	425.9^{ab}	442.1^{a}	15.77	***
ADF	298.3^{c}	326.5^{b}	338.7^{ab}	349.3^{a}	12.87	***
ME (MJ/d)	5.1^{c}	7.4^{b}	7.8^{ab}	8.7^{a}	0.64	***
Substitution rate	-	0.42^{a}	0.44^{a}	0.49^{a}	0.07	Ns

$^{a-d}$means within a row not bearing a common superscript are significantly different; ***= (p<0.001); **= (p<0.01); *= (p<0.05); Ns= non significant; DM= dry matter; NSC= noug seed cake; g/kg W$^{0.75}$ = gram per-kilogram metabolic body weight, OM= organic matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ME= metabolizable energy; SEM= standard error of mean; SL= significance level; T1= Grass hay *ad libitum* + 50g NSC; T2= grass hay *ad libitum* + 50g NSC + 200g LH and NSC mixture; T3= grass hay *ad libitum* + 50g NSC + 300g LH and NSC mixture; T4= grass hay *ad libitum* + 50g NSC + 400g LH and NSC mixture; Supplement= LH and NSC mixture (67:33 ratio)

Total DM intake as percent of body weight (%BW) and per metabolic body weight (g/kg W$^{0.75}$) in the current study was significantly higher (p<0.05) in T4 than T1. However, there were no significance differences (P>0.05) among the supplemented treatments and between T1, T2 and T3. Total DM intake as percent of BW in the current study ranged between 3.1-3.6% and per metabolic BW ranged 70.9-80.6 on g/kg W$^{0.75}$. The total DM intake expressed as percent of BW obtained from the current study is comparable to the values 3-3.7% and 3.3-3.9% reported by Awoke (2011) and Melese (2011) for Washera and Farta sheep, respectively. The total DM intake in the present study is in the range of the recommended dry matter intake (2-4%) for sheep and goat (Susan, 2009).

The OM and CP intake increased significantly (P<0.001) with increasing levels of supplementation and all the supplemented groups consumed more OM and CP (P<0.001) than the non-supplemented group. The CP intake of sheep in the current experiment was in the order of T4>T3>T2>T1 (p<0.001). According to Van Soest (1994), protein supplementation increases the supply of nitrogen to the rumen microbes, which have a positive effect on the rate of fermentation of the digesta. As the rate of degradation of digesta increased, feed intake increased, which supported the result of the current study. The average daily protein requirement of a 19.1 kg body weight sheep for maintenance is 38g CP (NRC, 1981). This indicates that the total average daily CP intake (59.1 g/day) of the control group in the current study was above the minimum CP requirements for maintenance.

Low CP intake of non-supplemented sheep compared with the supplemented ones in this study might be due to the relatively low CP content of the basal feed and low total DM intake. The variations in total CP intake among the supplemented groups might also be related to the differences in the CP amount of the supplemented feeds. Accordingly, the CP intake increased with increasing level of LH and NSC mixture in the supplemented groups and partly might be associated with the increases in total DM intake with increasing level of the supplementation. Similar to the result of the current study, Melese (2011) and Gezu *et al.* (2017) reported a significant increased in total intake of OM and CP with increased level of supplementation for Farta and Menz sheep, respectively.

In the current study, NDF and ADF intakes were significantly higher (P<0.001) for supplemented groups compared to the control one. The increased level of supplemental feed (LH and NSC mixture) in the current study might lead to better balance of nutrients and consequently a higher DM and nutrient intakes which might have resulted in improvement and performance of sheep signifying the importance of supplementation of hay or roughage based diets. Generally, the result of the current study indicated that supplementation significantly (p<0.001) increased the total DM, OM, CP, NDF and ADF intakes as compared to the control group.

Apparent Dry Matter and Nutrient Digestibility

The values for apparent DM and nutrients digestibility are given in Table 3. The apparent DM digestibility was significantly higher (p<0.01) in supplemented sheep than the control group although no significance difference (p>0.05) was noted between T1 and T2. Similarly, OM and CP digestibility was highly significant (p<0.001) for supplemented groups as compared to non-supplemented ones. However, no significance differences were observed (p>0.05) among supplemented treatments for DM, OM and CP digestibility. The higher DM, OM and CP digestibility observed in supplemented sheep in the current study might be due to the higher CP content of the supplemented feeds. McDonald *et al.* (2010) also reported that higher CP intake is associated with better CP digestibility.

On the other hand, the lower digestibility of DM, OM and CP recorded for the control group might be due to lower CP content and higher fiber content of the hay. Most of the differences in digestibility of total diet with supplemented versus non-supplemented sheep might be attributed to the high digestibility of supplements as observed by Ferrell *et al*. (1999). The same author reported that the high fiber and low CP contents of low quality forages are expected to result in low apparent digestibility of nitrogen.

The digestibility of NDF in T3 and T4 was higher (p<0.01) than the control group while significant difference was not recorded between T1 and T2. The current study also revealed the apparent digestibility of ADF in T4 was higher (p<0.05) compared to the non-supplemented group (T1). Contrary to the current study, Aschalew (2011) and Meaza (2012) documented absence of significance difference on digestibility of NDF and ADF between the supplemented and non-supplemented group in Farta and Tigray highland sheep, respectively.

Body Weight Change and Feed Conversion Efficiency

The values for mean initial body weight (IBW), final body weight (FBW), body weight change (BWC), average body weight gain (ADG) and feed conversion efficiency (FCE) of Farta sheep in the current study are presented in Table 4. The FBW and ADG were significantly higher (P<0.001) in the supplemented groups than non-supplemented ones, but no significant difference (p>0.05) was detected between T3 and T4 for the former parameter. The increased BWC and ADG in supplemented groups might be explained by the higher total DM and CP intake as compared to the control group. Among the supplemented treatments, significantly lower (P<0.001) records of BWC and ADG were observed in T2 which might be due to the lower intake of CP in T2 compared to T3 and T4. The result of the current experiment agrees with many previous studies (Melese, 2011; Meaza, 2012; Mesganaw, 2014; Gezu *et al.,* 2017) in which supplementation improved final body weight (FBW), BWC and ADG.

The ADG of Farta sheep in T2, T3 and T4 of the current experiment were 33.33, 53.7 and 64.44 g/day/head, respectively. In agreement with the present finding, 46.67-64.44g/day/head ADG were observed by Habte and Yayneshet (2016) for lambs fed different level of lentil hull along with 200g of wheat bran, 20g of molasses and *adlib* feeding of teff straw. But the ADG of the supplemented sheep in present study were higher than those reported by Melese (2011) for the same sheep breed supplemented with 420g rice bran and rape seed cake mixtures, and lower than the ADG values (70.11-82.44 g/day) reported by Fentie (2007) for Farta sheep fed hay and supplemented with 300 g/day of wheat bran, NSC and their mixtures in different proportion. The above variations in ADG between the current and the previous studies might be due to the difference in initial body weight (IBW) of the experimental animal and the environment in which the experiment was conducted.

Average daily body weight gain followed the same trend as that of total DM, OM and CP intakes, implying that increased intake resulted in improved performance of the animal. Since the animals in the control group offered with 50 g NSC/day, the ADG of sheep in the current study was 7.96 g/day. The other reason could be due to the relatively high CP content (7.13%) of the basal diet which could possibly fulfill the minimum requirement of CP value for maintenance of sheep. This result is comparable to the body weight gain of Tigray highland sheep (8 g/day) fed sole grass hay as reported by Gebresilassie (2012). However, it was higher than the findings of Bimrew *et al.* (2010) and Gezu *et al.* (2017) who reported ADG of 2.7 and 1.92 g/day in that order for the same sheep breed fed sole natural pasture hay and Menz sheep fed natural grass hay with 50 g NSC for maintenance and lower than the reports of Meaza (2012) who recorded ADG of 23.33 g/day for Tigray highland rams fed grass hay alone.

The feed conversion efficiency (FCE) obtained in the current study was higher (P<0.001) in supplemented groups than the non-supplemented group. Among the supplemented groups, animals in T2 showed significantly

Table 3. Apparent dry matter and nutrients digestibility of Farta sheep fed natural grass hay basal diet supplemented with different levels of lentil hull and noug seed cake mixture

Apparent digestibility (%)	Treatments				SEM	SL
	T1	T2	T3	T4		
DM	53.3^{b}	62.6^{ab}	65.2^{a}	68.6^{a}	6.97	**
OM	55.6^{b}	67.5^{a}	68.4^{a}	70.3^{a}	5.38	***
CP	43.7^{b}	63.4^{a}	68^{a}	74.4^{a}	7.31	***
NDF	50.4^{b}	60.5^{ab}	63.6^{a}	65.4^{a}	6.83	**
ADF	44.7^{b}	50.8^{ab}	54.5^{ab}	61.2^{a}	9.54	*

$^{a-b}$means within a row not brearing a common superscript are significantly different; ***= (p<0.001); **= (p<0.01); *= (p<0.05); SEM= standard error of mean; SL= significance level; DM= dry matter; OM= organic matter; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; T1= Grass hay *ad libitum* + 50g NSC; T2= grass hay *ad libitum* + 50g NSC + 200g LH and NSC mixture; T3= grass hay *ad libitum* + 50g NSC + 300g LH and NSC mixture; T4= grass hay *ad libitum* + 50g NSC + 400g LH and NSC mixture; Supplement= LH and NSC mixture (67:33 ratio)

Table 4. Body weight and feed conversion efficiency of Farta sheep fed natural grass hay basal diet and supplemented with different levels of lentil hull and noug seed cake mixture

Parameter	Treatments				SEM	SL
	T1	T2	T3	T4		
IBW (kg)	18.02	18.07	18.05	18.07	1.16	Ns
FBW (kg)	18.73^{b}	21.07^{ab}	22.88^{a}	23.87^{a}	1.89	***
BWC (kg)	0.71^{c}	3.00^{b}	4.83^{a}	5.80^{a}	1.12	***
ADG(g/day)	7.96^{c}	33.33^{b}	53.70^{a}	64.44^{a}	12.45	***
FCE	0.013^{c}	0.067^{b}	0.118^{a}	0.161^{a}	0.03	***

$^{a-c}$means within a row not bearing a common superscript are significantly different; ***= (p<0.001); **= (p<0.01); *= (p<0.05); Ns= non-significant; SEM= standard error of mean; SL= significance level; IBW= initial body weight; FBW= final body weight; BWC= body weight change; ADG= average daily gain; FCE= feed conversion efficiency; T1= Grass hay *ad libitum* + 50g NSC; T2= grass hay *ad libitum* + 50g NSC + 200g LH and NSC mixture; T3= grass hay *ad libitum* + 50g NSC + 300g LH and NSC mixture; T4= grass hay *ad libitum* + 50g NSC + 400g LH and NSC mixture; Supplement= LH and NSC mixture (67:33 ratio)

(p<0.001) lower FCE than those in T3 and T4 although no significant difference (p>0.05) was observed between T3 and T4. These results indicated that diets which have higher digestibility values result in higher final body weight gain, average daily gain and feed conversion efficiency. On the other hand, the lowest FCE for the control might be due to low intake of nutrients which in turn limited by high contents of fiber that depress digestibility, and thereby absorption of nutrients. The low feed intake contributed to the low body weight gain which consequently might have affected FCE.

Partial Budget Analysis

The partial budget analysis of Farta sheep fed grass hay basal diet and supplemented with different levels of lentil hull and noug seed cake mixture is presented in Table 5. The partial budget analysis was performed to evaluate the economic advantages of the feeding regime. The result of the partial budget analysis indicated that the gross financial margin or total return obtained in this trial was 80.8, 332, 487 and 555 ETB/head for the sheep fed on T1, T2, T3 and T4 diets, respectively. Accordingly, sheep fed on higher level of LH and NSC mixture (T4) returned a higher net income (230.7 ETB/sheep) as compared to the other supplemented and un-supplemented groups. The highest net income gained in T4 might be due to higher body weight gain and better FCE of the sheep in this treatment as compared to those in the other treatments. On the other hand, sheep fed on

Table 5. Partial budget analysis of Farta sheep fed natural grass hay basal diet and supplemented with different levels of lentil hull and noug seed cake mixture

Variables	Treatments			
	T1	T2	T3	T4
Purchase price of sheep (ETB/head)	875	873	871	870
Hay consumed (Kg/head)	52.8	45	40.8	36.2
LH and NSC mixture consumed (Kg/head)	-	18	27	36
NSC Consumed for maintenance (Kg/head)	4.5	4.5	4.5	4.5
Total feed consumed (Kg/head)	57.3	67.5	72.3	76.7
Cost of hay (ETB/head)	73.9	63	57.1	50.7
Cost of supplement (ETB/head)	-	118.8	178.2	237.6
Cost of NSC (ETB/head)	36	36	36	36
Total feed cost (ETB/head)	109.9	217.8	271.3	324.3
Total variable cost (TVC) (ETB/head)	984.9	1090.8	1142.3	1194.3
Gross income (Sell price) (ETB/head)	955.8	1205	1358	1425
Total return (TR) ETB/head)	80.8	332	487	555
Net return (NR) ETB/head)	-29.1	114.2	215.1	230.7
Change in net return (ΔNR)	-	143.3	244.2	259.8
Change in total variable cost (ΔTVC)	-	105.9	157.4	209.4
Marginal rate of return (MRR= ΔNR/ΔTVC)	-	1.35	1.55	1.24

ETB= Ethiopian birr; NSC= noug seed cake; TR= total return; ΔNR change in net return; ΔTVC= change in total variable cost; MRR= marginal rate of return; T1= Grass hay *ad libitum* + 50g NSC; T2= grass hay *ad libitum* +50g NSC + 200g LH and NSC mixture; T3= grass hay *ad libitum* +50g NSC + 300g LH and NSC mixture; T4= grass hay *ad libitum* +50g NSC + 400g LH and NSC mixture; Supplement= LH and NSC mixture (67:33 ratio)

the control diet (T1) resulted in lost of 29.1 ETB/sheep. The loss could be attributed to the fact that the control sheep did not gained as much as the supplemented groups and their body condition was poor. In Ethiopia, estimation of sheep price is closely related to body condition, and the estimators judged the control sheep as poor in condition and lowered their price.

The changes in net returns from the supplemented groups were 143.3, 244.2, and 259.8 ETB/head. Marginal rate of return measures the increase in net income and effects of additional investment in a new technology on additional net return. Thus, the current study indicated that each additional unit of one birr per sheep cost increment resulted in one birr and additional 1.35, 1.55 and 1.24 birr profit for T2, T3 and T4, respectively. Sheep fed the highest level of supplement (T4) had the highest net income, but had the lowest MRR value as compared to the other supplemented groups, because of differences in the cost of the supplement among the treatments.

The results of this study indicated that supplementation of poor quality diets like hay with non- conventional feeds like lentil hull together with noug seed cake not only improvement in animal performance biologically, but also offer a positive and higher net return. Thus, from the overall results of this study, it would appear that supplementation with 400 g of LH and NSC mixture plus 50 g NSC (T4) on DM basis could be recommended for growing Farta sheep based on biological performance and net return.

CONCLUSIONS

The CP content of hay, LH, NSC and the mixture of LH and NSC were 7.13, 22.3, 34.65 and 26.37%, respectively. Therefore, the basal diet of hay CP (7.13%) value may be fulfill the maintenance requirement of sheep and lentil hull may be used as protein supplement to small ruminants fed on poor quality roughages by smallholder farmers who have no access to conventional protein supplements. Hay DM intake was highly recorded in the control group while the total dry matter intake was significantly higher ($P<0.001$) in supplemented groups compared to un-supplemented group. In addition, sheep on the supplemented group had a higher ($p<0.001$) total DM, OM and CP intake compared to control group.

The apparent DM, OM, CP, NDF and ADF digestibility were improved by supplementation. Average daily body weight gain (ADG) for T2 (33.33), T3 (53.70) and T4 (64.44) in g/day were significantly (P<0.001) higher than the ADG for T1 (7.96).

Partial budget analysis revealed that as the level of LH and NSC mixture increased, net return as well as change in net income increased. Accordingly, the study confirmed that the practice of supplementation of poor quality hay with agro-industrial by-product and non-conventional feed mixture not only improve animal performance biologically but also increase net income. Thus, from the overall results of the current study (biological performance and net return), supplementation with a 400 g inclusion level of LH and NSC mixture plus 50g NSC (T4) could be recommended for growing Farta sheep.

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