Effects of Supplementing Leaves of Desert Date (*Balanites aegyptiaca*), Maize Grain and their Mixture on Growth Performance and Economic Return of Indigenous Goats Fed a Basal Diet of Native Pasture Hay

Nigatu Dejene[1]*, Mohammed Beyan[2], and Yoseph Mekasha[3]

[1]Office of Agriculture, Mirab Abaya District of Gamo Zone, P. O. Box 500, Ethiopia
[2]School of Animal & Range Sciences, P. O. Box 05, Hawassa University, Ethiopia
[3]Agricultural Transformation Agency (ATA), P. O. Box 708, Addis Ababa, Ethiopia

Abstract: This study was conducted to evaluate the effect of supplementing leaves of desert date *(Balanites aegyptiaca),* maize grain and their mixture on growth performance and economic return of indigenous goats fed on a basal diet of natural pasture hay. Twenty intact indigenous goats with ages 8-10-months and an average initial body weight of 16.13±1.17kg (Mean± SD) were used in the study. The experimental animals were acquired from volunteer goat producers at Fetele Doronje *kebele*, Mirab Abaya district of Gamo Zone, southern Ethiopia. The animals were blocked into five blocks with a block containing four kids. The kids were randomly assigned to one of the four treatments within a block allowing five bucks per treatment feeds. Dietary treatments consisted of feeding natural pasture hay *ad libitum* (T1); natural pasture hay *ad libitum* supplemented with 200g maize grain (T2); natural pasture hay *ad libitum* supplemented with 200g dried leaves of desert date (T3), and natural pasture hay *ad libitum* supplemented with mixture of 200g of dried leaves of desert date and maize grain at 1:1 ratio (T4) on dry matter (DM) basis. 50 g wheat bran was added to all animals to satisfy the maintenance requirement of the control group. The total DM intake in the current study was higher ($p<0.001$) for the supplemented group than the control ones. The result showed that supplementing goats with maize grain, desert date and their mixture (T2-T4) attained ADG of 48.7, 48.9 and 66.8g/day for T2, T3 and T4, respectively as compared to the control (33.2g/day). However, among the supplemented groups, goats fed on T4 diet gained superior ($p<0.001$) ADG than goats fed on T2 and T3 diets. Moreover, supplementing indigenous goats with desert date, maize grain and their mixture relatively improved the return compared to the control group. The partial budget analysis further revealed that T4 was more profitable as compared to other supplementary treatments. Therefore, supplementing growing goat kids with T4 could be recommended to smallholder goat producers in the study area for better animal performance and profitability.

Keywords: *Average daily gain, Dry matter, Economic return, Supplement*

Introduction

Ethiopia possesses about 32.7 million goat population with diverse breed types that are distributed across all parts of the country (Solomon *et al.,* 2014; CSA, 2017/18). The country accounts for 7.2% of African and 2.6% of the global goat population (FAOSTAT, 2015) that puts the country eighth among the top ten countries in the world and third in Africa next to Nigeria and Sudan (FAOSTAT, 2013).

Goats possess unique abilities to adapt harsh tropical environments and are closely associated with resource-poor households often found in marginal and harsh environments. In such area, investments in improving goat productivity can contribute to livelihood and the food security of producers in equitable ways (Homann *et al.,* 2007; Solomon *et al.,* 2014). However, the productivity per unit of animal and the contribution of the sector to the national economy is relatively low due to poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system (Tesfaye, 2009).

In the arid and semi-arid parts of Gamo Zone where the amount of rainfall is insufficient and its distribution is seasonal, food crops usually fail to grow at the young stage. However, goat rearing becomes an important form of livelihood compared to other farming activities in these areas, and the sector is an alternative and preferred strategy to fulfill family needs and generate income in moisture stress areas. Nonetheless, the goat production is inefficient due to lack of access for improved feeds such as concentrate and poor-quality basal diet. It is, therefore, important to look for alternative and locally available feed sources that improve the performance of goats. On the other hand, there has been massive campaigns underway on natural resource conservation and watershed development by the government in Ethiopia including Gamo Zone. Consequently, the watersheds have been enclosed and protected from humans and livestock for the last few years. Hence, this gives an opportunity to use the feed

*Corresponding Author. E-mail: nigatud1987@gmail.com

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resources from the enclosed areas (mainly grasses and browses) in a form of cut and carry and conserved hay.

Desert date, which is locally known as *Bedena*, is one of the dominant browse species commonly available in the lowlands of Gamo Zone of Southern Ethiopia. The leaves of desert date are used for livestock feed mainly during dry season when other feed resources become scarce. Desert date contains moderate crude protein (15.2%) and could serve as good supplement for goats (Belete *et al.,* 2012). However, though, the enclosures can be used as a source of roughage feeds, it cannot provide the required nutrients for optimum growth performance of goats. Besides, due to lack of access and higher prices, smallholder farmers could not supplement goats with commercial concentrate. Although the production and productivity of food grains is limited due to insufficient amount and distribution of rainfall in the area, maize (*Zea mays*) is produced widely and could serve as energy supplement for growth performance of goats. It is, therefore, envisaged that feeding the combination of maize and desert date have a positive effect on growth performance and economic return of goats. Hence, the objective of this research was to evaluate the effect of supplementing desert date, maize grain and their mixture on growth performance of indigenous goats and its economic feasibility in the study area.

Materials and Methods

Description of the Study Area

The study was conducted in Mirab Abaya district of Gamo Zone of SNNPRS of Ethiopia, which is located at 463 km south of Addis Ababa. It has 23 rural peasant association (PA) administrations and has a total land of 107,971 hectares. The district is situated between 1200 and 2500 m.a.s.l (Yilkal, 2015). Its latitude and longitude are 6^0N and 37^0E, respectively (ODLFRD, 2020). The district is divided into three agro-ecological zones, namely, *Dega* (2300-3200masl), *Woina Dega* (1500-2300masl) and *Kolla* (500-1500masl) which account for about 11%, 27% and 62% of the total area, respectively. The rainfall regime in the district is bimodal. The first round of rain occurs between March and May and the second from June to August (Yilkal, 2015). The annual rainfall distribution varies between 800-1600mm; the average minimum and maximum temperature is 23 and 25 °C, respectively. The district has 58,613 cattle; 7,573 sheep; 33,398 goats; 2,825 donkeys; 384 mules; 167 horse and 73,864 chickens (ODLFRD, 2020). The map of the study area is presented in figure 1.

Household Selection

Fetele Doronje PA community-based goat breeding cooperative of Mirab Abaya district was selected purposively based on goat population. Five voluntary farmers who were experienced in goat rearing, and able to contribute four uniform kids each were selected from this breeding cooperative randomly for the study.

Experimental Feed Preparation

The experimental feed consisted of a basal diet of natural grass hay supplemented with the leaves of desert date, cracked maize grain and their mixture. The natural grass hay was collected from enclosure area, and the leaves of desert date was collected from the farmer's farm. The collected leaves of desert date were dried under shade before packing in the sacks. The maize grain and wheat bran were purchased from the district town. The maize grain was cracked by shredder, which was introduced and demonstrated to smallholder livestock producers by LIVES project.

Experimental Animal Selection and Management

Twenty intact indigenous kids aged 8 to 10 months with an average initial body weight of 16.13±1.17kg (Mean± SD) were contributed by volunteer smallholder producers. The age of the kids was determined based on the information from producers and by dentition (Solomon and Kassahun, 2009). Prior to actual study, the experimental animals were vaccinated for commonly known small ruminant diseases in the study area such as pest des petit ruminants (PPR), contagious caprine pleuropneumonia (CCPP) and ovine pasteurellosis, and also treated with Fenbendazole and Ivermectin against internal and external parasites, respectively. The kids were provided with plastic tags as neck collars for the ease of identification and allowed to adapt the treatment feeds for about 15 days before the actual 90 days' experimental period.

Experimental Design and Treatments

The experiment was arranged using a randomized complete block design (RCBD). The number of producers participated in the trial were five, and each of them contributed four kids according to the number of treatments. Thus, each of the five participant producers served as a block. In each block, dietary treatments were randomly allocated to the four kids independently. Initial body weight of kids was used as covariate to adjust final measurements. The treatments consisted of feeding natural grass hay *ad libitum* supplemented with 50g wheat bran (T1; positive control); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g cracked maize grain (T2); feeding natural grass hay *ad libitum* supplemented with mixtures of 50g wheat bran and 200g dried leaves of desert date (T3), and feeding natural grass hay *ad libitum* supplemented with 50g wheat bran, and mixture of 200g of dried leaves of desert date and cracked maize grain at 1:1 ratio (T4). The quantity of supplements provided was on dry matter basis. The supplement was offered at 17:00 hour. The basal feed was provided in such a way that it consists of 15% refusal. When the amount of refusal was less than 15%, it was adjusted on weekly basis. All animals had free access to mineral (Bole) lick and water.

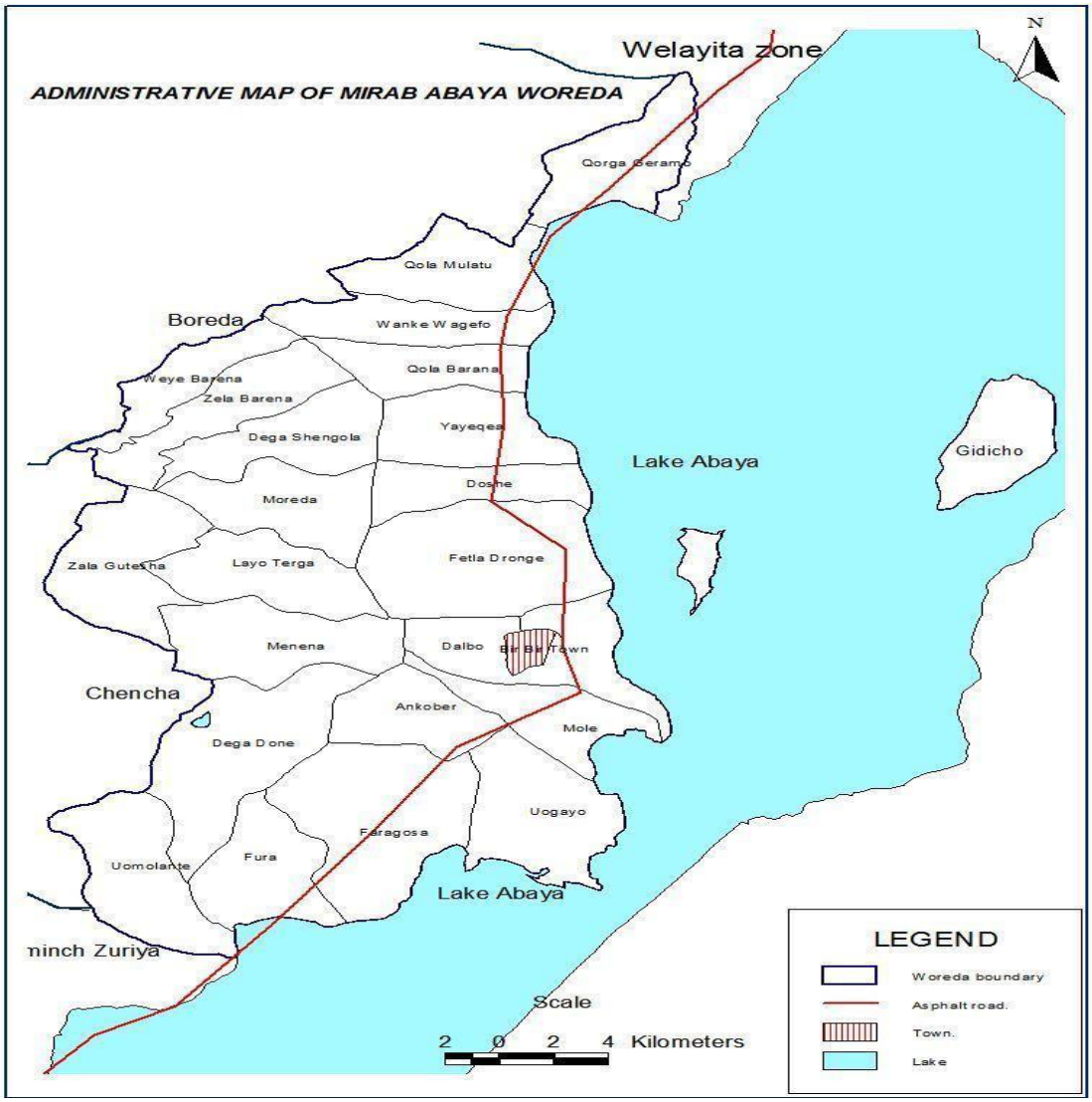

Figure1. Map of Mirab Abaya district of Gamogofa Zone, southern Ethiopia.

Feed Intake

Daily feed offered and refusal of each kid were measured and recorded throughout the experimental period to assess the daily feed intake. Daily feed intake of the individual kids was recorded as a difference between the feed offered and the refusal. Feed samples of test feeds were taken before feeding separately while refusals were collected and bulked on individual animal basis separately.

Body Weight Gain and Feed Conversion Efficiency

The animals initial body weight was determined by taking an average of two consecutive days' weight measurements after overnight withdrawal of feed and water. Live weight changes of the animals were measured at 15-day interval after overnight fasting. Average daily body weight gain was calculated as the difference between the final body weight and initial live weights of the kids divided by the number of experimental days. Feed conversion efficiency (FCE) was calculated by dividing average daily body weight gain by total average daily feed intake in dry matter basis.

FCE= ADG in g/ TDMI in g

Chemical Analysis of the Experimental Feeds

Chemical analysis of the experimental feeds and refusals was carried out at Hawassa University Animal Nutrition Laboratory. Prior to analysis, air dried feed samples were milled to pass through 1mm Willey mill sieve size and labeled for easy identification. The chemical analysis was run in duplicates. The DM, organic matter (OM) and ash contents of sample feed offered and refusal were analyzed according to the procedure of proximate method of AOAC (1990). The N content was determined by Kjeldahl technique and the crude protein (CP) content was calculated by multiplying N content with 6.25. Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were analyzed as described by Van Soest and Robertson (1985).

Partial Budget Analysis

Partial budget analysis was used to determine the profitability of the feeding regime (Upton, 1979). The purchasing cost of experimental feeds was recorded, and the market price of experimental kids at the beginning and at the end of the experiment was assessed in local animal market and estimated by experienced goat dealers of the area. In the analysis, the difference between the purchasing cost and selling prices of animals was considered as total return (TR). Net return (NR) was calculated by subtracting the total variable costs (TVC) or feed cost from the total return (TR).

$$NR = TR - TVC$$

The change in net return (ΔNR) was calculated as the difference between change in total return (ΔTR) and the change in total variable costs (ΔTVC).

$$\Delta NR = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) measures an increase in net return (ΔNR) associated with each additional unit of expenditure (ΔTVC), which is the difference among the three treatments excluding positive control and normally expressed as percentage. $MRR = \Delta NR/\Delta TVC * 100$.

Data Analysis

Data from the feeding trial was stratified into treatment and block and analyzed by using the General Linear Model procedure (GLM) in SPSS (2007). Initial body weight was considered as covariate in the analysis. When F-test declared significance at $p<0.05$, treatment means were separated by using the least significant difference. The statistical model used for the analysis of data from the feeding trial was:

$yijk= \mu + \alpha i + \beta j + b\ (FBW- IBW) + eijk$

Where: yij = the observation in the i^{th} treatment & j^{th} block;

μ = the overall mean;
αi = the i^{th} treatment effect (i=1-4);
βj = the j^{th} block effect (j=1-5);
b = linear regression;
FBW = final body weight;
IBW = initial body weight; and
eijk = the random error associated with yijk

Results and Discussion

Chemical Composition of Experimental Feeds

Chemical composition of feed stuff in the present study is presented in Table 1. The CP content of natural grass hay observed in the present study was lower than 6.23% reported by Birhanu *et al.* (2013). However, it is comparable with 5.5% reported for natural pasture hay in the central highlands of Ethiopia (Yoseph *et al.,* 2003). The NDF content of natural grass hay in the present study was lower than 80.9% reported for the same type of basal feed hay (Birhanu *et al.,* 2013). However, the CP content of natural grass hay in the current study was not sufficient to meet maintenance requirement of ruminants (Van Soest, 1994). Therefore, supplementation of natural grass hay with feeds that contain better nutrients is important to catalyze more efficient utilization of poor-quality roughages (Alemu, 2008).

The CP content of desert date evaluated in the present study lies within the range of 8.9% to 36.50% reported for different browse species (Nyako *et al.,* 2014). The CP content of desert date observed in the present study was comparable with the value 15.2% reported by Belete *et al.* (2012). However, the current result is higher than the finding 14.45% of Liman *et al.* (2016), but lower than 15.86% reported by Kubmarawa *et al.* (2008).

Table 1. Chemical composition of feedstuffs

Feed ingredients	Chemical composition					
	% DM					
	DM	OM	CP	NDF	ADF	ADL
Natural grass hay	94.5	85.4	5.28	64.6	63.0	11.4
Desert date	95.2	87.6	15.11	38.6	37.5	10.2
Maize grain	91.3	97.0	9.23	32.2	5.30	1.20
Wheat bran	92.4	94.4	14.12	36.2	13.4	3.70

DM= Dry matter; OM= Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ADL= Acid detergent lignin.

The ADF and ADL content of desert date in the present study were higher than 23.1% and 5.2%, respectively reported by Liman *et al.* (2016). On the other hand, the NDF value of the leaf of desert date in the present study was lower than 49.2% reported by the same author. The CP, NDF and ADF content of maize grain observed in the present study was comparable with 9.73%, 29.21% and 3.87%, respectively reported for the same feed by Guyo (2016). The CP content of wheat bran in the present study (14.12%) was lower than 17.5% reported by Neamn *et al.* (2014) and 17.4% reported by Endashaw *et al.* (2013). However, it is comparable with 13.8% reported by Tesfaye (2009). The variation in chemical constituents of the feeds might be due to difference in soil composition, agro-climate, stage of harvesting and processing methods.

Dry Matter and Nutrient Intakes

The mean daily DM and nutrient intakes of experimental kids fed basal diet natural grass hay supplemented with the leaf of desert date, cracked maize grain and their mixture is given in Table 2. The

DMI of the basal diet increased ($p<0.01$) in the order of T4 >T2>T3>T1. Among the goats involved in the current experiment, animals in T1 had low ($p<0.01$) hay DM intake. This is because voluntary feed intake declines in forages containing less than 7% CP (NRC, 2000). According to Lazzarini *et al.* (2009) optimum rumen function requires adequate amount of protein in the diet. The total DM intake in the current study was higher ($p<0.001$) for the supplemented goats than the positive controls.

The higher DMI in supplemented kids might be attributed due to higher nutrient content (CP) in the supplement as compared with kids in control which facilitates the digestion activity of microorganisms in the rumen. The low total DM intake for goats fed on the supplement (T3) as compared to T4 and T2 may be due to the higher ADF (36.6%) and ADL (9.7%) content, and the presence of anti-nutritional substance known as saponin in the leaf of desert date (Das *et al.,* 2012).

Table 2. Dry matter and nutrient intakes (g/day/head) of indigenous bucks fed natural grass hay basal diet supplemented with the leaves of desert date and maize grain

Parameter	Treatments				SEM	P-value
	T1	T2	T3	T4		
DM intake:						
Hay	432.6^{d}	452.7^{b}	444.7^{c}	455.5^{a}	2.15	$p<0.01$
Supplement	46.20^{d}	230.0^{c}	235.0^{a}	233.5^{b}	1.91	$p<0.001$
Total	478.8^{d}	682.7^{b}	679.7^{c}	688.9^{a}	2.99	$p<0.001$
Total OM intake	410.6^{d}	605.9^{a}	586.2^{c}	600.5^{b}	2.65	$p<0.001$
Total CP intake	30.3^{d}	48.5^{c}	57.8^{a}	56.2^{b}	0.28	$p<0.001$
Total NDF intake	292.0^{d}	361.9^{c}	364.6^{b}	369.1^{a}	1.59	$p<0.001$
Total ADF intake	276.4^{d}	299.9^{c}	362.0^{a}	340.8^{b}	1.57	$p<0.001$
Total ADL intake	49.1^{d}	54.5^{c}	72.2^{a}	63.8^{b}	0.33	$p<0.001$

$^{a-d}$ Means with different superscript letters in the same row differ significantly ($p<0.05$); SEM= Standard error of mean; T1= Natural grass hay ad libitum +50g wheat bran; T2= Natural grass hay ad libitum +200g maize grain + 50g wheat bran; T3= Natural grass hay ad libitum +200g dried leaves of desert date + 50g wheat bran; T4= Natural grass hay ad libitum + 200g of maize grain and leaves of desert date at 1:1 ratio + 50g wheat bran; DM= Dry matter; OM= Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ADL= Acid detergent lignin.

The result of the current study was in accordance with the report for Somali goats fed hay basal diet supplemented with Cactus and selected browses (Daniel *et al.,* 2014). Similar to the current study, previous study showed that the basal DM intake was low in non-supplemented sheep compared to the sheep supplemented with *Acacia alibidae* and *Acacia seyal* leaves (Neamn *et al.,* 2014).

Body Weight Change and Feed Conversion Efficiency

The current study showed that final body weight (FBW), body weight change (BWC), average daily gain (ADG) and feed conversion efficiency (FCE) of kids were positively affected by supplementation (Table 3). The highest average daily gain (66.7g/d) was recorded for kids supplemented with mixture of the leaves of desert date and maize grain (T4), followed by kids in T3 and T2 which were supplemented with maize grain and sole leaves of desert date, respectively. The higher body weight gain over the feeding period by supplemented goats might be attributed to better nutrient supply, higher feed digestibility, and metabolic efficiency of absorbed nutrients as compared with the control (T1).

Table 3. Mean body weight gain of indigenous kids fed natural grass hay supplemented with the leaves of desert date, maize grain and their mixtures

Parameter	Treatments				SEM	P-value
	T1	T2	T3	T4		
Initial body weight (kg)	16.0	15.9	16.2	16.4	0.26	0.924
Final body weight (kg)	19.12^{c}	20.51^{b}	20.53^{b}	22.14^{a}	0.38	0.007
Body weight change (kg)	2.99^{c}	4.38^{b}	4.40^{b}	6.02^{a}	0.27	0.000
Average daily gain (g)	33.24^{c}	48.72^{b}	48.94^{b}	66.86^{a}	2.98	0.000
FCE (g ADG/g TDMI)	0.069^{b}	0.072^{b}	0.072^{b}	0.097^{a}	0.003	0.001

$^{a-d}$ Means with different superscript letters in the same row differ significantly ($p<0.05$); SEM= Standard error of mean; FCE= Feed conversion efficiency; ADG= Average daily gain; TDMI= Total dry matter intake; T1= Natural grass hay ad libitum +50g wheat bran; T2= Natural grass hay ad libitum +200g maize grain + 50g wheat bran; T3= Natural grass hay ad libitum +200gm dried leaves of desert date + 50g wheat bran; T4= Natural grass hay ad libitum + 200g of maize grain and leaves of desert date at 1:1 ratio + 50g wheat bran.

The higher body weight gains for T4 compared to T3 indicates that the leaves of desert date have a better impact on body weight change of animals when mixed with energy sources such as maize grain. Similarly, FARM-Africa (2008) reported that the overall performance of goats grazing pasture and supplemented with *Prosopis juliflora* pods mixed with corn was higher compared to supplementing with *Prosopis juliflora* pods alone.

The ADG of goats observed in the present study was consistent with 66.4g reported by Dereje (2014) for sheep fed natural grass hay basal diet and supplemented with 300g mixture of concentrate and Tagasaste (*Chamaecytisus palmensis*) forage. However, the ADG of goats in T4 in the current study was higher than the range values 60.6 - 63.7g/day reported for Horro rams (Bahran, 2014). The ADG of kids in T3 of the current study was higher than 20.3 g/d ADG of Small East African goats fed *ad libtum* maize (*Zea mays*) stover supplemented with 10g of the leaves of desert date per kg metabolic weight reported by James *et al.* (2013).

The low BW of goats in T1 might be attributed to the lower total DM and CP intakes as compared to supplemented groups. The improved FCE in the supplemented groups as compared to the controls appeared to be related with higher nutrient concentration in the supplement feeds and the consequent increase in BWG and the ability of kids to convert feed efficiently to flesh. The finding was in accordance with the work of Ebrahimi *et al.* (2007) who noted that high protein and energy levels in the diet improves ADG and FCE of animals.

Partial Budget Analysis

Partial budget analysis helps the farmer or pastoralist to evaluate the economic feasibility in the small ruminant business and used to decide about the future use of new technology or practice (Adane, 2008). In the current experiment, the partial budget analysis was done to evaluate the smallholder farmers' profitability through supplementing kids with the leaves of desert date, maize grain and their mixture (Table 4). The result of partial budget analysis revealed that supplementing indigenous kids with desert date, maize grain and their mixture resulted relatively higher return as compared to kids in the control groups.

Table 4. Partial budget analysis of goats fed on natural pasture hay and supplemented with the leaves of desert date, maize grain and their mixture

Descriptions	Treatments			
	T1	T2	T3	T4
Purchasing price (ETB/buck)	480	480	490	490
Selling price (ETB/buck)	722	860	864	982
Cost of natural grass hay (ETB/buck)	187.2	195.3	191.7	196.2
Cost of wheat bran (ETB/buck)	24.75	24.75	24.75	24.75
Cost of maize grain (ETB/buck)	-	100.8	-	50.4
Cost of the leaf of desert date (ETB/buck)	-	-	90	45.0
Total variable cost/TVC (ETB/buck)	211.95	320.85	306.45	316.35
Total return/TR (ETB/buck)	242.0	380.0	374.0	492
Net return/ NR (ETB/buck)	30.05	59.15	67.55	175.65
Change in total variable cost/ΔTVC (ETB/buck)	-	100.8	90.0	95.4
Change in total return/ΔTR (ETB/buck)	-	138.0	132	250
Change in net return/ΔNR (ETB/buck)	-	37.2	42	154.6
Marginal rate of return /MRR (%)	-	36.9	46.7	162.1

T1= Natural grass hay ad libitum +50g wheat bran; T2= Natural grass hay ad libitum +200g maize grain + 50g wheat bran; T3= Natural grass hay ad libitum +200g dried leaves of desert date + 50g wheat bran; T4= Natural grass hay ad libitum + 200g of maize grain and leaves of desert date at 1:1 ratio + 50g wheat bran; ETB= Ethiopian Birr.

Although the net return was positive across all the treatments, it was higher for bucks supplemented with T4 (175.65 ETB) compared to the other treatments. The result of this study showed that per unit of expenditure could result in return of 0.37, 0.47 and 1.62 ETB per bucks for T2, T3, and T4, respectively. Therefore, supplementing the kids with mixture of desert date and maize grain (T4) was economically feasible because it returned high net return than the other treatments.

Conclusion

This study showed that supplementing goats with desert date, maize grain and their mixture of the two improved ADG (48.7 to 66.8 g/day) as compared to the control (33.2g/day). Furthermore, the partial budget analysis confirmed that T4 was more profitable as compared to other supplementary treatments. Therefore, it is concluded that supplementing growing kids with desert date and maize grain at 1:1 ratio as in T4 could be recommended for smallholder goat producers for better performance and profitability of goats in the region.

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Conflict of Interests

The authors declare that they have no competing interests.

References

Adane Hirpa (2008). Sheep and goat economics of production and marketing. In: Alemu Yami and R. C. Merkel (eds.), Sheep and goat production handbook for Ethiopia, Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), pp: 302-303.

Alemu Yami (2008). Nutrition and feeding of sheep and goats. In: Alemu Yami and R.C. Merkel (eds.), Sheep and goat production handbook for Ethiopia, Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), pp: 118-121.

AOAC (Association of Official Analytical Chemists). (1990). Official methods of the analysis, 15th ed., AOAC, Arlingston, Virginia, USA, pp: 1298.

Bahran Fikrae (2014). Effect of cassava leaf meal substitution on feed intake, digestibility, body weight gain and carcass parameters in Horro yearling sheep, MSc Thesis, Haramaya University, Ethiopia.

Belete Shenkute, Hassen, A., Assafa, T., Amen, N. & Ebro, A. (2012). Identification and nutritive value of potential fodder trees and shrubs in the mid Rift Valley of Ethiopia. *Journal of Animal & Plant Sciences,* 22 (4): 1126-1132.

Birhanu Tesema, Getachew Animut & Mengistu Urge (2013). Effect of green *Prosopis juliflora* pods and Noug seed *(Guizotia obissynica*) cake supplementation on digestibility and performance of Blackhead Ogaden sheep fed hay as a basal diet. *Science, Technology and Arts Research Journal,* 2 (2): 38-47.

CSA (Central Statistical Agency) (2017/18). Federal Democratic Republic of Ethiopia Central Statistical Agency agricultural sample survey, volume II, report on livestock and livestock characteristics, statistical bulletin 587.

Daniel Taddesse, Solomon Melaku & Yoseph Mekasha. (2014). Effect of supplementation of cactus and selected browses mix on feed utilization of Somali goats. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS),* 9 (1): 24-25.

Das, T. K., Banerjee, D., Chakraborty, D., Pakhira, M. C., Shrivastava, B. & Kuhad, R. C. (2012). Saponin: Role in animal system. *Veterinary World,* 5 (4): 248-254.

Dereje Kebede (2014). Evaluation of tagasaste (*Chamaecytisus palmensis*) forage as a substitute for concentrate in diets of sheep fed natural pasture hay, MSc Thesis, Haramaya University, Ethiopia.

Ebrahimi, R., Ahmadi, H. R. Zamiri, M. J. & Rowghani, E. (2007). Effect of energy and protein levels on feedlot performance and carcass characteristics of Mehraban ram lambs. *Pakistan Journal of biological Science*, 10 (10): 1679-1684.

Endashaw Terefe, Yibra Yaqob, Kidanie Dessalegn, Abebe Tafa, Ashebir Kifle, Weldegebrel Gebregziabher & Weldegebrel Tesfamariam (2013). Market weight and carcass characteristics of intact yearling afar goats under semi-intensive feeding management. *International Journal of Livestock Production,* 4 (6):95-101.

FAOSTAT (2013). Food and Agricultural Organization of the United Nations.

FAOSTAT (2015). Food and agricultural organization of the United Nations, statistical division.

FARM-Africa (2008). The Afar prosopis management project, August 2008 to December 2011, proposal document FARM-Africa, submitted to the Development Fund (Norway), 6th June 2008, pp: 8.

Guyo Demisse Anno (2016). Assessment of fattening and marketing system, and effect of concentrate supplementation with locally available feeds on fattening performance of indigenous cattle in Bonke district of Gamogofa Zone, MSc Thesis, Hawassa University, Hawassa, Ethiopia, pp: 28 & 49.

Homann, S., van Rooyen, A., Moyo, T. & Nengomasha, Z. (2007). Goat production and marketing: Baseline information for semi-arid Zimbabwe, International Crops Research Institute for the Semi-Arid Tropics, Matopos Research Station, Bulawayo, Zimbabwe, p: 84.

James Ombiro Ondiek, Ogore, P. B., Shakala, E. K. & Kaburu, G. M. (2013). Feed intake, digestibility and performance of growing small East African goats offered maize (*Zea mays*) stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages. *Basic Research Journal of Agricultural Science and Review*. 2 (1): 21-26.

Kubmarawa, D., Andenyang, I. F. H. & Magomya, A. M. (2008). Amino acid profile of two non-conventional leafy vegetables, *Sesamum indicum* and *Balanites aegyptiaca*. *African Journal of Biotechnology*, 7 (19): 3502-3504.

Lazzarini, I., Detmann, E., Sampaio, C. B., Paulino, M. F., Filho, V., Augusto de Souza, M. & Albani, F. (2009). Intake and digestibility in cattle fed low quality tropical forage and supplemented with nitrogenous compounds. *Revista Brasileira de Zootecnia*, 38: 2021-2030.

Liman, A. A., Malgwi, I. H., Nyako, H. D., Ardo, B. A., Mohammed, I. D., Yahya, A. A., Antiev, M., Zarah A. I., Yahya, M. M. & Abdullahi, S. (2016). Nutrient evaluation and degradation characteristics of some

browse plants in Taraba State, Nigeria. *International Journal of Information Research and Review*, 3 (1): 1612-1617.

Neamn Gebreselassie, Getachew Animut & Mengistu Urge (2014). Effect of supplementation with dried Leaves of *Acacia albida*, *Acacia seyal* and their mixture on feed intake and digestibility of local sheep fed barley straw as a basal diet. *Journal of Fisheries and Livestock Production*, 3: 125.

NRC (National Research Council) (2000). Nutritional requirement of beef cattle, 7th ed., National Academy Press, Washington, D.C.

Nyako, H. D., Kibon, A., Magaji, M. Y. & Abdullahi, S. (2014). Chemical composition and rumen degradability of forages browses, crop residues and agricultural by-products in Adamawa State. *39th Conference of Nigerian Society for Animal Production*, 16-19 March 2014, Babcock University, Ilesha-Remo, Ogun State, Nigeria.

ODLFRD (Office of District Livestock and Fish Resource Development) of Mirab Abaya district. (2020). Annual work plan.

Solomon Abegaz & Kassahun Awgichew (2009). Estimation of weight and age of sheep and goats. In: Alemu Yami, T.A. Gipson & R.C. Merkel (eds.), Sheep and goat production handbook for Ethiopia, Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), *Technical Bulletin* No 23, pp: 8 & 9.

Solomon, A. K., Mwai, O., Grum, G., Haile, A., Rischkowsky, B. A., Solomon, G. & Dessie, T. (2014). Review of goat research and development projects in Ethiopia, ILRI Project Report, Nairobi, Kenya: International Livestock Research Institute, p: 28.

SPSS (Statistical Package for Social Sciences) (2007). SPSS version 16.0 for windows.

Tesfaye Tsegaye (2009). Characterization of goat production systems and on-farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metema *woreda*, Amhara Region, MSc Thesis, Haramaya University, Haramaya, Ethiopia, pp: 108.

Upton, M. (1979). Farm management in Africa: The principle of production and planning, Oxford University Press, UK, pp: 282-298.

Van Soest, P. J. & Robertson, J. B. (1985). Analysis of forages and fibrous foods: Laboratory manual for animal science, vol. 613, Cornel University, USA, p: 202.

Van Soest, P. J. (1994). Nutritional ecology of ruminant, 2nd ed., Cornell University Press, London, pp: 476.

Yilkal Tadele (2015). Small ruminant production and marketing: Constraints and opportunities in Chencha and Mirab Abaya districts, Southern Ethiopia. *World Journal of Biology and Medical Sciences,* 2 (1): 14-32.

Yoseph Mekasha, Azage Tegegne, Alemu Yami, Umunna, N. N. & Nsahlai, I.V. (2003). Effects of supplementation of grass hay with non-conventional agro-industrial by-products on rumen fermentation characteristics and microbial nitrogen supply in rams. *Small Ruminant Research,* 50 (1-2): 141-151.