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Effects of Substitution of Concentrate Mixture with Dried Moringa (*Moringa Stenopetala*) Leaves on Feed Intake, Digestibility and Body Weight Gain of Woyto-Guji Goats

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Abstract: The study was carried out at Arbaminch Agricultural research center, Gamo Gofa zone, Ethiopia, using twenty five intact male yearling Woyto-Guji goats. The objective of the study was to evaluate the effect of dried moringa leaf substitution to concentrate mixture on feed intake, digestibility and body weight gain of Woyto-Guji goats and to assess the economic benefit of dried Moringa leaf substitution. The experimental design was randomized complete block design. Goats were blocked into five block based on their initial body weight (BW) and randomly assigned to one of the five treatments. The experiment consisted of 90 days of feeding trial and 7 days of digestibility trial. The five dietary treatments used were100% concentrate mixture (CM) consisting of wheat bran (57%), noug (*Guizota abyssinica*) seed cake (23%), maize (19%) and salt (1%) [T1]; 75% CM+25% dried *moringa stenopetala* leaf (DMSL) [T2]; 50% CM+50% DMSL [T3]; 25% CM+75% DMSL [T4] and 100% DMSL [T5]. The natural pasture hay of this study was medium quality grass and the CP content was better demanded for maintenance requirement of goats. Total dry matter intake (TDMI) expressed as% BW and metabolic BW (kg/$w^{0.75}$) were different ($p<0.05$) among treatments with an overall mean of 3.46% of BW and 64.59 g DM/kg $w^{0.75}$ per day. The TDMI was in the range of 3.3 to 3.7% BW. The CP intake has increased in ascending order with increased level of DMSL supplementation. The trend in TDMI (g/day) of goats across the feeding period showed progressive increment. The increase in BW throughout the feeding period is an attribute of increase in feed and digestible nutrient intakes. Based on the partial budget analysis as well from biological point of view, supplementation of 75% and 100% dried *moringastenopetala* leaf could be recommended as profitable for goat producer. Therefore, goat producers can use moringa to attain higher body weight gain within a short period of time.

Keywords: Digestibility, Intake, Moringa, Supplementation, Woyto-GujiGoat

1. Introduction

More than 80% of the Ethiopian population is dependent on agriculture for their livelihoods (10). Ethiopia is believed to have the largest livestock and goat population in Africa [8], stands third in Africa and sixth in the world, accounting 9% and 3% of African and global goat populations, respectively [37]. Estimates indicated that about 30.20 million goats are found in the country, out of which 99.97% are indigenous breeds [8]. The productivity of Ethiopiangoat is low mainly because of inadequate year round nutrition (both in terms of quantity and quality), unimproved genetic potential and prevalence of diseases and parasites [39]. Consequently, the digestibility and intake of these feeds are low which causes slow growth rate, loss of body condition, increased susceptibility to disease and parasites and decreased reproductive performance in ruminant livestock [23].

In order to mitigate problems associated with the lack of protein supplement, there is a need to look for alternative

protein sources by farmers to produce at their own farm. The use of multipurpose tree parts as alternative feed resources for ruminant livestock is becoming increasingly important in many parts of the tropics and sub-tropics because of its availability and abundance [20]. In this regard, Moringa (*moringastenopetala)* is among the multipurpose trees that can be used as animal feed [27] mainly as a protein and energy supplement for ruminant livestock [25] during the dry season. Moringa (*moringastenopetala)* leaves are rich in CP, minerals and essential amino acids; low in tannin content [26] and able to improve the microbial protein synthesis in the rumen [34]. Asbeing rich in available sources of protein and cell wall materials, moringa foliage may be one of the alternatives to conventionally mixed concentrates used for feeding goats [35]. Therefore, the objective of this experiment was to evaluate the effects of dried moringa *(moringa stenopetala)* leaf supplementation on feed intake, digestibility and body weight change of Woyto-Guji goats as an alternative to conventionally mixed concentrate and assess its economic benefit.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at Arbaminch agricultural research center, located in Gamo Gofa Zone, Southern Nation Nationalities and Peoples Region, Ethiopia. Arbaminch agricultural research center is located 480 km south of Addis Ababa at 6 02′3″ North latitude, 37 34′17″ East longitude and 1200 meters above sea level. The mean annual maximum and minimum temperature and rainfall is 31.38 and 17.91 degree Celsius and 900 mm, respectively [15].

2.2. Experimental Animals and Their Managements

Twenty five intact male yearling Woyto-Guji goats with an average initial BW of 19.48±2.58 Kg (mean±SD) were purchased from cooperatives involved in community based goat breeding program with Arbaminch agricultural research center. The ages of the animals were determined both by dentition and information obtained from the research center. Before the start of the experiment, goats were ear tagged, de-wormed with Albendazol bolus and sprayed using Diazinon 60% against internal and external parasites following manufacturer's recommendation. Goats were vaccinated against Contagious Caprine Pleura Pneumonia (CCPP) and Pasteurelosis. To fully acquaint goats with their experimental diets, environment and pen management, the actual study period of ninety days were preceded by a preliminary feeding period of two weeks. The supplemental feeds were weighed every morning and animals were fed 50% of their daily ration at 8:00 AM in the morning and 50% at 4:00 PM in the afternoon. Throughout the experimental period, supplemental feeds and grass hay were weighed every morning using sensitive balance. The experimental goats were carefully observed for the occurrence of any illness and records were taken for any physiological disorder throughout the experimental period.

2.3. Experimental Feeds Preparations

The experimental feeds were consisting of natural pasture grass hay, air dried Moringa (M*oringa stenopetala*) leaf and concentrate mix. The basal diet of the experiment was native grass hay. For ease of feeding, grass hay was chopped approximately 4 to 5 cm and offered for *ad libitum* intake (≈ 20-25% refusal). Hay offered and refusals were weighted and recorded daily once in the morning before the next feeding throughout the experimental period, so as to determine the daily feed intake. Water was accessed *ad libitum* at all times.

The concentrate mixture was comprised of wheat bran (57%), noug cake (23%), maize (19%) and salt (1%) on DM basis. The concentrate was formulated to contain 18% CP to meet the optimum recommendation for intensive feeding (13). Concentrate supplementation was based on the findings of [9] indicating the potential of Ethiopian indigenous goat for meat production through supplementation of concentrate at the rate of 1.5% body weight. Fresh moringa *(moringastenopetala*) leaf was bought from farmers on contract base. Fresh leaves were harvested from available trees regardless of tree age, and the leaves were trimmed from its twigs on a plastic sheet. The trimmed leaves were thinly spread on plastic sheet under shade and were turned regularly to ensure uniform drying for safe storage. The leaves were dried under the shade until they are crispy. The air dried moringa (m*oringastenopetala*) leaf mixtures were offered in two equal portions at 8:00 AM and 4:00 PM.

2.4. Experimental Design and Treatments

The experiment was conducted in a randomized complete block design (RCBD) with five treatments and five blocks. At the end of the acclimatization period goats were fasted overnight; body weight was measured and blocked into 5 groups based on their initial body weight. Animals within a block were randomly assigned to the five treatments as indicated:

T1=Grass hay *ad libitum* + 100% concentrate mix

T2=Grass hay *ad libitum* + 75% concentrate mix + 25% dried Moringa leaf

T3=Grass hay *ad libitum* + 50% concentrate mix + 50% dried Moringa leaf

T4=Grass hay *ad libitum* + 25% concentrate mix + 75% dried Moringa leaf

T5=Grass hay *ad libitum* + 100% dried Moringa leaf

2.5. Data Collection and Chemical Analysis

2.5.1. Feeding Trial

Samples of feed offered and refusal of each animal was collected over the experimental period and stored in plastic bags. Sub-samples of feed offered and refusal were taken

after thorough mixing for nutrient composition determination. The sub-samples taken were dried at 60 degree Celsius for 72 h in forced draft oven for chemical analysis. Animals were fasted overnight at the beginning of the feeding trial and average weights of two consecutive measurements were taken as an initial body weight. Throughout the experimental period, body weights change (BWC) of the experimental goats was taken every week. Weight gain over experimental period was calculated as the difference between final and initial body weights. Average daily weight gain was calculated as a weight gain divided by the number of feeding days. Feed conversion efficiency (FCE) was estimated as a ratio of average daily weight gain per units of daily feed intake (consumed) and the inverse is feed conversion ratio FCR.

2.5.2. Digestibility Trial

At the end of the feeding trial period, experimental animals were fitted with feces collection bags for digestibility trial. After allowing an adaptation period of three days to the harness, daily total feces excretion per animal was collected for seven days. Each day's fecal output of each animal was weighed using sensitive balance and 10% of sub-sample stored frozen at-20 degree Celsius and pooled over the collection period to make a single weekly composite fecal sample. The dried feed and fecal samples were ground to pass through 1 mm sieve for chemical analysis. In the laboratory, DM of the feed and feces was determined by drying the partially dried samples at 105 degree Celsius to constant weight. The daily total fecal excretion collected for seven days and feed consumed were used for the determination of digestibility co-efficient using the equation [19].

$$\text{Digestablity coeficent} = \frac{\text{Ntrient consumed} - \text{Nutrient in feces}}{\text{Nutrient consumed}}$$

2.5.3. Chemical Analysis

Samples of feed offered, refusals and feces were chemically analyzed for dry matter (DM), ash and organic matter (OM), which were determined following to the standard procedure of association of official analytical chemists [4]. Nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as N*6.25. Neutral detergent fibers (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to the procedure of [4].

2.6. Partial Budget Analysis

The partial budget analysis was conducted according to [40] to determine the potential profitability of substituting dried *moringastenopetala* leaf (DMSL) for concentrate mixture as supplement to goats fed with grass hay. Partial budget analysis was performed to evaluate the economic advantage of the different treatments and involved in the calculation of variable costs and benefits. The price difference between selling and purchasing price of the goat was considered as total return (TR) in the analysis. Other costs like labor and veterinary service was common for all treatment and not considered. For the calculation of the variable costs, the expenditures incurred on various feedstuffs were taken into consideration. The cost of the feeds was computed by multiplying the actual feed intake for the whole feeding period with the prevailing prices. Partial budget method measures profit or loss, which is the difference between gains and expenses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR): NR=TR-TVC. Total variable costs include the costs of all inputs that changed due to the change in production technology. The change in net return (ΔNR) was calculated by the difference between the change in total return (Δ TR) and the change in total variable cost (Δ TVC). ΔNR=ΔTR-ΔTVC

2.7. Statistical Analysis

Data related to feed intake, feed conversion efficiency, body weight change and digestibility were subjected to analysis of variance using the General Linear Model (GLM) procedure of SAS Version [31]. Mean comparison was made using Tukey's adjustment. Statistical differences between means were considered at $P<0.05$. The statistical model used for data analysis was

$$Y_{ijk}=\mu + T_i + B_j + e_{ijk};$$

Where

Y_{ijk}=Response variable (body weight gain, feed intake, digestibility)

μ=The overall mean;

T_i=The feed effect;

B_j=The block effect; and

e_{ijk}=The random error.

3. Results and Discussion

3.1. Chemical Composition of Experimental Feed Ingredients

Crude protein (CP) value of feeds ranging from 7-7.5% is required to satisfy maintenance requirement of small ruminant animals [41]. The 7-8% CP content of feeds maintains the minimum requirement of the host ruminant and minimum microbial requirement to support acceptable ruminal microbial activity [18]. In this connection, the CP content of grass hay of the present study (Table 1) is better demanded for maintenance of goats. The value of NDF contents of natural pasture hay of this study is medium quality feed based on [33] who pointed out that roughage feeds containing NDF value of less than 65% as mediumquality and those with values higher than 65% as low quality.

Table 1. *Chemical composition of feed ingredients.*

Chemical composition	Hay	DMSL	Wheat bran	NSC	Maize
DM (%)	92	92	91	94	90
Ash (% DM)	7.6	13.1	4.3	6.4	2.2
OM (% DM)	92.3	86.9	95.6	93.6	97.8
CP (% DM)	8.9	27.2	16.1	33.8	9.8
NDF (% DM)	62.2	30.5	30.5	38.7	28.8
ADF (% DM)	45.6	21.7	21.7	26.1	20.9
ADL (% DM)	11.2	4.4	4.4	54.4	4.4

DM=Dry Matter; OM: Organic Matter; CP=Crud Protein; NDF=Neutral Detergent Fiber; ADF=Acid Detergent Fiber; AD=Acid Detergent Lignin;%DM=Percentage in Dry Matter; DMSL=Dried Moringa Stenopetala Leaf, NSC=Noug seed cake.

Table 2. *Chemical composition of treatment feeds and hay refusal.*

	DM	OM	Ash	CP	NDF	ADF	ADL
Feed offered Chemical composition% DM							
T1	90.59	94.60	4.39	18.80	31.82	22.36	4.60
T2	90.94	92.69	6.55	20.91	31.50	22.20	4.50
T3	91.30	90.78	8.71	23.03	31.86	22.05	4.51
T4	91.65	88.87	10.87	25.14	30.86	21.89	4.47
T5	92.00	86.96	13.04	27.25	30.54	21.73	4.42
Grass hay refusal							
T1	92.00	90.22	9.78	8.70	68.72	49.46	13.24
T2	92.00	90.22	9.78	6.90	70.00	51.61	14.36
T3	92.00	89.04	10.96	8.56	60.00	43.01	12.90
T4	92.00	88.52	11.48	7.49	77.68	58.06	16.54
T5	92.00	90.22	9.78	7.13	73.16	55.91	15.46

T1=Grass hay ad libitum +100% concentrate mix (CM); T2=Grass hay ad libitum +75% CM + 25% dried Moringa stenopetalaleaf (DMSL); T3=Grass hay ad libitum +50% CM + 50% DMSL; T4=Grass hay ad libitum +25% CM + 75% DMSL; T5=Grass hay ad libitum +100%DMSL; DM=Dry matter; OM=Organic matter; CP=Crud protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin.

3.2. Feed Intake

The daily DM and nutrient intake and trends in DM intake of Woyto-Guji goats across the experimental period are presented in Table 3 and Figure 1, respectively. All goats readily consumed the dietary supplement without any refusal throughout the experiment period. Total DM intake expressed as percent of BWand metabolic body weight (kg/$w^{0.75}$) were different ($p<0.05$) among treatments with an overall means of 3.46% of BW and 64.59 g DM/kg $w^{0.75}$ per day.

Table 3. *Dry matter and nutrient intake of Woyto-Guji goats consumed natural pasture hay and supplemented with concentrate mixture containing graded levels of dried Moringa leaf.*

Intake (g/day)	Treatments						
	T1	T2	T3	T4	T5	SEM	SI
Hay DM	436.03	436.52	437.38	437.51	436.49	20.09	Ns
Supplement DM	259.08^{e}	261.86^{d}	271.89^{b}	274^{a}	269.59^{c}	0.49	*
Total DM	695.1^{c}	698.38^{c}	709.27^{ab}	711.51^{a}	706.09^{b}	20.83	*
DM (% BW)	3.29^{b}	3.34^{ab}	3.43^{ab}	3.57^{ab}	3.67^{a}	0.001	*
Total DM (g/kg $w^{0.75}$)	66.66^{a}	65.89^{ab}	65.19^{ab}	63.54^{ab}	61.69^{b}	2.52	*
CP	96.17^{e}	104.81^{d}	111.27^{c}	119.43^{b}	124.23^{a}	1.82	*
NDF	377.32^{b}	376.33^{b}	390.43^{a}	369.42^{c}	371.52^{c}	16.75	*
Ash	45.82^{e}	52.07^{d}	57.98^{c}	63.77^{b}	71.47^{a}	2.51	*
OM	660.73^{a}	645.23^{c}	651.37^{b}	647.34^{c}	634.75^{d}	17.64	*
ADF	274.37^{b}	273.12^{b}	285.7^{a}	267.3^{c}	268.01^{c}	12.5	*
ADL	63.46^{b}	62.25^{c}	64.36^{a}	59.93^{e}	60.69^{d}	3.2	*

[a, b, c]Means within arrow not bearing similar superscript letter significant differ *=($p>0.05$); DM=Dry matter; OM=Organic matter; CP=Crude protein; SEM=Standard error of means; SI=Significance level; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin; T1=Grass hay ad libtium+100% concentrate mix (CM); T2=Grass hay ad libtium +75% CM + 25% dried Moringa stenopetala leaf (DMSL); T3=Grass hay ad libtium +50% CM +50%DMSL; T4=Grass hay ad libtium +25% CM +75% DMSL; T5=Grass hay ad libtium +100%DMSL.

The total DM intake was comparable to range of 3.6 to 3.9% BW reported by [2], higher than the value of 2.5 to 3.25% reported by [36] and lower than the value of 4.74 to 4.87% reported by [9]. The CP intake of goats increased in ascending order and such variation in CP intake could be attributed to the differences in CP content of the supplemented (concentrate

mixture, dried *moringa stenopetala* leaf, and their mixture) feeds. The total DM intake of 695.1 to 711.51 gm/day/animal was higher than the report of [35] (569.6-646.51gm/day/animal), [7] (241 g/day/animal) and (288 g/day/animal) but lower than the finding of [21] (572 to 825 gm/day/animal) in Arsi-Bale goats fed *moringa stenopetala* and [3] (942.85 gm/day/animal) in sheep fed graded levels of *moringa stenopetala* meal. Reports of [11, 14] have also indicated the improvement of sheep DM intake during *moringa stenopetala* supplementation to grass hay basal diet. Crude protein intake has increased with increased level of DMSL supplementation and consistent with the findings of [29, 21]. The total NDF intake was comparable to 332 to 408 g/day reported by [21], higher than the value of 131 to 131.8 g/day reported by [25, 11], but lower than value of 456.3 to 516.8 g/day reported by [3]. The total ADF intake of this study was higher than the value of 137.4 to 184.3 g/day reported by [25], but lower than value of 288.9 to 307.4 g/day reported by [3]. Generally, the trend in TDMI (gm/day) of goats across the feeding period showed progressive increment.

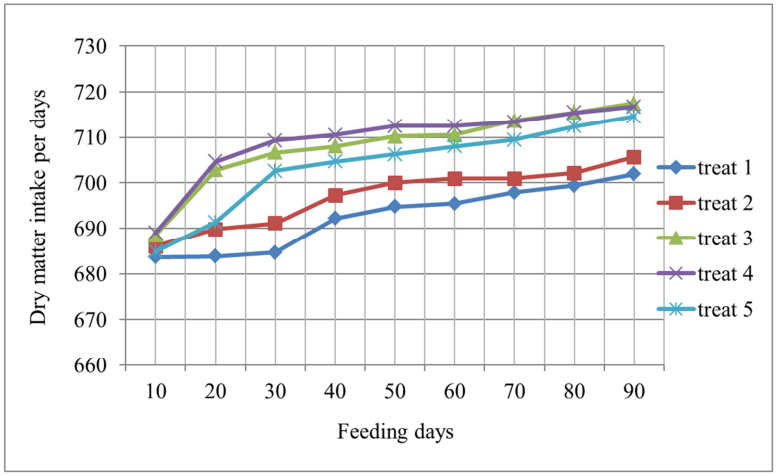

Figure 1. *Trends in DM intake (g DM/head) of Woyto-Guji goats supplemented with concentrate mixture containing graded levels of dried moringa stenopetala leaf.*

3.3. Dry Matter and Nutrients Digestibility

Apparent nutrient digestibility coefficient values are similar across all the treatments except for CP (Table 1). The higher CP digestibility value of DMSL containing diet in this experiment could be due to the increased availability of CP in DMSL compared to concentrate mix for reticulo-rumen microorganism, which increases its digestibility. The absence of significant differences in DM, OM, NDF and ADF digestibility among treatments were in agreement with [11].

Table 4. *Dry matter and nutrient digestibility and digestible nutrient intake of Woyto-Gujigoats consumed natural pasture grass hay supplemented with concentrate mixture containing graded levels of dried moringa leaf.*

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	Sl
Digestibility (%)							
DM	60.7	61.5	61.3	65.1	63.2	0.12	Ns
CP	62.6^{b}	64.6^{b}	67.3^{ab}	76.1^{a}	75.9^{a}	0.096	*
OM	65.1	64.1	64.7	67.7	65.4	0.111	Ns
NDF	48.5	49.0	55.7	50.8	50.2	0.164	Ns
ADF	50.7	50.8	52.3	53.8	51.4	0.160	Ns
ADL	40.1	40.3	39.9	43.5	40.8	0.192	Ns
Digestible nutrient intake (g/day)							
DM	424.11	431.66	436.23	465.44	449.94	14.28	Ns
CP	60.5^{d}	67.95^{c}	75.13^{b}	91.12^{a}	94.68^{a}	10.7	*
OM	472.33	471.14	465.5	490.98	465.7	17.64	Ns
NDF	186.11	183.01	217.7	188.02	187.28	11.97	Ns
ADF	138.67	133.27	162.28	139.98	141.05	7.87	Ns
ADL	25.84	25.51	25.95	26.76	25.16	2.35	Ns

$^{a, b, c}$Means within arrow not bearing similar superscript letter significant differ *=(p>0.05); DM=Dry matter; OM=Organic matter; CP=Crude protein; SEM=Standard error of the mean; SL=Significance level; NS=Not significant; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin; T1=Grass hay ad libtium +100 concentrate mixture (CM); T2=Grass hay ad libtium +75% CM+ 25%dried moringa stenopthala leaf (DMSL); T3=Grass hay ad libtium +50% CM +50%DMSL; T4=Grass hay ad libtium +25% CM +75% DMSL; T5=Grass ad libtium +100%DMSL.

The digestibility coefficient of DM was comparable to 56-59.6% reported by [29] on Tanzanian goat fed moringa foliage, 61.8-67.7% reported by [3] in sheep fed graded level of *moringa stenopetala* meal, but lower than the value obtained 77.19% in West African dwarf goat fed fresh moringa foliage [5]. Moreover, [16] reported the apparent DM digestibility values between 78.2 and 82.6%*moringaoleifera* leaves as sole feed for goats and is higher than the obtained value of this study. The higher digestibility of CP and NDF for DMSL at 75%and 100% supplementation were in agreement with the reported of [24].

As the level of protein in the feed increase, the apparent nutrient digestibility would also increase because the level of protein influence the digestibility of feed [28]. The increase in N retention with increased levels of moringa leaf resulted from increased N intake and increased CP digestibility. Generally, digestibility of CP increases as CP intake increases because metabolic faecal N is inversely related to CP intake and is higher at lower intake than at higher intake [14].

3.4. Body Weight Change and Feed Conversion Efficiency

Total BW change of goats and trends of BW change across the experimental period is indicated in Table 5 and figure 2. Goats receiving 100% dried moringa leaf tended to have higher value for all parameters except FCR which may point out efficient utilization of nutrient. The ADG of this study was similar to [35] in 6-8 month old goats supplemented with 5% BWof moringa foliage. Higher weight gain of 54-114 g/day was reported by [21] for Arsi-Bale goat consumed*ad libitum* natural pasture hay supplement with concentrate containing 0,35,50,65% dried *moringastenopetala* [5] did not found significance difference in ADG of goats fed *moringa oleifera* and concentrate mixture and is in disagreement with the present study.

Table 5. *Body weight change and feed conversion efficiency of Woyto-Guji goats consumed natural pasture grass hay supplemented with concentrate mixture containing graded levels of dried moringa leaf.*

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	Sl
IBW (kg)	19	19.2	19.8	19.9	19.5	0.62	Ns
FBW (kg)	22.8^{b}	23.3^{ab}	24.4^{ab}	25.4^{ab}	25.7^{a}	1.38	*
TBWC (kg)	3.8^{b}	4.1^{ab}	4.6^{ab}	5.5^{ab}	6.4^{a}	1.26	*
ADG (g/d/head)	42.2^{b}	45.6^{ab}	51.1^{ab}	61.1^{ab}	70.9^{a}	14.03	*
FCE (ADG/TDMI)	0.060^{b}	0.065^{ab}	0.072^{ab}	0.086^{ab}	0.097^{a}	0.02	*
FCR (TDMI/ADG)	16.47^{a}	15.32^{ab}	13.88^{ab}	11.65^{ab}	9.95^{b}	3.75	*

NS=Not significant; SEM=Standard error of mean; SI=Significant level; TDMI=Total dry matter intake; T1=Grass hay ad libitum +100% concentrate mixture (CM); T2=Grass hay ad libitum +75% CM + 25% dried moringa leaf (DML), T3=Grass hay ad libitum +50% CM + 50% DML, T4=Grass hay ad libitum +25% CM + 75% DML, T5=Grass hay ad libitum +100%DML; DM=Dry matter; OM=Organic matter; CP=Crud protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin FCE=Feed conversion efficiency; FCR=Feed conversion ratio; ADG=Average daily gain, IBW=initial body weight, FBW=Final body weight, TBWC=Total body weight change.

[1] Did not found differences in ADG of sheep fed *moringa oleifera* leaf meal that replaced cotton seed cake at a proportion of 0,25,50,75 and 100% *moringa oleifera* leaf meal containing diet and disagree with the present study. That difference in daily gain between various studies could be attributing to the difference in growth potential of the goats. The average daily weight gain isin accordance with [22], who supplement *moringa oleifera* leaf meal to goats. Average daily gain obtained in the present study is similar to the reports of [17] (41.67-65.28 g/day) and [39] (52.9-68g/day) for goats supplemented with concentrate. The increase in body weight throughout the feeding period is an attribute of increase in feed and digestible nutrient intakes (Figure 2).

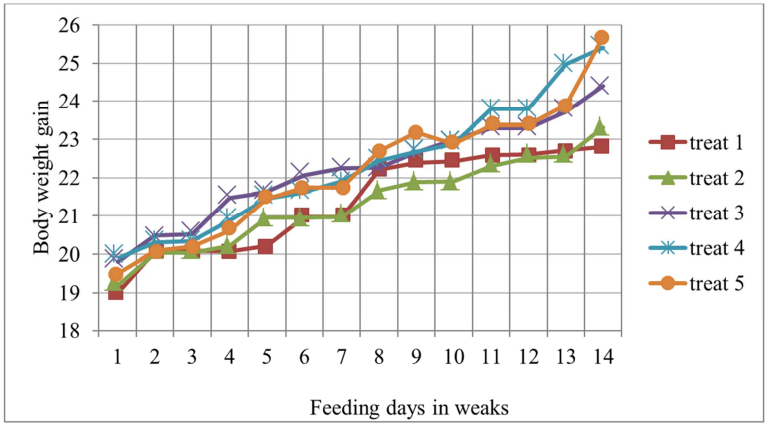

Figure 2. *Trend of body weight change of Woyto-Guji goats fed natural pasture grass hay and supplemented with concentrate mixture containing graded levels of dried moringa leaf.*

3.5. Correlations of Intake, Digestibility and Body Weight Change

Pearson linear correlation coefficients among feed intake, digestibility, and body change are presented in Table 6. TDMI was positively correlated with OMI, CPI, NDFI and ADFI. The positive correlation between these factors indicated the improved fermentation and passage rate, which leads to improve intake. DMD was negatively correlated with ADFIbecause cell wall constituent reduces DM digestibility and passage rate. CP digestibility of the current study is in agreement with [12] and [35] who reported that CP digestibility was negatively correlated with NDF and ADF intake.

Table 6. *Correlation between nutrient intake, digestibility and body weight gain in Woyto-Guji goats fed natural pasture hay supplemented with concentrate mixture and dried moringa leaf.*

	TDMI	OMI	CPI	NDFI	ADFI	DMD	OMD	CPD	NDFD	ADFD	ADG
TDMI	1										
OMI	.786*	1									
CPI	.472*	.133	1								
NDFI	.536*	.695*	-.13	1							
ADFI	.633*	.853*	-.201	.827*	1						
DMD	.124	.082	.116	.017	-.252	1					
OMD	.096	.083	.074	.023	0.021	.989*	1				
CPD	.167	.0104	.34*	-.034	-.067	.894*	.895*	1			
NDFD	.12	.104	.079	.092	.067	.933*	.928*	.826*	1		
ADFD	.138	.139	.059	.092	.093	.962*	.958*	.853*	.929*	1	
ADG	.33	.036	.65*	.046	.09	.040	.069	.095	.046	-.043	1

*=p>0.01; ADG=Average daily gain; DMI=Dry matter intake; TDMI=Total dry matter intake; OMI=Organic matter intake; ODM=Organic matter digestibility; CPI=Crude protein intake; CPD=crude protein digestibility; NDFI=Neutral detergent fiber intake; NDFD=Neutral detergent fiber digestibility; ADFI=Acid detergent fiber intake; ADFD=Acid detergent fiber digestibility.

3.6. PartialBudget Analysis

Partial budget analysis of Woyto-Guji goats fed natural pasture hay supplemented with concentrate mixture and dried *moringa stenopetala* leaf is presented in Table 7. The total feed cost decrease with increasing level of DMSL substitution for concentrate mixture. Gross return (selling price of goat) was higher for goat fed with T4 and T5 diet due to the comparatively higher final body weight. Net income per goat was higher for the goat supplement with 75% (T4) and 100% (T5) of dried *moringastenopetala* leaf as compared with other supplemented and non- supplemented ones. The net return increase of DMSL substitute at increasing level was mostly due to comparatively lower cost per unit of DMSL (4.5 ETB/kg) as compared to CM (5.5 ETB/kg). Therefore, DSML could substitute concentrate mix with higher profit (net return) in the diet of Woyto-Guji goats fed basal diet of natural pasture grass hay.

Table 7. *Partial budget analyses of Woyto-Guji goats fed natural pasture hay supplemented with concentrate mix and dried moringa (moringa stenopetala) leaf.*

Parameters	Treatments				
	T1	T2	T3	T4	T5
Number of animals	5	5	5	5	5
Purchase price of animals	513	518.4	534.6	537.3	526.5
Feed consumed					
Grass hay (kg/head)	39.3	39.3	39.4	39.4	39.3
Concentrate mix (kg/head)	25.7	19.4	13.4	6.8	0
Dried moringa leaf (kg/ head)	0	6.5	13.4	20.16	26.4
Feed cost					
Grass hay (ETB/head)	98.3	98.3	98.5	98.5	98.3
Concentrate mix (ETB/head)	141.4	106.7	73.7	37.4	0
Dried moringa leaf (ETB/head)	0	29.3	60.3	90.9	118.8
Total variable cost (ETB/head)	239.7	234.3	232.5	226.8	217.1
Gross return (ETB/head)	843.6	862.1	902.8	939.8	950.9
Total return (ETB/head)	330.6	343.7	368.2	402.5	424.4
Net return (ETB/head)	90.9	109.4	135.7	175.7	207.3
ΔNR		18.5	44.8	84.8	116.4
Δ TVC		-5.4	-7.2	-12.9	-22.6

T1=Grass hay ad libitum +100% concentrate mixture (CM), T2=Grass hay ad libitum +75% CM + 25% dried moringa leaf (DML), T3=Grass hay ad libitum +50% CM + 50% DML, T4=Grass hay ad libitum +25% CM + 75% DML, T5=Grass hay ad libitum +100%DML; ETB=Ethiopian birr; ΔTVC=change in total variable cost; ΔNR=Change in net return; ΔNI=Change net income; MRR=Marginal rate of return.

4. Conclusion

The result of this study suggest that substitution of *moringastenopetala* leaf to natural pasture grass hay has enhanced the feed intake and body weight gain of Woyto-Guji goats as compared to non-supplemented goats. Based on the partial budget analysis as well from biological point of view, supplementation of 75 and 100% dried *moringa stenopetala* leaf could be recommended as profitable for goat producer. Therefore, moringa (*moringa stenopetala)* leaf can be used by goat producers so as to attain higher body weight gain in goats within a short period of time.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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