Study of Carcass Characteristics of Goats Fed Rice Straw Supplemented with *Moringa* (*Moringa oleifera* Lam.) Foliage

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ABSTRACT—*The study was conducted to investigate the effects of different dietary levels of Moringa foliage on the growth performance, and carcass quality of Black Bengal goats. Thirty buckling of 6 to 8 months of age with an average initial live weight (LW) of 8.07 (±0.87) kg were allocated into five different dietary groups having six in each group for 105 days. Keeping molasses treated rice straw ad libitum as sole diet, 70% of dietary dry matter (DM) requirement was supplied with a conventional concentrate which was replaced with Moringa foliage in treatment diets at the rate of 25, 50, 75 and 100%, respectively. Consequently, Moringa foliage represented 17.8, 35.6, 52.9 and 67.2% of total dietary DM intake or 0.85, 1.7, 2.5 and 3.4% of LW of goats in treatment diets which did not affect the daily gain, DM intake and digestibility (P>0.05) significantly. The dietary DM intake and LW gain ranged from 4.6 to 4.8% of average LW and 67.3 to 79.3 g/d. The slaughter weight and dressing percentage, ranging from 15.0 to 15.6 kg and 51.9 to 52.5, did not vary significantly (P>0.05). The lean to fat ratio in carcass was 15.0 and 11.8 when diet contained 52.9 and 67.2% Moringa foliage, respectively which were significantly (P<0.05) higher than other diets. It was concluded that Moringa foliage may be included to the diet of goat up to 67.2% or 3.4% of LW which will produce more lean than fat without affecting dietary intake and daily gain.*

Keywords— Intake of *Moringa* foliage, Black Bengal goat, digestibility, carcass composition

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1. INTRODUCTION

In the tropics, small ruminant animals are usually raised on crop residues, native pasture, agro-industrial by products and the non-conventional feed resources, mainly fodder, from shrubs and trees that are generally low in protein. As a result, high levels of production cannot be attained only from low quality feeds that hardly meet even the maintenance requirements of the animals. It has been reported that intake and digestibility of low quality hay was improved by supplementing with concentrates [1]. However, supplementation with concentrate is limited under smallholder production systems due to unavailability and high cost. Moreover, economic constraints and competition between humans and monogastric animals for cereal grains limits prospects for usage of cereal grains as ruminant feed by small holder farmers. In order to alleviate the problems related with the lack of protein supplements, there is a need to search for alternative protein sources that farmers can produce easily on their own farms without involving extra cost.

In recent years, there has been increased attention on alternative protein sources from forage trees and shrubs that can be fed to goats [2, 3 and 4]. It has been reported that the replacement of conventional concentrates by trees fodders has made it cheaper than the commercial concentrates [5]. Manaye *et al.*, [4] observed that intake, digestibility and body weight gain of sheep were improved when a low-quality grass was supplemented with *Sesbaia sesban* tree leaves.

Moringa is a potent protein source for ruminant production that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan [6] and is distributed throughout the tropics. The leaves of this tree posses nutritious, therapeutic and prophylactic properties with crude proteins varying from 23 to 40% [5 and 7]. The leaves of the tree have high antioxidant capacity due to the presence of high quantity of polyphenols [6, 8 and 9]. It was reported that both phenolic and flavonoid compounds in *Moringa* leaves not only influence lipid oxidation potential, but may also influence the meat quality and fatty acid composition [6]. Therefore, the objective of the present experiment was to evaluate the effect of replacement of conventional concentrate with *Moringa* foliage on growth, nutrient utilization and carcass characteristics in Black Bengal goats.

2. MATERIALS AND METHODS

2.1 Preparation of Rice Straw

Experimental animals were fed rice straw (RS) as a basal diet by chopping into 2 to 3 cm pieces. This chopped RS was mixed with 2.5% molasses on dry matter (DM) basis prior to feed to animals in order to increase appetite. The physical and chemical composition of molasses treated RS is presented in Table 1.

2.2 Preparation of Moringa Foliage Mixture

Moringa foliage was collected from the *Moringa* plots of Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka by harvesting the re-growth of stem and leaves of 56 days after trimming, which maintained a leaf and stem ratio of 2:1. During feeding trial, this foliage was mixed with soybean oil, vitamin-mineral premix, DCP and common salt at the rate of 4.5, 0.5, 1 and 1%, respectively on the basis of DM. This harvested biomass was chopped into 1 cm pieces, dried in sun for 36 hours and stored in plastic bags until feeding. It was consisted of leaves, petioles, soft rachis and stems, and the height of trees during harvesting was 120 (±8.5) cm. The physical and chemical composition of this *Moringa* foliage mixture is presented in Table 1.

2.3 Preparation of Concentrate Mixture

A concentrate mixture was prepared by mixing conventional concentrate ingredients (broken maize, soybean meal, kheshari bran, wheat bran, soybean oil, vitamin mineral premix, DCP and salt) in order to supplement the experimental animals. The physical and chemical composition of the conventional mixture on DM basis is presented in Table 1. The concentrate mixture and *Moringa* foliage mixture were iso-caloric and iso-nitrogenous.

Table 1. Physical and chemical composition of dietary components

Ingredients (%DM)	**Molasses treated RS**	***Moringa* foliage mixture**	**Concentrate mixture**
Broken maize	-	-	36
Soybean meal	-	-	42
Kheshari bran	-	-	8
Wheat bran	-	-	7
Soybean oil	-	4.5	4.5
Vitamin mineral premix	-	0.5	0.5
Dicalcium phosphate (DCP)	-	1.0	1.0
Common salt	-	1.0	1.0
Molasses	2.5	-	-
Chemical Composition (% DM)			
DM	90.17	89.67	89.53
OM	83.54	89.42	93.10
CP	5.52	23.91	24.17
EE	2.18	5.13	5.23
ADF	35.78	19.01	12.36
NDF	63.31	32.38	40.66
ME, MJ/kg DM	5.26	11.36	11.31

RS, rice straw; DCP, dicalcium phosphate; DM, dry matter; OM, organic matter; CP, crude protein; EE, ether extract; ADF, acid detergent fiber; NDF, neutral detergent fiber; ME, metabolizable energy.

2.4 Selection of Experimental Animals

A total of thirty Black Bengal buckling of 6 to 8 months of age with an average live weight (LW) of 8.07 (±0.87) kg were allocated into five different dietary groups having six in each group. All goats were treated with prescribed doses of antihelminthes (Endex, Novartis, India limited) before the commencement of the experiment. The sheep were housed in individual pens measuring 1.25 m^2 (1.25 m × 1.0 m) and provided individual feeders and water buckets. The bucklings were allowed 14 days of adjustment period during which they were gradually accustomed to experimental diets and management.

2.5 Diets of the Experiment

The calculated maximum DM requirements of all growing buckling of all dietary groups, according to NRC [10], was offered by concentrate and/or *Moringa* foliage mixture by 70%, while molasses treated RS was offered ad-*libitum* as a basal diet. The diet of control group, thus, was consisted of molasses treated RS (ad *libitum*) and concentrate mixture (70% of DM requirement). In case of treatment groups, the calculated amount of concentrate was replaced with *Moringa* foliage mixture at the rate of 25, 50, 75 and 100%, respectively. Therefore, the supply of *Moringa* foliage mixture to different treatment groups was 17.5, 35, 52.5 and 70% of total DM requirement of animals. The requirements of concentrates and/or *Moringa* foliage mixture of all animals were adjusted by taking fasted LW of every animal by every

7 days interval during the whole trial period. The stipulated amount of molasses treated RS, concentrate mixture and/or *Moringa* foliage for each buckling were weighed once a day. They are divided in to two equal parts; one part was offered at 08:00 and another part was given at 15:00. In case of concentrate and *Moringa* foliage combination diets, concentrate was offered prior to *Moringa* foliage. Representative mixture of them of all batches was collected and stored for laboratory analysis. The molasses treated RS was offered after concentrate and *Moringa* foliage feeding in separate feeders. The trial was conducted for a period of 105 day during which fresh and clean was supplied ad-libitum to all animals. The feed offered and refusals were recorded on a daily basis throughout the experimental period in order to determine daily DM intake. The DM content of feed samples and refusals was analyzed on the same day the sample was collected, and representative dry samples were stored for further chemical analysis.

2.6 Determination of Digestibility and Collection of Samples

During the last ten days of the study, four buckling were randomly selected from each treatment and were subjected to a digestibility trial. Metabolic trays were placed under individual pens for the collection of faeces and urine. They were allowed a 3 days adjustment period prior to the start of total collection of urine and faeces for 7 days. During the collection period, samples of feed and refusals were collected and weighted and sampled (10%). A portion of representative sample was sent to determine DM content daily, and another portion was passed through 1 mm screen to grind and kept for further chemical analysis. Similarly, faeces were collected daily, weighed, and composited samples were sent to laboratory where a portion of them were used for determining fresh DM content and another portion was kept in a deep freeze (-20°C) until chemical analysis. Daily excreted urine was collected in plastic containers containing 100 ml 6N H_2SO_4 to prevent ammonia loss by evaporation. Urine was weighed, sampled (10%), and kept frozen (-20°C) for further analysis. While chemical analysis, all samples of feed, refusals, faeces and urine of 7 days were thawed to room temperature and composited by animal.

2.7 Slaughtering and Sampling of Goat Carcass

At the end of the experiment, four goats were randomly selected from each treatment for slaughtering after keeping fasted for about 24 hours. All the animals were slaughtered according to the ‘Halal’ method by severing the major vessels of the throat by a transverse cut. Fasted LW was recorded before slaughter, and subsequently hot carcass weights were recorded immediately after evisceration. Non-carcass components (skin, head, feet, lung, heart, liver, spleen, kidneys, kidney fat, and gastro-intestinal tract fat) were removed and weighed. The stomach (rumen, reticulum, omasum and abomasum) and post-ruminal tract (small intestine, large intestine and caecum) were removed and weighed separately. The digesta of them were removed, washed and weighed to obtain the weight of empty stomach and post-ruminal tract. Carcasses were kept for 24 hours at 4°C, and then the cold carcass was weighed and the chilling loss the next morning was calculated. Dressing percentage was calculated as hot carcass weight relative to fasted body weight. The carcasses were divided into equal halves along the midline using a carcass saw and the right half was assigned for carcass composition (lean, bone and fat) and carcass cut.

2.8 Carcass Cuts

The right side of each carcass was weighed and then fabricated into eight primal cuts according to AUS-MEAT specifications: neck, shoulder, rack, loin, fore shank, flank, leg champ and leg. The cuts were weighed and expressed as percentage of total cold carcass weight. Each cut was dissected into components of lean, bone, subcutaneous and intramuscular fat. The rib eye area (LD muscle area) from 12^{th} - 13^{th} ribs was determined by tracing paper using two-dimension polygon area calculator software (Branscome and Jesseman, 1999).

2.9 Chemical Composition

Samples of molasses treated RS, concentrate mixtures, *Moringa* forage, feed refusal and faces in each animal during the collection period were taken separately and thoroughly mixed together according to animal. All mixed samples (Feed and refusal) were ground through 1 mm sieve and sub-sample was taken for subsequent chemical analysis. The proximate composition were done according to AOAC (11). The Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to the method of Van Soest et al. [12]. ME (metabolizable energy) (MJ/kg DM) was calculated according to the following formula [13]: ME in straw = 0.36×GE (Gross Energy); ME in high quality pasture or concentrate = 0.66×GE

2.10 Statistical Analysis

The data were subjected to a one way ANOVA as a completely randomized design using the GLM procedure in SAS [14]. The differences between means were compared using the Duncan’s multiple range test [15].

3. RESULTS AND DISCUSSION

3.1 Intake and Digestibility of Nutrients

The intake and digestibility of nutrients are presented in Table 2. There were no significant (P>0.05) differences in DM, CP, and ME intakes among dietary groups. The DM intake from RS and concentrate mixtures ranged from 157.4 to 169.5 and 385.6 to 406.1 g/d, respectively, which resulted in DM total intake of 543.3 to 577.1 g/d. Therefore, based on the levels of replacement of concentrate mixtures by *Moringa* foliage (25%, 50%, 75% and 100%, respectively), it can be calculated that the intake of *Moringa* foliage in different treatment diets were 99.1, 203.1, 304.0 and 387.7 g/d, respectively in the diets containing 17.5%, 35%, 52.5% and 70% *Moringa* foliage, and they represented 17.8%, 35.6%, 52.9% and 67.2% of total dietary DM intake. The total DM intake were 4.6%, 4.8%, 4.7%, 4.7% and 4.8% of LW of goats (Table 2) in diets consisted of 0, 17.5, 35, 52.5 and 70% *Moringa* foliage, respectively, which were 3.3%, 3.4%, 3.4%, 3.3% and 3.4% of LW in case of DM intake from concentrate. Based on the replacement levels of conventional concentrate (25%, 50%, 75% and 100%, respectively), the intakes of DM from *Moringa* foliage represented 0.85%, 1.7%, 2.5% and 3.4% of LW of goats fed diets containing 17.5%, 35%, 52.5% and 70% *Moringa* foliage, respectively. The intake of CP and ME among treatments varied from 98 to 112 g/d, and 6.1 to 6.8 MJ/d, respectively. The digestibility of DM and CP was statistically similar (P>0.05) among the dietary treatments and they ranged from 76.8 to 80.2% and 80.7 to 81.7%, respectively.

Table 2. Effects of inclusion of *Moringa* foliage on the intake and digestibility of diets in goats

Variables	Inclusion of *Moringa* foliage to diets (% DM)					P-value
	0	17.5	35	52.5	70	
DM intake from molasses treated RS (g/d)	157.7±11.11	160.5±10.63	164.1±10.31	169.5±9.44	169.4±13.93	0.78
DM intake from concentrate (g/d)	385.6±22.83	396.4±19.52	406.1±19.19	405.3±22.31	387.7±27.84	0.77
Total DM intake (g/d)	543.3±45.54	556.9±48.3	570.2±28.1	574.8±45.7	577.1±41.33	0.98
Total DM intake (% LW)	4.6±0.14	4.8±0.11	4.7±0.13	4.7±0.12	4.8±0.23	0.30
DM intake from concentrate (%LW)	3.3±0.13	3.4±0.13	3.4±0.13	3.3±0.14	3.4± 0.22	0.21
CP intake (g/d)	98.0±7.10	107.0±9.32	111.0±6.3	111.0±8.8	112.0±9.6	0.74
ME intake (MJ/d)	6.1±0.41	6.1±0.63	6.5±0.51	6.8±0.64	6.3±0.60	0.89
Digestibility of DM (%)	80.2±2.03	79.5±0.04	79.1±1.71	78.8±1.06	76.8±1.34	0.60
Digestibility of CP (%)	81.2±0.7	81.7±0.4	81.4±2.0	80.7±1.4	81.6±1.4	0.99

^{a,b,c} Means within rows with different superscripts are significantly different. LW, live weight; FCR, feed conversion ratio; DM, dry matter; CP, crude protein; ADF, acid detergent fiber; NDF, neutral detergent fiber; ME, metabolizable energy

The intake of total DM in all dietary groups (g/d) with values ranging from 543.3 to 577.1 were higher than that of findings of Moyo *et al*., [8] who reported that intake of DM was 490 g/d in case of crossbred Xhosa lop-eared goat on sole *Moringa* leaves diet. When total DM intake was expressed as percentage of LW, the values ranged from 4.6 to 4.8, which fell within the recommended DM intake levels for small ruminants [10]. The CP intake was increased with increasing DM intake. Mtenga Shoo [16] reported a positive correlation between CP and DM intake. The DM, and CP digestibility was not found to be significantly different (P>0.05) among the treatments. These results suggest that digestibility value of *Moringa* foliage diet was similar to the conventional concentrate mixed diet. The present values of DM digestibility were comparable with the ranges of 73 to 74% DM digestibility as reported by Mendieta-Araica *et al*., [5].

3.2 Live Weight Gain

The LW of buckling and their daily gains fed different diets are presented in Table 3. The initial and final weights of the experimental goats between the treatments were not significantly different (P>0.05). The average daily gains and FCR were also not significantly different (P>0.05) between the treatment groups. The FCR values ranged from 6.3 to 6.8.

Table 3. Live weight gain of goats

Variables	Inclusion of *Moringa* foliage to diets (% DM)					P-value
	0	17.5	35	52.5	70	
Initial LW (kg)	8.2±0.96	7.9±1.07	8.0±0.73	8.2±0.81	8.1±1.17	0.99
Final LW (kg)	15.2±1.24	15.4±1.18	16.1±0.82	16.3±1.19	14.9±0.84	0.88
LW gain (g/d)	67.3±3.14	71.3±2.82	74.3±3.66	79.3±4.50	67.8±2.83	0.12
FCR	6.8±0.29	6.5±0.57	6.3±0.48	6.3±0.37	6.4±0.44	0.92

LW, live weight; FCR, feed conversion ratio

It suggests that nutrients in all diets impacted positively and similarly on utilization of available nutrient of goats receiving varying levels of *Moringa* foliage. The average LW gain of goats under this experiment were lower than the value reported by Moyo *et al*., [8] who obtained 103.0 g/d when supplemented with *Moringa oleifera* leaf compared to the grass hay basal diet. This could be attributed to differences in feed quality and the breed type used.

3.3 Nitrogen Balance

The nitrogen balance of goats fed a basal diet of molasses treated RS supplemented with different levels of *Moringa* foliage is shown in Table 4. No significant differences (P>0.05) were observed for nitrogen intake, faecal nitrogen excretion, urinary nitrogen excretion and total nitrogen retention among treatments. The daily nitrogen retention among the dietary groups was 12.0 to 13.1 g/d.

Table 4. Effect of dietary levels of *Moringa* foliage on nitrogen balance of goats

Variables	Inclusion of *Moringa* foliage to diets (% DM)					P-value
	0	17.5	35	52.5	70	
Nitrogen intake, g/d	15.7±1.13	17.1±1.49	17.8±1.00	17.7±1.40	17.9±1.53	0.74
Fecal nitrogen excretion, g/d	2.9 ±0.25	3.1±0.22	3.3±0.17	3.4±0.33	3.3±0.16	0.75
Urinary nitrogen excretion, g/d	1.5±0.17	2.0±0.24	1.5±0.20	1.5±0.15	1.9±0.20	0.24
Total nitrogen excretion, g/d	4.5±0.36	5.1±0.35	4.7±0.18	4.9±0.37	5.1±0.31	0.59
Nitrogen retention, g/d	11.3±0.83	12.0±1.23	13.1±1.10	12.8±1.27	12.8±1.49	0.79

The high nitrogen retention values obtained in the study from all treatments indicated that the protein requirements in the diets for maintenance and growth were sufficient for the experimental goats. Ajayi *et al*., [17] reported that high nitrogen retention could be due to presence of higher levels of CP in the experimental diet. The study suggests that the efficiency of CP utilization of *Moringa* foliage on a paddy straw based diet was comparable to the conventional concentrate mixture. The nitrogen retention value in the diet consisted of 70% *Moringa* foliage, in the current study, was higher than the findings of Asaolu *et al*., [18]. Nevertheless, it has been reported that the shift in N-excretion from urine to faeces might lead to a reduction in ammonia emission to the environment, with positive implications to natural resource management and sustainability [19]. The positive nitrogen retention indicates that replacing conventional concentrate with moringa foliage in a paddy straw based diet could improve efficiency of nitrogen utilization in the body resulting in maintaining body requirement as well as enhancing LW gain.

3.4 Carcass Characteristics

The carcass characteristics of growing goats fed with different replacement levels of *Moringa* foliage are presented in Table 5. Slaughter weight, hot and cold carcass weights were not significantly different (P>0.05) between the treatments. Similarly, there were no variations (P>0.05) in dressing (%) and chilling loss of carcass (%), although chilling loss appeared to increase with increased levels of *Moringa* foliage. The dressing percentage of growing goats in this study ranged from 51.4 to 52.6. The percentage of lean, fat and lean:fat ratio was found to differ with the inclusion of *Moring* foliage to diets. Diets containing 52.2 to 70% *Moringa* foliage had the lean of 72.2 to 73.7%, which was significantly higher than diets containing less *Moringa* foliage, at 69.3% on average. Similarly, fat content was also found to decrease significantly in diets containing more than 52.5% *Moringa* foliage (5.1 to 6.1%) compared to less *Moringa* foliage diets. The best lean fat ratio of carcass (15.0) was resulted in the dietary group which contained 52.5% *Moringa* foliage followed by dietary group containing 70% *Moringa* foliage (11.8%), and they were significantly higher than other dietary groups. However, the percentage of bone, lean bone ratio and, rib eye muscle area did not differ significantly with the inclusion of *Moringa* foliage to diets. The average percentage of bone, lean bone ratio and, rib eye muscle area were 21.3%, 3.3 and 6.7 cm^2.

The values of hot and cold carcass weights, and dressing percentage found in different diets containing increasing levels of *Moringa* foliage were comparable with the values obtained by Moyo *et al*., [8] and Mushi *et al*., [20] who used *Moringa* leaf meal, sunflower seed cake at 66% and 100% concentrates in the diet, respectively. However, increasing concentrate supplementation decreased (P<0.01) the lean tissue and lean: fat in the carcass, and conversely increased fat content (P<0.001), while the dietary treatment did not influence bone formation. Exchanging the conventional diet to partially or entirely substituted diets can alter the quantity of fat deposited in finisher steers, and thereby affect profitability and consumer acceptance [21]. Energy density and feeding intensity are the main factors that affect carcass and intramuscular fatty acid composition [22]. The diets used in the present study were iso-nitrogenous and caloric. However, carcass fat content was different among the treatment groups, which may be attributed to the presence of polyphenols in *Moringa* foliage. Tian *et al*., [23] observed that tea polyphenols reduced fat deposits and acted as anti-lipogenosis in high fat fed rats. In addition, a higher proportion fat was deposited in carcass of steer, sheep and goats when they received higher proportion of concentrates [24, 26 and 26]. The proportion of lean and fat obtained ranged from 69.1 to 73.7 and 5.1 to 9.6% in the present study, which was in agreement with Webb *et al*., [27]. In general, goats receiving 52.5 or 70% of *Moringa* foliage to diets produced higher proportion of leaner meat compared to the other treatments. In this study, the values of chilling losses decreased (P>0.05) while fat content in the carcass increased. It has been reported that the quantity of fat has a large impact on carcass chilling loss, while fat acts as an insulator and slows down moisture evaporation [20]. The present findings are in agreement with those observed by others [8 and 20].

Table 5. Carcass characteristics of goats fed different level of *Moringa* foliage

Variables	Inclusion of *Moringa* foliage to diets (%DM)					P- Value
	0	17.5	35	52.5	70	
Slaughter weight (kg)	15.6±1.29	15.3±1.23	15.0±1.59	15.5±1.59	15.0±0.79	0.99
Hot Carcass weight (kg)	8.1±0.62	8.0±0.71	7.7±0.71	8.2±0.95	7.9±0.58	0.99
Cold carcass weight (kg)	7.9±0.63	7.8±0.70	7.5±0.71	8.0±0.92	7.6±0.57	0.99
Dressing (%)	51.9±1.46	52.1±0.82	51.4±1.31	52.6±0.93	52.1±1.12	0.96
Chilling loss (%)	2.5±0.33	2.8±0.11	2.9±0.29	3.0±0.38	3.4±0.16	0.23
Lean (%)	69.3±0.72^{b}	69.1±0.79^{b}	69.6±0.65^{b}	73.7±0.73^{a}	72.2±0.25^{a}	<0.01
Bone (%)	21.1±0.39	21.7±0.40	21.1±0.34	21.2±0.36	21.6±1.07	0.86
Fat (%)	9.6±0.69^{a}	9.2±0.78^{a}	9.3±0.31^{a}	5.1±0.61^{b}	6.2±0.25^{b}	<0.01
Lean: Fat	7.3±0.67^{c}	7.7±0.83^{c}	7.5±0.33^{c}	15.0±1.64^{a}	11.8±0.64^{b}	<0.01
Lean: Bone	3.3±0.08	3.1±0.08	3.3±0.09	3.5±0.08	3.4±0.23	0.58
Rib eye muscle area (cm^2)	6.2±0.06	6.9±0.65	6.8±0.89	6.8±0.57	6.7±0.63	0.07
Reticulo-rumen with digesta (%)	7.5±1.10	7.4±0.58	8.2±0.44	8.5±1.01	10.1±0.27	0.15
Post ruminal tract with digesta (%)	6.9±0.38	6.7±0.07	7.67±0.28	7.31±0.81	6.63±0.43	0.47
Total gasto-intestinal tract (%)	14.5±1.42	14.1±0.64	15.8±0.65	15.8±1.82	16.7±0.67	0.51
Empty total gastrointestinal tract (%)	7.1±0.68	7.2±0.34	7.7±0.34	6.3±0.53	6.6±0.63	0.36
Rumen digesta (%)	7.0±1.28	7.3±0.48	8.2±0.72	9.9±1.10	10.1±0.85	0.09
Non-carcass fat contents						
Omental fat/rumen fat (%)	3.8±0.20^{a}	2.7±0.39^{b}	2.8±0.10^{b}	1.9±0.21^{c}	1.8±0.04^{c}	<0.01
Mesenteric/ Intestinal (%)	2.1±0.18	1.8±0.16	1.8±0.16	1.6±0.22	1.5±0.10	0.18
Channel /kidney fat (%)	1.5±0.09^{a}	1.6±0.04^{a}	1.6±0.16^{a}	1.0±0.04^{b}	1.0±0.10^{b}	<0.01
Heart fat (%)	0.3±0.04	0.3±0.07	0.2±0.03	0.2±0.02	0.2±0.01	0.11

^{a,b,c} Means within rows with different superscripts are significantly different (P<0.05 or 0.01)

The numerical higher values of gut fill content in goats fed the 70% *Moringa* supplemented diets was of a bulky nature leading to higher gastrointestinal content without affecting intake, growth as well as dressing percentage. The findings of the study were in contrast with the reports of Moyo *et al*., [8] and Mushi *et al*., [20]. On the other hand, a lower gut filled content resulted in a higher hot carcass weight and dressing percentage for 70% *Moringa* supplemented diet. These results are supported by that of Moyo *et al*., [8], who supplemented 100% *Moringa* leaf meal and sunflower cake in the diets. The gut fill in the study ranged from 7.0 to 10.1% which is comparable to the value reported by Mahgoub *et al*., [28].

The percentage of total non-carcass fat in goats decreased with increasing level of *Moringa* foliage supplementation, probably due to the utilization of high energy from the diets. The main contributors to the lower total non-carcass fat were omental and channel fat. These results are in line with those obtained by Mushi *et al*., [20], Mahgoub and Lu [29]. It has been reported that generally goats deposit less fat in carcass, with much of it in the fat around viscera resulting in lean carcass with a proportion of subcutaneous fat [30]. Moreover, breed, age, maturity stage, carcass weight and birth weight influence distribution of fat deposits in the goats' body [29].

3.5 Yield of Non –Carcass Components

Table 6. Slaughter weight of goats and their non-carcass components

Variables	Inclusion of *Moringa* foliage to diets (% DM)					P -value
	0	17.5	35	52.5	70	
Slaughter weight (kg)	15.6±1.27	15.3±1.23	15.0±1.59	15.5±1.59	15.0±0.79	0.99
Skin (%)	8.7±0.37	10.1±0.16	9.4±0.09	10.1±0.19	10.1±0.84	0.15
Head (%)	6.2±0.28	6.2±0.33	8.5±1.04	8.0±0.75	7.1±0.28	0.07
Blood (%)	3.8±0.03	3.6±0.22	4.1±0.22	4.2±0.17	3.9±0.21	0.19
Four feet (%)	2.4±0.32	2.6±0.12	2.4±0.14	2.4±0.17	2.6±0.11	0.68
Lung (kg)	1.2±0.10	1.3±0.08	1.2±0.03	1.3±0.08	1.3±0.05	0.77
Kidney (%)	0.4±0.02	0.4±0.04	0.5±0.02	0.4±0.02	0.4±0.01	0.10
Spleen (%)	0.3±0.02	0.3±0.03	0.3±0.02	0.3±0.01	0.3±0.01	0.24
Liver (%)	2.7±0.02	2.7±0.18	2.8±0.23	2.3±0.19	2.2±0.18	0.14
Heart (%)	0.5±0.01	0.4±0.03	0.4±0.04	0.4±0.02	0.4±0.01	0.15

The percent slaughter weights of non-carcass components are summarized in Table 6. The dietary treatments did not significantly (P>0.05) influence the percentage slaughter weights as well as non-carcass organs such as skin, head, blood, four feet, lungs, kidney spleen, liver, heart, empty digestive tract and rumen digesta. Similarly, among the non-carcass fat, mesenteric and heart fat contents did not change significantly (P>0.05) with the increase of *Moringa* foliage in diets. However, omental and channel fat were decreased (P<0.001) with increasing levels of *Moringa* foliage in diets.

3.6 Primal Cuts of Carcass

The effects diets on different primal cuts as percent of cold carcass are presented in Table 7. Primal cuts, such as, neck, loin and flank were significantly different (P<0.01) due to inclusion of different levels of *Moringa* foliage to diets. The highest proportion of neck (12.1%) was obtained from goats receiving 52.5% of *Moringa* foliage to diets. Although the proportion of neck of goats receiving 35% of *Moringa* foliage to diets did not differ significantly (P>0.01) with goat receiving 17% % or 52.4% *Moringa* foliage in diets, it was significantly higher (P<0.01) than goats receiving no or 70% *Moringa* foliage to diets. The proportion of loin to cold carcass weight was found to be similar (P>0.01) in goats received 17.5% or 35% *Moringa* foliage in diets (13.1% or 14.2%), which was significantly higher than other dietary groups (P<0.01). The proportion of flank (9.7%) in diet contained 35% *Moringa* foliage had no significant difference (P>0.01) with other dietary groups; the proportion of flank was found similar in goats fed 0% or 17.5% *Moringa* foliage in diets (9.9 or 10.8%) which were significantly higher than goats fed 52.5 or 70% *Moringa* foliage (8.4%). The proportion of shoulder, rack, fore shank, leg chump and leg cut were similar among treatments (P>0.05). In general, different combinations of *Moringa* foliage and concentrate dietary supplementation had no specific trend on the proportion of different carcass cuts to chilled carcass weight.

Table 7. Percent of primal cut of cold carcass of goats fed different level of *Moringa* foliage

Variables (% of cold carcass)	**Inclusion of *Moringa* foliage to diets (% DM)**					**P- Value**
	0	**17.5**	**35**	**52.5**	**70**	
Cold carcass weight (kg)	7.9±0.63	7.8±0.70	7.5±0.71	8.0±0.92	7.6±0.57	0.99
Neck (%)	8.8±0.22^{c}	9.9±0.42^{bc}	10.9±0.47^{ab}	12.1±0.88^{a}	8.4±0.49^{c}	<0.01
Shoulder (%)	18.3±0.59	18.0±0.38	17.6±0.84	20.0±0.22	21.8±2.28	0.10
Rack (%)	10.9±0.78	10.0±0.30	9.9±0.52	9.6±0.37	10.3±0.33	0.46
Loin (%)	13.8±0.48^{a}	13.1±0.32^{a}	14.2±0.36^{a}	11.5±0.70^{b}	11.6±0.49^{b}	<0.01
Fore shank (%)	8.1±0.42	7.9±0.36	7.9±0.79	8.7±0.44	8.1±0.94	0.89
Flank (%)	9.9±0.40^{a}	10.8±0.57^{a}	9.7±0.5^{ab}	8.4±0.35^{b}	8.4±0.50^{b}	0.01
Leg chump (%)	24.2±0.58	24.5±0.67	24.4±0.36	23.9±0.72	25.5±0.64	0.47
Leg (%)	5.9±0.32	5.7±0.35	5.5±0.09	5.8±0.18	5.9±0.21	0.67

^{a,b,c} Means within columns with different superscripts are significantly different

4. CONCLUSION

It may be concluded that inclusion of *Moringa* foliage to the diet of goat up to 67.2% or 3.4% of LW did not affect on feed intake, digestibility, feed conversion ratio and daily gain. Goats fed *Moringa* foliage supplemented diets up to that level produced desirable leaner carcass- a carcass with higher proportion of meat with lower weight of subcutaneous fat- after a 105 days feeding trial.

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