The Journal of Animal & Plant Sciences, 24(1): 2014, Page: 35-42
ISSN: 1018-7081

EFFECT OF FEEDING CONCENTRATE, DRIED KHAT (*CATHA EDULIS*) LEFTOVER OR THEIR MIXTURES ON FEED INTAKE, DIGESTIBILITY AND BODY WEIGHT CHANGE OF HARARGHE HIGHLAND GOATS FED BASAL DIET OF NATURAL GRASS HAY

Y. Getinet and M. Yoseph*

School of Agriculture, Department of Animal and Range Sciences, Madawalabu University, P.O. Box 247, Bale- Robe, Ethiopia
*School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia.
Corresponding Author E-mail: getanbe@ gmail.com

ABSTRACT

The effect of feeding concentrate mix, khat leftover or their mixtures on intake, digestibility and body weight change were studied using twenty five yearling intact male Hararghe Highland goats with mean initial body weight of 17.8 ± 1.30 kg (mean ± SD). Goats were grouped into five blocks of five animals and randomly assigned to five dietary treatments**.** Dietary treatments were prepared in such a way that crude protein from concentrate mix (CMCP) was substituted with crude protein from khat leftover (KCP) at a ratio of 0, 33, 67 and 100% on dry matter (DM) basis. Treatments consisted of *ad labitum* feeding of natural grass hay alone (T_1, control) and natural grass hay supplemented with CMCP-100% (T2), KCP-33% + CMCP-67% (T_3), KCP- 67% + CMCP-33% (T_4), KCP-100% (T_5) on DM basis. The study consisted of 90 days growth and 7 days digestibility trials. Supplemented (T2-T5) goats consumed more (P<0.001) total dry matter intake and metabolisable energy than the control (T1). The highest (P<0.001) total crude protein (CP) intake was observed in goats supplemented with T2 (80.5±1.26) which followed by T3 (75.7±1.26), T4 (57.7±1.26), T5 (43.8±1.26) and lowest in T1 (28.7±1.26). Digestibility of dry matter (64-65%) and organic matter (66-67%) were higher (P<0.001) for goats supplemented with T2, T3, T4 and T5 than the goats in T1 (52 and 54% for DM and OM, respectively), but similar (P<0.001) among the T2, T3, T4 and T5 supplemented goats. The effect of dietary treatment on crude protein (CP) digestibility was higher (p<0.001) in order of T1<T4=T5<T3=T2. Average daily gain [-5.6, 61.3, 55.7, 42.2 and 28.4 g/day *(SEM=5.9)* for T1, T2, T3, T4 and T5, respectively were greater *(P<0.001)* for T2, T3, T4 and T5 as compared to T1. Goats supplemented with T3 had higher (p<0.001*)* TDM and TCP intakes and CP digestibility, daily body weight gain compared to goats in T4 and T5. Therefore, it is recommended that supplementation with T3 is optimum combination that could be used to enhance production of goats under small-scale farming system. Further, since supplementation with higher level of khat leftover (T4 and T5) resulted in higher total DM and CP intakes and digestibility and growth performance compared to control goats, these treatments could also be considered as an alternative feeding strategies under smallholder farming systems.

Key words: digestibility, goats, intake, khat leftover (catha edulis)

INTRODUCTION

Ruminants' productivity in sub-Saharan African (SSA) is limited due to the low nutritive value of feeds available for the animals (Van soest, 1982). The most abundant feeds in sub-Saharan African are over mature natural grasses and crop residues which are limited both in quantity and quality during the dry season resulting in low growth (Preston T.R., 1995). It has been recognized that intake and utilization efficiency of tropical grasses are influenced by the rate of rumen fermentation (Van Soest, 1982) and the balance of nutrients absorbed in the intestine. Improvement in the nutritive value, removal of nutritional limitations to rumen fermentation, and a balanced supply of nutrients to host animals can result in improved animal productivity. Therefore, effective utilization of the available feed resources and appropriate supplementation of poor quality natural pasture and crop residue based diets appear to be the necessary step to alleviate the problem (Adugna *et al.*, 2000). The use of tree and shrub fodders have been used an alternative protein supplements for livestock fed on low quality diets (Le Houerou, 1980) indicating an enormous potential as a protein source for ruminants in tropics. These alternative feed resources provide nitrogen and digestible nutrients consequently improving intake, animal performance and digestibility, (Tanner *et al*., 1990). Furthermore, these plants are locally grown, easily available, and cheap thereby reducing the cost of production (Devendra, 1988). One of such feed resources in Ethiopia is khat (*Catha edulis*) leftover. Khat is perennial cash crop grown by the great majority of smallholder farmers in Eastern and Southern Ethiopia (Mulatu and Kassa, 2001).

Despite the daily use and consumption of khat by millions of people and khat leftover by livestock in Ethiopia and other countries, very little is known of the acceptability and nutritional constituents of khat for feeding livestock as sole diet or as a supplement. Fresh Khat leftover is considered as non-conventional feed with reasonable nutritive value such as better gross energy and calcium, moderate content of CP and *in vitro* organic matter digestibility (IVOMD). It has been demonstrated that feeding indigenous Ogaden bucks with fresh khat leftover resulted in higher body weight gain, body condition scores, testicular size, sperm production and sperm motility as compared to the native hay (Yoseph *et al*., 2007). However, adequate information on effective utilization of khat leftover in the diets of goats is not exhaustively studied and documented except few indicative studies (Mohammed, 2005; Yoseph *et al*., 2007 and Misganaw, 2009) that demonstrated its usefulness in goat nutrition. Therefore, the current study was designed to evaluate the effect of feeding concentrate, dried khat leftover or their mixture on feed intake, digestibility and body weight change of Hararghe Highland goats fed a basal diet of natural grass hay.

MATERIALS AND METHODS

The experiment was conducted at Kombolcha Agricultural Technical Vocational Education and Training College, Ethiopia, which is located at an altitude ranging from 1600 to 2400 meters above sea level between latitude 42˚0ʹ 0˝ E and longitude 9˚2ʹ 60˝ N. The annual rainfall ranges between 600 to 900 mm and the minimum and maximum temperature are 16ºC and 25˚C, respectively.

Experimental animals and management*:* Twenty-five yearly intact male growing Hararghe Highland goats with initial body weight of 17.8 ± 1.3 kg (mean ± SD) were purchased from a local market kombolcha, Ethiopia. Age of the animals was determined by their dentition and information obtained from the owners. The experimental animals were neck tagged for identification. Experimental animals were quarantined for 15 days during this time each animal were treated against internal (albendazol) and external (Ivermectin) parasites and vaccinated against ovine pasteurellosis based on the recommendation of a veterinarian. Experimental goats were housed individually in 1m x 1.25 m floor pens equipped with feeding and watering troughs. In addition, they were adapted to the experimental diets and site for another 15 days before the actual data collection.

Experimental design and treatments: The experiment involved five treatments and laid out in randomized complete block design (RCBD), for feeding, digestion and body weight change trails. Experimental animals were grouped into five blocks of five animals each based on the initial body weight which were determined by two consecutive weighing after overnight fasting. Before the start of experiment, goats were quarantine period of 15 days followed by another 15 day adaptability period to the experimental feeds. Treatments included feeding of natural grass hays alone *ad libitum* and natural grass hay supplemented with different proportion of dried khat leftover and concentrates mix. The concentrate feed consisting of 300gm dry matter (DM) and 55gm of crude protein (CP) on DM basis, was made up of a mixture of wheat bran and dried brewery grain at ratio of 2:1, respectively. Dietary treatments were prepared in such a way that CP from concentrate mix was substituted with CP from dried khat leftover at a ratio of 0, 33, 67 and 100% on DM basis. Common salt lick and clean water was offered to the animals' free of choice. Goats were offered native hay *ad libitum*, at 35% refusal, and adjusted every ten days based on the average feed consumed during the previous period. Supplementary diets were offered at 8:00 and 16:00 hour in two equal portions daily. Supplementary treatments (T2-T5) were estimated to supply 55 g CP to achieve estimated body weight gain of 50 g per day as recommended by Ranjhan (2001).

Table 1. Experimental Treatments

Treatment	Natural grass hay (basal diet)	Crude protein from khat leftover (KCP) (%)	Crude protein from concentrate mix (CMCP) (%)	Total CP (g)	Total supplement dry matter (g)
1	*ad libitum*	-	-	-	-
2	*ad libitum*	0	100	55	300.0
3	*ad libitum*	33	67	55	376.2
4	*ad libitum*	67	33	55	454.7
5	*ad libitum*	100	0	55	530.9

Feed preparation: The basal diet, mixed stand sward natural grass hay was harvested manually, sun dried for 2-3 days at the site, packed into sacs and stored under a shade until further use in the experiment. Before feeding, the basal diet, natural grass hay was chopped to about 4-6 cm length so as to minimize wastage and selection by

goats. Fresh khat leftovers were collected from kombolcha khat traders and were air dried for 5-6 days under shade by spreading on plastic sheets. Before starting the actual experiment, the dried khat leftover was sampled for moisture determination. Further, to avoid selective feeding, dried khat were crushed and woody parts were removed. Fresh wet brewer' grains required were purchased from Harar brewery factory and were sun dried on a plastic sheet. The plastic sheet was stretched out on a tilted area to ensure uniform drying and to avoid clumping. Samples of dried khat leftover, wheat bran and brewer's dried grain were analyzed for CP and DM. Concentrate was prepared by mixing ingredients in 2:1.

Chemical analysis: Representative samples of basal feed offered and refused after thoroughly mixing on daily basis and the concentrate per batch were collected over the experimental period and stored in plastic bags**.** At the end of the experiment samples of feed and refusal, both in the digestion and feeding periods and faecal samples were dried in an oven at 60°C for 72 hrs and ground in a Wiley Mill, to pass a 1 mm sieve screen and kept in airtight plastic bags pending analysis. Air dried feed subsamples were dried at 65ºc to constant weight in a forced draft oven for dry matter (DM) determination according to the standard procedures of AOAC (1990). Ash content was determined by igniting the DM residue at 550^0c for four hours in muffle furnace (AOAC, 1990). Organic matter was calculated as the difference between 100% dry matter and ash. Total nitrogen content was determined by macro-kjeldah1 method according to AOAC (1990) and the CP content was determined by multiplying the nitrogen value by a factor of 6.25. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analyzed according to the procedure of Van Soest and Robertson (1985).

Digestibility trial: Goats were adapted to the treatment feeds for 15 days which followed with adaptation to fecal collection bags (harness) for three days and total collection of feces done for seven days. Daily feces voided by each animal were weighed, recorded, thoroughly mixed and 10% representative was sampled and stored in deep freezer at -20ºC pending chemical analysis. The quantity of feces sampled daily was pooled over the experimental period for each animal.

Feeding trial: The feeding trial lasted for 90 days. For each experimental goat, the amount of feed offered and the corresponding refusals were recorded daily throughout the experimental period. Daily feed intake was measured as a difference between feed offered and refused. Samples of basal feed offered were collected weekly while the refusals of each animal were collected daily. Samples of feed offer and refusal were pooled per treatment, thoroughly mixed and sub sampled at the end of the experiment for chemical analysis. Metabolisable energy intake (ME) content of the feed was estimated as DOMI x 0.0157 using McDonald *et al.* (2002).

Body weight change and feed conversion efficiency: Body weight of each goat was measured at the beginning of the feeding trial and every ten days thereafter during the feeding trial. The record was taken in the morning after overnight fasting and before the morning feeding by using a spring weighing scale. The mean daily body weight change was calculated as a difference between the final body weight and initial body weight divided by the number of feeding days. Feed conversion efficiency (FCE) of experimental animals was determined as the total gain per DMI.

Statistical analysis: Data from the experiments was subjected to analysis of variances (ANOVA) by using the general linear model (GLM) procedure of statistical analysis system (SAS version 9.0) (SAS, 1999). Treatment means were separated using Tukey adjustment. The model used for feed intake, digestibility and body weight change were $Y_{ij} = \mu + t_i + b_j + e_{ij:}$ Where; Y_{ij} = response variable, μ = overall mean, t_i = treatment effect, b_j = the random effect of the i^{th} block and e_{ij} = residual error.

RESULTS

Chemical composition of treatment feeds*:* The chemical composition of the feeds used in this experiment was presented in Table 2. The CP content of the hay was lower (57.0g/kg DM), whereas that of the supplements were high and varied between (104.0g/kg DM) in khat leftover to 230.0g/kg DM in brewery dry grain. Khat leftover had lowest (397.1g/kg DM) NDF content, whereas the highest value of NDF (866.0g/kg DM) content was found in brewery dry grain, followed by grass hay (815.0g/kg DM). Among protein supplements, brewery grain had relatively high ADF content than the other two supplements, whereas the lowest quantity of this was obtained in wheat bran.

Body weight change: Goats supplemented with T2 and T3 had better performance in average daily body weight gain as compared to T1, T4 and T5. The highest daily body weight gain (61.3 g/d) was recorded in goats supplemented with concentrate alone (T2), followed by goats in T3 (55.7 g/d) (Table 5). Average daily body gain for goats in T2 and T3 supplemented were 22.6% and 11.4%, respectively higher than the expected weight gain of 50 g/ day, but goats supplemented with T4 and T5 were lowered by 15.6 and 44% than the daily gain of 50 g/day expected, respectively.

Nutrient digestibility: The apparent digestibility coefficient of DM and OM were higher ($p<0.001$) for goats supplemented with T2, T3, T4 and T5 than for

goats in T1, but there was no difference ($p<0.001$) among the supplemented goats (Table 3). Difference in CP digestibility was in the order of T1<T5=T4<T3=T2 ($p<0.001$), but apparent digestion coefficients of NDF and ADF were similar ($p<0.001$) among the treatments.

Dry matter and nutrient intake: The results indicate that the highest ($P<0.001$) basal hay DM intake was observed for the goats receiving T1 (Table 3). Goats supplemented with T2 had higher ($p<0.001$) basal natural grass hay DM intake than those supplemented with T3, T4 and T5. However, no significant differences were observed among the animals in the supplemented with T3, T4 and T5. Supplemented (T2-T5) goats consumed more ($P<0.001$) total DM and ME than the non-supplemented group. The supplement DM intake was in the order of T5<T4 <T2 <T3 ($P<0.001$), whereas total CP intake as percent of daily DM intake was in the order of T1 <T5 <T4 <T3 <T2 ($P<0.001$).

Table 2. Chemical composition of treatment feeds

Types of feed offered	g/kg DM						
	g/Kg DM	OM	CP	NDF	ADF	ADL	Ash
Natural pasture grass hay	9120.0	909.0	57.1	815.1	476.0	39.0	91.0
Brewery dry grain	9040.0	954.2	230.0	865.2	351.0	89.0	45.0
Wheat bran	900.0	954.2	160.0	417.0	110.1	22.2	46.0
Dry khat leftover	900.0	909.1	104.0	397.0	266.0	133.1	90.0

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

Table 5. Average growth parameters and feed conversion efficiency of Hararghe Highland goats fed natural grass hay and supplemented with concentrate, dried khat leftover or their mixtures.

Variables	Treatment						
	T1	T2	T3	T4	T5	SEM	SL
Initial BW (kg)	17.9	17.8	17.7	17.6	17.9	0.19	ns
Final BW (kg)	17.4^{d}	23.4^{a}	22.6^{ab}	21.7^{b}	20.5^{c}	0.52	***
ADG (g/d)	-5.6^{d}	61.3^{a}	55.7^{a}	42.2^{b}	28.4^{c}	5.9	***
FCE	-1.3^{b}	0.23^{a}	0.2^{a}	0.2^{a}	0.2^{a}	0.05	***

^{abcd} means within a row with different superscript letters are significantly different at *** = $p<0.001$; ADG =Average daily weight gain; FCE = Feed conversion efficiency; SL= level of significance; SEM = standard error of mean; ns = non significant; T1= natural grass hay alone; T2 = natural grass hay + CMCP-100%; T3 = natural grass hay + KCP-33% + CMCP-67%; T4 = natural grass hay + KCP-67% + CMCP-33%; T5 = natural grass hay + KCP-100%.

Table 4. Apparent nutrient digestibility coefficient of Hararghe Highland goats fed natural grass hay supplemented with concentrate, dried khat leftover or their mixtures.

Coefficient of digestibility	Treatment						
	T1	T2	T3	T4	T5	SEM	SL
DM	0.52^{b}	0.65^{a}	0.64^{a}	0.64^{a}	0.65^{a}	0.05	***
OM	0.54^{b}	0.67^{a}	0.67^{a}	0.65^{a}	0.66^{a}	0.02	***
CP	0.53^{c}	0.75^{a}	0.74^{a}	0.58^{b}	0.57^{b}	0.01	***
NDF	0.56	0.60	0.60	0.58	0.58	0.02	ns
ADF	0 .57	0.60	0.58	0.57	0.56	0.02	ns

^{abc}Means within row having different superscript letters are significantly different at *** = $p<0.00$; SL= Significant level; SEM= standard error mean; ns= non significant; ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM= dry matter; NDF = neutral detergent fiber; OM= organic matter; T1= natural pasture grass hay alone; T2 = natural grass hay + CMCP-100%; T3 = natural grass hay + KCP-33% + CMCP-67%; T4 = natural grass hay + KCP-67% + CMCP-33%; T5 = natural grass hay + KCP-100%.

Table 3. Dry matter and nutrient intake of Hararghe Highland goats supplemented with concentrate, khat leftover or their mixtures.

	Treatment						
Intake (g/day)	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**SEM**	**SL**
Hay DM	505.2^{a}	447.3^{b}	363.2^{c}	362.7^{c}	360.8^{c}	6.83	***
Supplement DM	-	300^{c}	376.2^{a}	327^{b}	277.2^{d}	8.90	***
Total DM	505.2^{d}	747.3^{a}	739.4^{a}	689.8^{b}	630.0^{c}	11.6	***
TDMI (g/kgBW$^{0.75}$)	58.3^{c}	77.5^{a}	77.1^{a}	75.2^{ab}	72.1^{b}	1.40	***
TDM (% BW)	2.8^{b}	3.6^{a}	3.6^{a}	3.5^{a}	3.4^{a}	0.07	***
ME (MJ/kg DM/d)	4.0^{c}	7.5^{a}	7.4^{a}	6.5^{b}	6.1^{b}	0.33	***
CP	28.7^{e}	80.5^{a}	75.7^{b}	57.7^{c}	43.8^{d}	1.26	***
NDF	410.2^{c}	532.9^{a}	486.7^{b}	438.7^{c}	424.8^{c}	21.53	***
ADF	240.5^{c}	261.6^{a}	264.8^{a}	249.4^{c}	240.9^{c}	7.71	***
Substitution rate	-	0.18^{b}	0.38^{a}	0.42^{a}	0.4^{a}	0.03	***

^{abc}Means in the same rows with different superscript differ at SL= Significant level, *** = p<0.00; SEM= standard error mean; ADF = acid detergent fiber; ADL = acid detergent lignin; CP= crude protein; DM= dry matter; NDF = neutral detergent fiber; OM= organic matter; T1= natural grass hay alone; T2 = natural grass hay + CMCP-100%; T3 = natural grass hay + K CP-33% + CMCP-67%; T4 = natural grass hay + K CP-67% + CMCP-33%; T5 = natural grass hay + K CP-100%.

DISCUSSION

Body weight changes: The final body weight, daily body weight change and feed conversion efficiency were higher (p<0.001) for the supplemented (T2-T5) group compared to the control treatment (T1). The highest daily body weight gain (61.3 g/d) was recorded in goats supplemented with concentrate alone (T2) in the present study was in agreement to the result of Asnakew (2005) who reported that a daily body weight gain of 63 g/day for the same breed of goats fed natural grass hay and supplemented with different proportion poultry litter inclusion. Abule *et al*. (1998) also showed that Arsi-Bale goats supplemented with 300 g concentrates gained more weight (62.2 g/day) compared to non supplemented ones. The extra weight gain obtained in goats supplemented with concentrate alone(T2) might be due to the fact that concentrate supplemented goats obtained optimum nutrient combinations (energy and protein as well as by-pass protein from brewery grain) for better microbial degradation of the feed, which resulted in further increased intake of the basal feed. It has been reported that concentrate feeds promote rapid growth in goats and cattle (McDonald *et al.*, 1996), reduce ruminal methane production and increase ruminal propionate production, thereby lowering energy losses and contributing to higher overall efficiency of utilization of dietary energy for body weight gain. Whereas the extra weight gain (11.4%) obtained than the expected value (50g/day) in goats supplemented with T3 might be due to positive associative effects of the high level of concentrate (CP-67%) and low level of khat leftover (CP-33%) supply that provided sufficient fermentable substrates to rumen microbes, enhancing their growth and protein synthesis and subsequently improving intake, digestibility and availability of microbial protein in the small intestine. According to Abdulraak *et al*. (2005) mixing high acacia pond and low dried acacia leaves presumably synchronized fermentability of all individual chemical constituents (especially nitrogen and carbohydrate) leading to associative effect in DM intake and digestibility, hence the difference in the weight gain. In support of this result, Mali goats supplemented with 30:70 *sesbania* and maize bran mixture (on DM basis), respectively gained maximum weight and had the highest intake as compared to the control and shown a declined in daily body weight gain and intake when supplemented at higher than 30% s*esbani*a (on DM basis) (Kanyama *et al.,* 1993). On other hand lower average daily gain obtained in goats supplemented with T4 and T5 might be due to the cumulative effect of lower feed DM, crude protein and ME intakes, CP digestibility, reduced microbial growth. This study showed that mixtures of different proportions of dried khat leftover and concentrate supplementation resulted in differences in daily body weight gain in goats. This indicates the importance of manipulating the ratio of these ingredients for a better animal performance. Thus, this study demonstrated that inclusion of dried khat leftover can replace concentrate up to 33% CP of the concentrate mix for optimum nutrient intake and average daily gain. The poor performance (-5.6 g/day) of the control group could be due to the fact that they did not meet their protein requirement because of the low CP(5.7%) and high NDF (81.5%) contents of the basal diet as well as low ME intake and low CP digestibility. This might have also attributed to low feed intake due to limits of the gastro intestinal tract and consequently reduced growth performance. Due to body weight loss, the control group had negative FCE (-1.3) and this was lower (P<0.001) than all the treatments. This indicated that supplemented goats were efficient in utilizing the nutrients for BW gain.

However, there was no significant difference in FCE among supplemented goats. Consistent with the present study, Hag and Shargi (1996) observed no significant difference in FCE among supplemented goats.

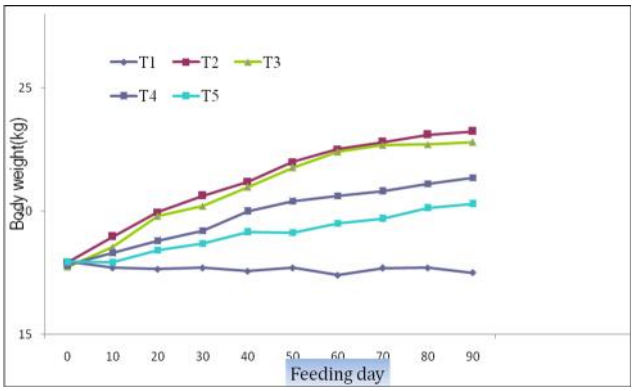

Figure 1: Trends in live weight changes over the feeding days of Hararghe Highland goats fed a natural grass hay and supplemented with concentrate, dried khat leftover or their mixtures.

T1= natural pasture grass hay alone; T2 = natural grass hay + CMCP-100%; T3 = natural grass hay + KCP-33% + CMCP-67%; T4 = natural grass hay + KCP-67% + CMCP-33%; T5 = natural grass hay + KCP-100%

The live weight of the experimental animals in the supplemented treatments increased through time with more prominent increase for goats supplemented with T2 andT3 than T4 and T5 (Figure 2). The pattern of body weight change is parallel to the trends of total DMI shown in Figure 1.

Apparent digestibility: The lower digestibility of DM, OM and CP in goats fed only natural grass hay (control) compared to all the supplemented goats (T2-T5) might be related to the low CP and high NDF content of the basal diet as well as low ME intake. The result in this study was consistent with the result of Mohammad (2005) who reported supplementation of Somali goats with different levels of fresh khat leftover (15, 30, 45 and 60 % on DM basis) increased DM, OM and CP digestibility and intake compared to basal diet sorghum stover. Alyon *et al.* (1998) also observed a similar increase in DM, OM and N digestibility with forage tree leaves supplementation to sheep fed star grass as a basal diet. This could be explained by the fact that feeds rich in protein content promotes high microbial population and facilitates rumen fermentation (McDonald *et al*., 2002). The better digestion coefficient of CP in T2 an T3 supplemented goats compared to control,T4 and T5 supplemented could be attribute to higher CP intake and better balance of dietary protein and energy in these groups. Hence, supplementation with T2 and T3 improves the accessibility of the cell wall component for better digestion by increasing the nitrogen content of feed. The lack of significant difference in digestibility ($P<0.001$) of NDF and ADF between the treatments in the present study was also in agreement to the result of McRae and Armstrong (1969) who reported that supplementation had little or no effect on digestibility of NDF and ADF. The lack of difference in fiber digestibility due to supplementation may be attributed to reduction in rumen PH which has a depressing effect on the population of fiber fermenting rumen microorganisms, as a result of feeding more digestible supplement to the animals.

Nutrient intake: The low total intake found in this experiment in T1 might be most likely due to the low level of CP and high NDF in the hay, as well as low CP digestibility. Increasing level of khat leftover in supplement diets did not cause significant difference in basal feed DM intake, implying the less likelihood of basal feed DM substitution with supplement DM at higher level of khat leftover supplementation as used in this study. However, increasing the dried khat leftover level in the supplement diet of goats resulted in reduced supplement DM intake in the order of T5<T4 <T3 due to appreciably refusal of the supplement diets offered to T4 and T5 supplemented goats. Lower intake of supplement DM in T4 and T5 supplemented goats than in those supplemented with T3 (Table 3) manly was reflection of the low nutritive value of the protein supply to the animals from khat leftover. Lower intakes of CP in T4 and T5 supplemented goats might be have reduced rumen NH_3-N supply leading to lower rate of rumen fermentation that could have reduced voluntary feed intake. This agrees with the report of Miganaw (2009) that reported appreciable refusal of dry khat leftover occurred by the similar breed of goats when supplemented with dry khat leftover at 1.5% body weight on DM basis. The mean daily total DM and CP intakes increased ($p<0.001$) with increasing level of khat leftover up to 33% CP from khat leftover in T3, but they declined ($p<0.001$) at 67% CP from khat leftover level in T4, and was lowest ($p<0.001$) in animal supplemented with khat leftover alone(T5). The improvement in dry matter (DM), crude protein, neutral detergent fiber and ME intakes with T3 might be due to positive associative effects of the high level of concentrate (CP-67%) and low level of khat leftover (CP-33%) that provided sufficient fermentable rumen substrates(NH_3-N) and subsequently improving intake and digestibility. According to Abdulraak *et al.* (2005) mixture of high acacia ponds with low acacia leaves supplementation presumably synchronized fermentability of all individual chemical constituents (especially nitrogen and carbohydrate) leading to associative effect in DM intake and digestibility, hence the difference in the weight gain. The higher CP intake ($p<0.001$) for goats supplemented with T2 as compared to those supplemented with T3 could be a function of the higher hay DM intake due to the fact that concentrate

supplemented goats obtained optimum nutrient combinations (energy and protein as well as by-pas protein from brewery dry grain) for better rumen microbial. This could lead to an increase in microbial population and efficiency, thereby facilitating the rate of breakdown of the digesta which eventually leads to increment intake of the basal feed. The higher NDF intake for goats supplemented with T2 than the other supplemented goats with T3, T4 and T5 could be a function of the higher concentrate and hay DM intakes as well as higher NDF content of the hay and brewery grain. The similarity in ADF intake among supplemented goats with T2 and T3 despite variations in these constituents in the supplements could be justified by the low content of ADF in khat leftover and low intake of hay DM in T3 supplemented goats. Intake of total DM was similar between the T2 and T3 supplementation, despite significant difference ($p<0.001$) in supplement DM intake. This was due to reduced intake of natural grass hay DM with T3 intake which was indeed significant difference (($p<0.001$) between T2 and T3 offers. The total DM intake of the supplemented goats (630.04 -747.3 g/d) obtained in the current study was in consistent with that reported by Asrat *et al*. (2008) who found a total DM intake in a range of 631- 738.4 g/d/h in intact yearly male Hararghe Highland goats fed natural grass hay and supplemented with different levels of poultry litter inclusion. However, total dry matter intake of Sidama goats fed natural pasture grass hay and supplemented with different levels of cottonseed meal study was lower than the total dry matter intake reported in the present study (Matiwos, 2007). The total DM intake as percentage of body weight in present study falls within the range of 2.5% to 3.9% of BW reported for various breeds of goats in the tropics (Devendra and Burns, 1983), but higher than the value reported by Asnakew (2005) for Hararghe Highland goats.

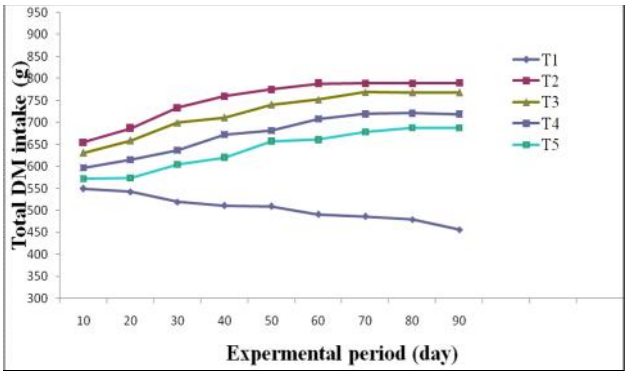

Figure 2: Trends of DM intake (g/d) over the feeding period of Hararghe Highland goats fed diet of natural grass hay and supplemented with concentrate, dried khat leftover or their mixtures.

T1= natural grass hay alone; T2 = natural grass hay + CMCP-100%; T3 = natural grass hay + KCP-33% + CMCP-67%; T4 = natural grass hay + KCP-67% + CMCP-33%; T5 = natural grass hay + KCP-100%

Total DM intake showed an increment for all supplemented goats throughout the feeding period as compared to control (Figure 1). Among supplemented animals, goats supplemented with T2 and T3 maintained the highest total DM intake throughout the feeding period compared to goats supplemented with T4 and T5.

Conclusion: Results of this experiment suggested that concentrate, khat leftover or their mixtures supplemented to natural grass hay improved total DM, CP and ME intakes, DM, OM and CP digestibility as well as animal performance. Among supplemented goats, goats in T2 and T3 might have better impact on total DM, CP, ME and ADF intakes, CP digestibility and growth performance of animals than supplementing the sole khat leftover(T5) or T4. Thus, it is recommended that supplementation with T3 is optimum combination that could be used to enhance production of goats under small-scale farming system. Further, since supplementation with higher level of khat leftover (T4 and T5) resulted in higher total DM and CP intakes and digestibility and growth performance compared to control goats, these treatments could also be considered as an alternative feeding strategies under smallholder farming systems.

Acknowledgement: I would like to acknowledge Oromia Bureau of Agriculture for sponsoring the study. My sincere gratitude goes to Kombolcha ATVET College for facilitating materials and allowing study site for this study.

REFERENCES

Abule, E., S. Amsalu and A. Tesfaye (1998). Effect of level of substitution of lablab (*Dolicos Lablab*) for concentrate on growth rate and efficiency in post weaning goats. In: Proceeding of the 6th Ethiopian Society of Animal Production (ESAP) conference held on 14-15 may 1998, ESAP, Addis Ababa, Ethiopia. PP. 264-269.

Abdulrazak, S. A., E. G. Njuguna and P. K. Karau (2005). The effect of supplementing Rhodes grass (*Chloris gayana*) hay with Acacia tortilis leaves and pods mixture on intake, digestibility and growth performance of goats. Department of Animal Science, Egerton Univesity Kenya. 5-7pp.

Adugna, T., C. Roger, L. Arthur, Goetsch, S. Tilahun, and N. Tegene (2000). Nutritional constraints and future prospects of goat production in east Africa. In: R. C. Merkel, G. Abebe and A. L. Goetsh (eds.). The opportunities and challenges of enhancing goat production in East Africa. Proceeding of conference

held at Debub University, Awassa, Ethiopia from November 10-12, 2000. E. (Kika) dela Garza Institute for Goat Research, Langston University. Langston, Ok. PP. 43-47.

Alayon, J., L. Ramirez-Aviles, and J. Ku-Vera, (1998). Intake, rumen digestion, digestibility and microbial nitrogen supply in sheep fed Cynodon nlemfuensis supplemented with Gliricidia sepium. Agro-for. Syst. 41: 115-126.

AOAC (Association of Official Analytical Chemists), (1990). Official method of analysis.15th ed. AOAC Inc., Arlington, Virginia, USA. pp. 12-98.

Asnakew, A., (2005). Feedlot fattening performance and carcass characteristics of intact male Hararghe highland goats fed different levels of hay to concentrate rations. An MSc. Thesis Presented to the School of Graduate Studies of Alemaya University. Haramaya, Ethiopia. pp. 45-65.

Asrat, G, T. Berhan, and M. Solomon (2008). Inclusion of different proportions of poultry litter rations of yearlying Hararghe Highland goats. Etiopia, J. Anim. Nutrition.20(3), 20-30 pp.

Devendra, C. and M. Burns (1983). Goats' production in Tropics. Farnhan Royal. Common wealth Agricatural Bureaux (CAB). Farnham, Slough. UK. 53-60 pp.

Devendra, C. (1988). Forage supplements: Nutritional significance and utilization for drought, meat and milk production in buffaloes. India J. Agric. Res. 2:409-423pp.

M., G., EI. and K., M., EI. Shargi (1996). Feedlot performance and carcass characteristics of local (Dhofari) and exotic (Cashmere) goats fed on a high-fiber by-products diet supplemented with fish sardine. Rumais Livestock Research Station. Ministry of Agriculture and Fisheries. Muscat. pp. 391-395.

Kanyama, G.,Y., C., Powell and M. Gill (1993). The effect of levels of supplementation with sesbania sesban foliage on intake and live weight changes in goats. J. Agriculture Sciences Agriculture Sciences. Bunda College of Agriculture Malawi. 118-119p.

Le Houerou, H. N. (1980). Browse in Northern Africa. In: Le Houerou, H. N. (Ed.), Browse in Africa, The current Statebof Kno ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia, pp. 55-80.

Matiwos, S. (2005). The effect of different levels of cottonseed meal supplementation on feed intake, digestibility, live weight changes, and carcass parameters of Sidama Goats. An MSc. Thesis Presented to the School of Graduate Studies Haramaya University. Haramaya, Ethiopia, pp. 1-53.

McRae, J. C. and G. D. Armstrong (1969). Studies on intestinal digestion in the sheep. Digestion of some carbohydrate constituents in hay, cereal and hay-cereal rations. Bri. J. Nutri. 23: 377-387.

McDonald, P, R .A. Eawards, J. F. D. F. Greenhalgh and C. A. Morgan (1996). Animal Nutrition. Longman Scientific and Techn Harlow, UK.

McDonald P, R. A. Eawards, J. F. D. Greenhalg and C. A. Morgan (2002). Animal nutrition. 6th edition, Copy right Licensing Agency Ltd., 90 Tottenham Court Road, London. pp. 29-590.

Misganaw, W. (2009). Effect of feeding different forms of khat leftover on feed intake, nutrient digestibility and growth performance of Haraghe Highland goats. An MSc Thesis Presented to School of Graduate Studies of Haramaya University. Haramaya, Ethiopia, 30-40 pp.

Mohammed, I. (2005). Effect of feeding different levels of Khat (*Catha Edulis*) left over on feed intake, and Growth performance of Goats fed on Sorghum Stover. An. MSc Thesis Presented School of Graduate Studies of Alemaya University of Agriculture, Haramaya, Ethiopia. 10-32 pp.

Mulatu, E. and H. Kassa (2001). Evaluation of Smallholder Mixed Farming system: Hararghe Highlands of Ethiopia: The shift towards trees and shrubs. In: J. sustainable agriculture, 18(4).5-11pp.

Preston, T.R. (1995). Tropical Animal Feeding. A Manual for Research Workers. FAO Animal Production and Health Paper 126. FAO (Food an Agriculture Organization), Rome, Italy.

Ranjhan, S. K., (2001). Animal nutrition in the tropics. 5th revised edition Vikas Publishing House P. Ltd. New Delhi, India. pp. 15-243.

SAS (Statistical Analysis System), (1999). Statistical analysis system institute Inc., NC. USA.

Tanner, J. C, J. D. Reed and E. Owen (1990). The nutritive value of fruits (pods with seeds from four Acacia species compared with extracted noug (Guizotia abyssinica) meal as supplements to maize stover for Ethiopian highland sheep. Animal production 51:127-133.

Van Soest, P. J. (1982). Nutritional Ecology of the Ruminant. O. and B. Books Inc. Corvallis, Oregon USA. pp.154-220 Van.

Van Soest, P. J. and J. B. Robertson (1985). Methods of dietary neutral detergent fiber and non- starch polysaccharide in ration of animal nutrition. J. Dairy Science 74:3583.

Yoseph, M., A. Tegegne, and H. Rodriguez-Martinez1 (2007). Feed Intake and Sperm Morphology in Ogaden Bucks Supplemented with Either Agro-industrial By-products or Khat (*Catha edulis*) Leftover. Division of Reproduction, Department of Clinical Sciences, Faculty of Veterinary Medicine and Animal Science, Swedish University of Agricultural Science (SLU), Sweden. 2-5 pp.