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Dried Khat *(Catha edulis)* Leftover and *Noug* Seed Cake Mixtures on Feed intake, Digestibility and Growth Performance of Arsi-Bale Sheep Fed Natural Pasture Hay Basal Diet

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The objectives of study was to evaluate the effect of dried Khat (Catha edulis) leftover and Noug seed cake (NSC) mixtures on feed intake, feed digestibility, live weight change and economic benefit of Arsi-Bale sheep fed natural pasture hay basal diet. The experiment was conducted using a randomized complete block design with four treatments and six sheep. Blocking was based on the initial body weight of sheep. Twenty four Arsi-Bale sheep with yearling age and average initial was 17.75kg used for the experiment. The experimental sheep were arranged randomly into six blocks of four animals each based on their initial body weight. The experimental feeds were evaluated for chemical composition. The Crude Protein (CP) content of the pasture hay, Catha edulis leftover and NSC were 9.6, 10.40 and 35%, respectively. Supplementation significantly (p<0.001) improved the total DM (609-904.2 g/d), CP (84.7-140.1 g/d) and OM (553.7-826.1 g/d) intakes than the total DM (522.3g/d), CP (62.9 g/d) and OM (472.2 g/d) intakes of the control group, respectively. Similarly, digestibility of DM (65.6-73.6) and nutrients, average daily gain (46.5-85.7 g/d) and feed conversion efficiency (0.076-0.094) was significantly (p<0.001) improved with supplementation. Based on the partial budget analysis, supplementation of T3 (300 g/d DM) Khat leftover and noug seed cake (NSC) mixtures had the highest net income (147.9 ETB/head). Generally, supplementation of 300 g/d DM dried Khat leftover and NSC mixtures at 2:1 (T3) is optimal level for better animal performance and profitability in Arsi-Bale sheep fed natural pasture hay.

Key words: Khat (Catha edulis), Noug seed cake, Average daily gain.

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INTRODUCTION

Ethiopia possesses genetically diverse sheep populations (Solomon *et al*., 2007). Sheep production in the mixed crop-livestock production systems in Ethiopia has a very important role in contributing to the food security as well as in generating direct cash income. However, sheep production has been impacted in feed shortage and it is limiting factors for increasing production and productivity of small ruminants in most of the agro-ecological zones of Ethiopia. The major feed resources for sheep include communal and private natural pasture, crop residues, grains and non-conventional feeds (Solomon *et al*., 2010). Most of the forages from

communal grazing areas and crop residues contain CP below 7% and NDF above 55% of DM, both of which indicate poor nutritive value not capable of meeting rumen microbial requirements, particularly with regard to CP content (Van Soest, 1994). This phenomenon requires the alleviation of nutrient deficiency faced by animals through implementing different feed utilization strategies.

One possible method of improving the nutritive value of feeds is through supplementation with concentrates (industrial by-products). However, utilization of these by-products as animal feed generally depends upon availability and cost (Malede, 2014), so supplementation with alternative locally available cheap energy and protein sources can promote feed intake, digestibility and growth performance of animals. In various areas of Ethiopia there are many fodder trees and shrubs grown for various purposes such as fences, soil management, animal feeds and for other economic activities. Of the different plants, Khat *(Catha edulis)* is a cash crop grown by the majority of smallholder farmers in eastern and southern Ethiopia, while the Khat leftover *(geraba)* such as pruned sprouts, twigs, leaves and young shoots that are discarded as unpalatable for chewing by human beings (Eshetu and Habtemariyam, 2001).

In the study area, the major crops grown include coffee, maize, enset and Khat (Gonfa *et al.,* 2015). However, Khat leftover was not given attention as feed for sheep and there were no available information about the use and effect of Khat leftover as the diet of sheep. In the area, many farmers had experience of supplementing their sheep with industrial by-products although the higher purchasing cost of those supplements is discouraging. In this regard, the use of other alternative sources like Khat leftover as a feed option for sheep has paramount importance. It was expected that the inclusion of Khat leftover with NSC may improve the performance of Arsi-Bale sheep as observed elsewhere in goats and may minimize the cost required for concentrate purchase. Therefore, taking the gap into consideration, this study was designed as objective to evaluate the effect of Khat *(Catha edulis)* leftover and NSC mixture supplementation on feed intake, digestibility, growth performance and economic benefits of Arsi-Bale sheep fed natural pasture hay basal diet.

MATERIAL AND METHODS

Description of Study Area

The study was conducted at Dale district, which is located in Sidama zone of Southern Nations and Nationalities (SNNP) regional state, Ethiopia. The mean minimum and maximum temperatures of the area are 9.6°C and 29.2°C, respectively (SEDPSZ, 2004). The mean annual rainfall of the area is about 1102 mm.

Experimental Animals and Management

Twenty four intact yearling male Arsi-Bale sheep were purchased and quarantined for 21 days. During this, animals were de-wormed with against internal parasites and sprayed for external parasites. Thereafter, penned in individually and acclimated to experimental diets for 15 days. Then, the actual feeding trial was conducted for 90 days followed by 7 day digestibility trial.

Feed Preparation and Feeding

Grass was harvested, air dried and stored under shade to maintain its quality and the Khat leftover was also from the chewers, farmers, traders and properly dried and crushed. Similarly, NSC was purchased stored at the study site. The hay were chopped to a size of about 3-5cm and offered *adlibtum*. The supplement feeds containing diet dried Khat leftover and *NSC* mixtures with a ratio of 2:1 was offered individually based on the treatment allocation by dividing into two equal portions at 0800 and 1600 hours. Common salt as a mineral lick and water were available to animals all the time throughout the experiment.

Experimental Design and Treatments

Randomized Complete Block Design was used to conduct the experiment. The initial body weight of animals was recorded after overnight fasting for two consecutive days in the mornings before the daily feed offer and the average was taken. Each animal in a block was randomly assigned to one of the four dietary treatments putting six animals per treatment. Supplement diets were leveled from 150 to 450g at a 2:1 of dried Khat *(Catha edulis)* leftover and NSC, respectively. The layouts of experimental diets were showed in Table 1.

Table 1. The layout of experimental diets used in DM basis.

Treatment	No. of animals per treatment	Basal diet		Supplement feed g/h/d		Total supplement g/h/d
		Grass hay	NSC	Dried Khat leftover	NSC	
T_1	6	*Adlibtum*	50g	-	-	-
T_2	6	*Adlibtum*	50g	100	50	150
T_3	6	*Adlibtum*	50g	200	100	300
T_4	6	*Adlibtum*	50g	300	150	450

Measurements

Feeding trial

The daily feed offered and refusals were weighed and recorded for each animal to determine daily feed intake every morning before the daily feed offered. To determine the weight change, subsequent body weight measurements were recorded every fifteen days throughout the experimental period. The mean average daily gain (ADG) was calculated by dividing differences of the final and initial body weight by the number of days of feeding. Feed conversion efficiency (FCE) of each animal was computed as a ratio of the ADG with daily feed intake. Generally Body weight changes calculated as the difference between the initial and final live weights.

Digestibility trial

Following feeding trial animals were acclimatized to carrying the fecal bags harnessed on them for three days, which was followed by seven consecutive days of total fecal collection. The daily total fecal output was weighed, thoroughly mixed and a 20% sub-sample was taken to form a seven days fecal composite sample for each animal and stored in deep freezer at -20°c pending for chemical analysis. The metabolizable energy (ME) was estimated from its digestible organic matter intake (DOMI) using the equation of AFRC (1993) as ME (MJ/d) = 0.0157*DOMI g/kg DM.

Chemical analysis

Feed and fecal samples were dried in a forced draft oven at 105^{o}c overnight and then milled to pass through 1 mm screen. The DM, OM, CP and total Ash was analyzed according to the procedure described by AOAC (1995). The NDF, ADF and ADL were also analyzed according to the procedure of Van Soest and Robertson (1985). The CP was calculated as N*6.25.

Statistical analysis

The data obtained on feed intake, digestibility and body weight change were subjected to analysis of variance (ANOVA) using the procedure of General Linear Model (GLM) of SAS (2003). Further comparisons were made between means using Turkey's Studentized Range (HSD) test.

Partial budget analysis

Partial budget analysis was determined to assess the profitability of the feeding regime. The calculations were done according to Upton (1979). Total returns (TR) were calculated as the difference between selling and purchasing price of the experimental animals. Net income (NI) was calculated as the amount of money left when total variable cost (TVC) is subtracted from total returns (TR).The change in net income (ΔNI) was calculated as the difference between the change in total return (ΔTR) and the change in total variable costs (ΔTVC).The marginal rate of return (MRR) measure the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC).

RESULTS AND DISCUSSION

Chemical Composition of Feeds Offered and Refused

The chemical composition of feeds offered and refused samples are shown in Table 2. The relatively good CP value 9.6% of hay indicated a moderate stage of maturity at harvest that can categorize the hay as good quality and may satisfy the maintenance requirement of the animals and proper rumen function in ruminants (Van Soest, 1994).

Table 2. Chemical composition of feeds offered and hay refused.

Feed offered	DM%	CP	NDF	ADF	Ash	OM	ADL
(%DM)							
Grass hay	94.01	9.6	58.7	46.8	9.57	90.43	12.46
Dried Khat leftover	93	10.4	51.05	40.4	6.45	93.55	11.03
NSC	93	35	51.05	40.4	9.67	90.33	11.03
Dried Khat leftover + NSC mixture	93	18.60	51.05	40.40	7.52	92.47	11.03

The low NDF and high CP contents of the hay used in this study could be attributed to the moderate stage of maturity of the grass which the hay was prepared. McDonald *et al*. (2002) reported that the moderate stage maturity of plants characterized, high CP and low fiber content. The CP content of dried khat leftover observed in this study implies that khat leftover are readily available cheap protein sources (Berhan and Mohammed, 2006). The value 10.4% CP of khat leftover in this study was similar to the value 10.4% CP reported by Getinet and Yoseph (2014) and more or less comparable to the values of 11% and 11.1% CP reported by Kedir (2011) and Misgana *et al.* (2012), respectively.

The CP content of NSC observed in this study was high value 35% CP as the feedstuffs having > 20% CP and 12-20% CP classified as high and medium, respectively (Lonsdale, 1989). The variation of nutrient composition of the same feed may be associated with environmental location and processing methods of concentrates as well as the harvesting stage and physical composition of natural pasture hay (Alemu, 1981). These two diets, Khat leftover and NSC have produce good mixture supplement and the moderate CP content (18.6%), higher OM and lower fiber fraction contents which indicates its good nutritional value to supplement the animals.

Dry Matter and Nutrient Intake

The dry matter intake of the basal diet was significantly (P<0.001) higher for sheep in the control group than the supplemented groups (Table 3). But, it was similar (P>0.05) in the supplemented group. The higher intake in the controlled group may be due to the fact that the controlled animals consume more basal diet than the supplemented group to meet their nutrient requirement. On the other hand, although no difference (P>0.05) was observed in the basal DM intake among supplemented groups, they consumed significantly (p<0.001) more total DM but less basal DM than the controlled group might be due to the positive and negative effects of supplementations on the intakes of total DM and basal DM, respectively (Becholie *et al*., 2005).

There was an increase (P<0.001) of total DM and nutrient intake with increasing level of supplement mixture in this study. This might be due to higher level of Khat leftover and NSC mixture supplement that supplied better nutrients to rumen microbes. Van Soest (1994) pointed out that supplementation of concentrates increased the supply of nitrogen to rumen microbes and thereby can bring a positive effect by increasing microbial population and their efficiency, thus enabling increased rate of digesta fermentation, increased feed intake and digesta passage rate.

Moreover, significant (p<0.001) improvement in intakes of OM, ME and fiber fractions were observed with the increased levels of Khat leftover and NSC mixture supplement. In accordance with the present study, Hailu *et al.* (2014) showed that supplementation of Arsi-Bale sheep with concentrate mixtures to the basal grass hay diet improved total DM, CP and OM intake, digestibility and growth performance.

The current finding showed that supplementation had a positive effect (p<0.001) on total DM (g/kg $W^{0.75}$) intake and there was significant (p<0.001) difference among the supplemented groups. This might be due to the differences in total DM intake. The total DM (g/kg $W^{0.75}$) intake of sheep in the present study was comparable with 56-80.7 DM (g/kg $W^{0.75}$) intake reported by Gebretnsae (2011) for local male sheep fed barley and supplemented with dried branches of *Acacia senegal* and *Cactus Cladodes.*

Table 3. Daily dry matter and nutrient intakes of Arsi-Bale sheep fed on grass hay basal diet supplemented with dried Khat *(Catha Edulis)* leftover and Noug seed cake mixtures.

DM and Nutrient intake	Treatments				P-value	SEM
	T1	T2	T3	T4		
Grass hay (g/d)	472.3^{a}	409^{b}	407^{b}	404.2^{b}	<0.001	50.3
Supplement Mixture (g/d)	-	150	300	450	-	-
NSC (g/d)	50	50	50	50	-	-
Total DM (g/d)	522.3^{d}	609^{c}	757^{b}	904.2^{a}	<0.001	50.3
DM (% BW)	2.63^{d}	2.79^{c}	3.14^{b}	3.57^{a}	<0.001	0.31
DM (g/kg $BW^{0.75}$)	55.5^{d}	60.3^{c}	69.6^{b}	80.1^{a}	<0.001	6.12
ME (MJ/d)	4.3^{d}	5.7^{c}	7.8^{b}	9.7^{a}	<0.001	0.81
Total CP (g/d)	62.9^{d}	84.7^{c}	112.4^{b}	140.1^{a}	<0.001	4.84
Total OM (g/d)	472.2^{d}	553.7^{c}	690.6^{b}	826.1^{a}	<0.001	45.5
Total NDF (g/d)	302.8^{d}	342.2^{c}	417.6^{b}	492.6^{a}	<0.001	29.5
Total ADF (g/d)	241.2^{d}	272.3^{c}	332^{b}	391.3^{a}	<0.001	23.5

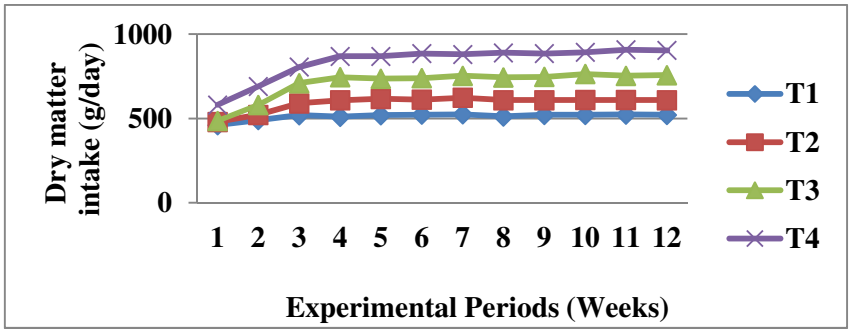

Figure 1. Trends in total dry matter intake of Arsi- Bale sheep fed grass hay and supplemented with Khat *(Catha edulis)* leftover and NSC mixture during the feeding trial.

The total DM intakes of percent body weight obtained in the current study were within the range recorded for sheep and goat that will generally consume 2 to 4% of their body weight on DM basis (Susan, 2003). The ME intake of sheep in this study was within the ranges indicated for 3.7-4.1 MJ ME estimated for 20 kg live weight sheep (ARC, 1980).Hence, the ME values in the current study showed all treatments received the higher ME intake than estimated energy for maintenance requirement.

The trends in total DM intake (Figure 1) above showed that all treatments till 3 week have almost similar change. However, after 3 week T3 and T4 showed slight increment in DM intake compared to T2 and control group probably due to the more adaptation and utilization of higher levels of supplements tend to increase the intakes. Generally, the trend in DM intake across the feeding period was superior for sheep in T4 and followed by T3 indicating the increased levels of Khat leftover and NSC mix in the diet improves the total DM intake accordingly.

Dry Matter and Nutrient Digestibility

Table 4. Apparent dry matter and nutrients digestibility by Arsi-Bale sheep fed on grass hay basal diet supplemented with dried Khat *(Catha edulis)* leftover and Noug seed cake mixtures.

Digestibility (%)	Treatments				P-value	SEM
	T1	T2	T3	T4		
DMD	59.8^{d}	65.6^{c}	69.7^{b}	73.6^{a}	<0.001	0.054
CPD	61.3^{d}	65.9^{c}	74.6^{b}	78.3^{a}	<0.001	0.059
NDFD	53.6^{c}	59.5^{b}	67^{a}	68.6^{a}	<0.011	0.160
ADFD	48.7^{d}	55.2^{c}	62.5^{b}	65.8^{a}	<0.001	0.144
OMD	57^{d}	65.7^{c}	72^{b}	75.1^{a}	<0.001	0.054

The result showed (Table 4) there was improvement in DM and nutrients digestibility with the increased levels of Khat leftover and NSC mixture supplements in the diet, which could be a consequence of the higher CP intake. Sufficient supply of concentrates supplements to rumen microbes promotes high microbial population that facilitates rumen fermentation and addition of protein source feeds to low quality feeds facilitates the activity of microorganism by increasing the availability of nitrogen in the rumen and eventually they degrade the crude fiber more vigorously (Ranjhan, 2001; McDonald *et al.,* 2002). The moderate digestibility of DM observed in T1 might be related to the provision of good quality basal diet with 50g NSC maintenance supplement. It was noted that feed with DM digestibility of less than 55% is considered as poor quality and will not maintain body weight, whereas feed having digestibility exceeding 65% is categorized as high quality (David, 2007). Hence, based on the results of current study supplementation of sheep with dried Khat *(Catha edulis)* leftover and NSC mixture had high potential to improve the digestibility of nutrients and DM.

Body Weight Change and Feed Conversion Efficiency

Initial body weight was similar among all treatments (P >0.05), whereas body weight change and ADG were

significantly ($p<0.001$) lowest for T1 as compared to supplemented group mainly due to the low intake of CP (Table 5). Low intake of CP and DM resulted in decreased microbial function, which lead to a reduction in degradation and consequently lowers final body weight, body weight change and ADG (Ebrahimi *et al*., 2007). This finding was in line with the report of Getahun (2015) who observed lower final body weight, body weight change and ADG with low DM and CP intake of Arsi-Bale sheep.

The higher ADG with increasing levels of supplement may be a function of higher intake and digestibility of nutrients and the ability of sheep to convert feed efficiently to flesh, which is in agreement with report of Tsegay *et al.* (2013) who observed higher ADG for the sheep supplemented with 350 g/d concentrate than those supplemented with 150 g/d. Among the supplemented treatments, lower records of body weight change and ADG were observed in T2, this might be due to the lower intake of CP. Vanes (1979) indicated that quantity of protein utilization will determine the growth rate.

The FCE observed among the treatments indicated that as the proportion of ADG and total DM intake increased, the FCE also increased. This is due to the better protein utilization as the result of high concentrate mix supplementation that resulted in higher ADG. This might be explained by an increased nutrient content due to higher total DM intakes, which improved the rate and efficiency of microbial biomass production than the control group. The finding agrees with Hirut (2008) and Dawit and Solomon (2009) who reported that FCE of sheep increased with enhancement of total DM intake. Similarly, Ebrahimi *et al*. (2007) noted that increasing protein and energy level in the diet improved FCE and ADG of animals. Among the supplemented group the higher FCE was recorded for T3 and T4 as compared to the T2. This could be due to the higher concentration of energy and protein in this treatment and consequent increase in ADG.

The ADG of supplemented Arsi-Bale sheep in this study were in the range 46.48-85.74 g/day, which were lower than that reported by Ermias (2008) which were in the range of 55.6-87.8 g/day gain for Arsi-Bale sheep supplemented with concentrates mixture (barley bran and linseed meal), respectively and higher than the findings of Abebe (2011), which were in the ranges 48.7-74.82 g/d for Arsi-Bale sheep. The variations in ADG for similar breed of sheep in various studies might be due to the type of feeds used, DM intake, growth stage of sheep and type of managements (Takele *et al.,* 2006). Generally, supplementation with dried khat leftover and NSC mixture improved the growth performance and FCE of the animal.

Table 5. The body weight parameters and feed conversion efficiency of Arsi-Bale sheep fed grass hay basal diet and supplemented with a mixture of dried Khat (*Catha edulis*) leftover and noug seed cake.

Parameters	Treatments				P-value	SEM
	T1	T2	T3	T4		
IBW (kg)	17.75	17.76	17.85	17.65	0.991	1.14
FBW (kg)	19.90^{c}	21.95^{bc}	24.23^{ab}	25.36^{a}	<0.002	1.78
BWC (kg)	2.15^{c}	4.18^{b}	6.37^{a}	7.71^{a}	<0.001	0.97
ADG (g/day)	23.88^{c}	46.48^{b}	70.83^{a}	85.74^{a}	<0.001	10.8
FCE (g ADG/g DMI)	0.046^{c}	0.076^{b}	0.093^{a}	0.094^{a}	<0.001	0.014

There was no weight losses observed in the control groups during the experimental period, rather a minimal body weight gain was recorded mainly due to the moderate quality of basal diet with 50 g NSC that supplied adequate nutrients more than the maintenance requirements of the animals. It was revealed that most productive animals such as rapidly growing lambs and lactating ewes need about 11% of CP for proper productive performance and the minimum level required for maintenance were about 8% CP in DM (CTA, 1991).

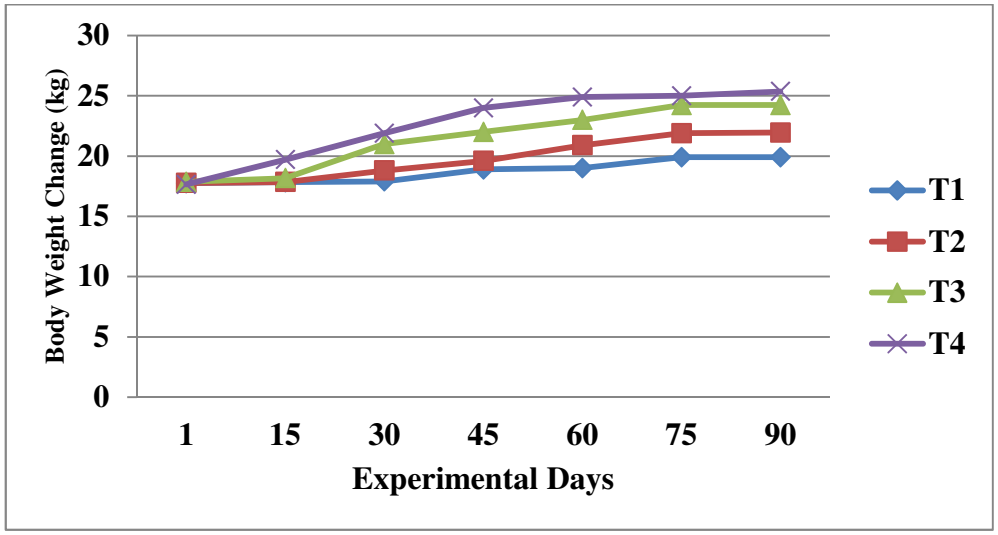

Figure 2. Trends in body weight changes across the experimental period for Arsi-Bale sheep fed Natural pasture hay and supplemented with Khat leftover and NSC mixture.

The trend in live weight change of sheep is given in Figure 2. The live weight change of the experimental animals in all treatments increased linearly across the study period, especially after 30 days, with more prominent increase in animals supplemented with high at T4 and medium at T3 levels of concentrate.

Partial Budget Analysis

The partial budget analysis of the current study demonstrated that the economic return of the feeding trial mainly depends on feed cost, purchasing and selling prices of the experimental sheep (Table 6). Although there was a slight body weight gain from the control group, negative net return -94.73Ethiopian birr (ETB) was obtained, which was mainly due to the less body weight gain. The highest net return 147.9 ETB was obtained in T3 and followed by 132.16 ETB in T4, which is mainly due to the higher body weight gain and feed utilization efficiency that improved performance and their sale values. The result of this study suggested that supplementation of pasture grass hay with 300g followed by 450 g DM/d Khat leftover and NSC mixture was found to be potentially profitable and economically feasible than supplementing with 150g and the control group.

Table 6. Partial budget analysis of Arsi-Bale sheep fed on grass hay basal diet and supplemented with a mixture of dried Khat (*Catha Edulis*) and noug seed cake.

	Treatments			
Parameters	T1	T2	T3	T4
Sheep purchasing price (ETB/h)	668.33	670.00	673.33	671.67
Hay consumed (kg/sheep)	42.50	36.81	36.63	36.37
Khat Leftover consumed (kg/sheep)	-	9	18	27
NSC consumed (kg/sheep)	4.5	9	13.5	18
Cost of hay (ETB/sheep)	112.6	97.5	97	96.3
Cost of Dried Khat Leftover (ETB/sheep)	-	19.35	38.7	58
Cost of NSC (ETB/sheep)	28.8	57.6	86.4	115.2
Total feed cost (ETB/h)	141.4	174.45	222.1	269.5
Sheep Selling price (ETB)	715	897.50	1043.33	1073.34
Total variable cost (TVC)	809.73	844.45	895.43	941.17
Total return (ETB/h)	46.67	227.5	370	401.66
ΔTR	0.00	180.8	323.3	354.99
Net return (ETB/h)	-94.73	53.05	147.9	132.16
ΔNR (ΔTR-ΔTVC)	0.00	146.08	237.6	223.55
ΔTVC (ETB)	0.00	34.72	85.7	131.44
MRR (ΔNR /ΔTVC)	0.00	4.29	2.77	1.70

SUMMARY AND CONCLUSIONS

The results of this study showed that the total DM and nutrients intakes were significantly ($P<0.001$) higher at highest level of supplements and lowest at the control group in the order of T4>T3>T2>T1. A similar trend was also observed in digestibility of DM and nutrients. Body weight change, ADG and FCE were significantly ($P<0.001$) higher for T3 (300 g/d) and T4 (450 g/d) which are medium and highest level inclusions, respectively than the low level of supplementation and control groups. Based on the partial budget analysis result, sheep supplemented with 300g DM/d (T3) Khat leftover and NSC mixture had the highest net return (147.9 ETB/head) followed by those sheep supplemented with 450 g DM/d (T4) with a net return value of 132.16 ETB/head. Therefore, it can be concluded that supplementation of 300 g/d DM dried Khat leftover and NSC mixtures at 2:1 (T3) could be recommended as optimal level than other treatments for better utilization of nutrients, animal performance and profitability in Arsi-Bale sheep fed natural pasture hay.

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