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# EFFECT OF SUPPLEMENTING *Moringa oleifera* LEAVES AS FEED ADDITIVES ON BLACK BENGAL GOAT

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## ABSTRACT

Moringa (*Moringa oleifera* Lam. moringaceae) is a highly valued plant that is mostly cultivated in the tropics and subtropics. It is used for food, medication and industrial purposes. The objective of the study was to assess the nutritional value of Moringa leaves and to determine the effect of supplementing *Moringa oleifera* leaves (MOL) on growth performance, carcass and non-carcass characteristics of Black bengal goats. The dried leaves had crude protein levels of 30.3%. The dried leaves had the following mineral contents: calcium (3.65%), phoshorus (0.3%), magnesium (0.5%), potassium (1.5%), sodium (0.164%), sulphur (0.63%), zinc (13.03 mg/kg), copper (8.25%), manganese (86.8 mg/kg), iron (490 mg/kg) and selenium (363 mg/kg). The fiber content was neutral detergent fibre (NDF) (11.4%), acid detergent fibre (ADF) (8.49%), acid detergent lignin (ADL) (1.8%) and (acid detergent cellulose (ADC) (4.01%). The condensed tannins had a value of 3.2%, while total polyphenols were 2.02%. In the other hand, a total of 36 castrated goats aged 8 months, with a mean initial weight of 7.63±0.8 kg, were randomly divided into three diet groups with twelve goats in each. The duration of the trial was 90 days. All goats received a basal diet of grass *ad libitum* and mixed basal diet (200 g/day each). The MOL groups were fed additional 100g (MOL1) and 200 g (MOL2) of dried *M. oleifera* leaves, respectively. The third group (Control) did not receive any additional ration. The attained average daily weight gain for goats fed MOL1, MOL2 and Con were 103.3, 101.3 and 43.3 g, respectively ($P<0.05$). Higher ($P<0.05$) feed intakes observed were in MOL2 (491.5 g) and MOL1 (490.75 g) compared with Con (404.5 g). The hot carcass weight was higher ($P<0.05$) for MOL2 (7.18 kg) and MOL1 (7.14 kg) than for the Con group (5.46 kg). The dressing percentage in MOL2 (50.8%) and MOL1 (50.0%) were higher ($P<0.05$) than that of the Con (44.9%). The growth performance and carcass characteristics of MOL2 and MOL1 goats were not different. Moreover the experimental result reveal that MOL has a cholesterol lowering effect and no lesion has been identified in the gastrointestinal mucosa of the parasitized animals fed on MOL mixed diet. Feeding MOL improved the growth performance and carcass characteristics of goats in an almost similar way, which indicates that *M. oleifera* could be used as a supplement or additives in goats.

**Keywords**: black bengal goat, carcass characteristics, growth performance, *moringa oleifera*, supplements

## INTRODUCTION

Goats are among the major economically important livestock species in the Bangladesh. The demand for goat meat is on the rise throughout the world, especially in developing countries due to increased human population, income growth and great need for lean meat (Sanon *et al.*, 2008). To meet this demand, there is a need to improve the productivity of goats, which is relatively low at the present moment (Solomon *et al.*, 2008). Ruminant feeding is mainly based on grazing, specifically of gramineas. Grass yield is in general not enough to satisfy the nutritional requirements of animals in the 6 months of dry period each year. The dry season causes nutritional stress and consequently decreases animal productivity. Supplementation with concentrates during the dry season is generally not a profitable practice due to high feeding costs, because available ingredients for concentrate production are limited. The limitations of nutrition could be attributed to seasonal fluctuations in feed quantity and quality. Supplementing goats with nutritious feed could increase the average daily gain, carcass weight and dressing percentage, resulting in the improvement of the meat quality (Safari *et al.*, 2009). Most trees and shrubs are easily propagated and do not require high management inputs (fertilizer,

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pesticides, etc.) or advanced technology. One of these potential tree forages is Moringa (*Moringa oleifera* Lam (synonym: *Moringa pterygosperma* Gaertner), which grows throughout the tropics. Moringa grows in all types of soil, from acid to alkaline and at altitudes from sea level to 1800 m. It is drought tolerant and grows even during the 6 months of the dry season. Dry matter (DM) yield is high, 15 tons/ha/year. It is reported to have nutritious, therapeutic and prophylactic properties with a crude protein range of 23–40%. This makes it an ideal protein supplement. This is of particular interest to animal nutrition since dietary protein sources are becoming increasingly expensive and difficult to access (Gebregiorgis *et. al.*, 2011). The plant is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanist. It is easy to establish and have fast growth, making it easier for farmers to grow. It is reported to be drought-tolerant and has the ability to grow on poor soils. The leaves and seeds after oil extraction could be used as a feed supplement to livestock. The leaves can be fed fresh or dried. Dried M. oleifera leaves can be stored for longer periods without deterioration in nutritive value (Mendieta-Araica *et al.*, 2011). As such, leaves can be harvested during the periods of high yields and later used for feeding during the dry season when the quality and quantity of feed is low. Despite, the nutritive value *M. oleifera* leaves, its use as a livestock supplementary feed to improve the growth and carcass characteristics of indigenous goats, is unknown and there are a limited number of studies done worldwide ( Mendieta-Araica *et al.*, 2011).

The use of affordable alternative plant materials that possess medicinal properties which can be used to replace the expensive modern antibiotics in developing countries then becomes a necessity. The nutritional and medicinal properties of *Moringa oleifera* leave suggest it as a good option for the replacement. *Moringa oleifera* leaf is rich in vitamins (especially vitamin A), amino acids, energy, crude protein, low levels of tannins, trypsin and amylase inhibitors (Ogbe *et al.*, 2012). It possesses antimicrobial properties, as well as the ability to boost immune system (Sanchez-Machado *et al.*, 2010). However, the growth performance and carcass characteristics of the Black Bengal goat when supplemented with *M. oleifera* are unknown. The objective of this study was therefore to determine the effects of different levels of moringa as feed additives on goat production performance.

## MATERIALS AND METHODS

### Study site

The study was conducted at Animal Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

### Plant collection and preparation

The plant leaves were collected at Sher-e-Bangla Agricultural University campus of Bangladesh. The leaves were harvested green, air-dried under shade and milled into powder through 1 mm sieve. They were stored in well-dried black plastic containers inside the store room at room temperature of 25°C.

### Nutritional composition determination

Dried powdered Moringa leaves were assessed for dry matter (DM), crude protein (CP), crude fat, calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P) zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), selenium (Se) and sodium (Na) using the Association of Official Agricultural Chemists (AOAC, 2005) procedures. Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), acid detergent cellulose (ADC) and hemi-cellulose were determined following the techniques established by Van Soest *et al.* (1991).

### Condensed tannins and total phenolics determination

Condensed tannins (CT) assays were performed calorimetrically with butanol-HCl method (Bate-Smith, 1981) using purified CT from *Desmodium intortum* as a reference standard.

### Management of experimental Animals

Thirty-six 8-month-old castrated Black Bengal goats with a mean initial body weights of 7.1±0.3 kg were collected from the local market of Savar Hat Dhaka and used in the study from November 2013 to January 2014. The goats were group penned for each of the replication in grilled partition with

concrete floor (1.5×1.5 m) that complied with welfare standards. The goats were given a 21-day acclimatisation period to feed and housing before commencement of the experiment. The animals were allocated to three groups of twelve goats each, balanced in terms of live weight and body condition scores. For immunization PPR vaccine was applied according to the commonly recognized schedule after taking goat in the experimental farm. In addition, anti helminthes (deworming) medicine was applied just after taking goat from the market and prior to trail. The supplementations of Moringa oleifera leaves (MOL) were used. The three feeding treatments— the MOL groups were fed additional 100g (MOL1) and 200 g (MOL2) of dried M. oleifera leaves, respectively. The third group (Con) did not receive any additional ration —were randomly assigned to one of the three groups. All goats were supplemented with 200g mixed concentrate per day as basal diet. The experimental and control diets were formulated at the beginning of the experiment as shown in Table 1.

**Table 1. Mixed concentrate feed & composition supplied to the goat during the experimental period**

| **Ingredients (%)** | **Diet for T1 (MOL1)** | **Diet for $T_2$ (MOL2)** | **Diet for $T_3$ (Con)** |
|---|---|---|---|
| Wheat bran | 21 | 21 | 21 |
| Rice bran | 20 | 20 | 20 |
| Maize crust | 20 | 20 | 20 |
| Khesari bran | 18 | 18 | 18 |
| Sesame oil cake | 10 | 10 | 10 |
| Jasoprot protein | 10 | 10 | 10 |
| MOL | 100g/d | 200g/d | -------- |
| Common salt | 1 | 1 | 1 |
| **Total** | 100 | 100 | 100 |
| **Chemical composition** | | | |
| Protein in mixed feed (%) | 16.37 | 17.01 | 16.05 |
| Energy ME(kcal/100g) in mixed feed | 258.42 | 258.57 | 258.35 |

The energy and protein requirements were estimated to be 6.4 MJ ME and 80 g/day to feed the goats for a 90-day period (NRC 2007). Each goat was individually fed in feeding troughs.

### Measurements

### Feed intake and body weights

The daily feed intake and feed left-over were recorded throughout experimental period. Goats were weighed at the beginning of the experiment and then fortnightly until the end of the experimental period using a digital scale (Casio). The goats were weighed in the morning (0800 hours) before they were fed. Daily live weight gain (in gram per day) was calculated by subtracting the initial body weight from the final body weight and divided by the number of experimental days (90). Concurrently, body condition scores were assessed using the five-point scale (1=very thin to 5=obese; Aumont *et al.*, 1994).

### Measurements of slaughter weights

At the end of the feeding trial, the final live weight (FLW) of each animal was obtained by averaging live weights recorded for two consecutive days, and then the goats were fasted for about 16 h. The goats were weighed again prior to slaughter to get the slaughter live weights. They were slaughtered using the knife by throat cut method, their jugular veins severed, fully bled and skinned thereafter. The heads were removed at the atlanto-occipital joint and the hooves cut off at the proximal end of the cannon bones, leaving the carpal and tarsal bones on the carcass. The carcass was split into two halves through the mid-ventral line and the entire alimentary tract removed (with adhering omental and mesenteric fat). The pluck (respiratory tract, heart and liver) were removed and weighed. The carcasses with kidneys and pelvic fat were immediately weighed after slaughter to determine the hot carcass weight. The carcasses were scored for conformation and fatness based on the meat industry conformation scale by assessing age and fatness. The carcass fatness was graded on a scale from 0 to 6 (0=no visual fat cover, 1=very lean, 3=medium, 4=fat, 5=over fat, 6=excessively over fat). The carcasses were also graded based on age using a scale of A- no permanent incisors; AB- one to two

permanent; B- three to six; and C- more than six permanent incisors (SAMIC, 2006). The meat industry (SAMIC, 2006) conformation scale of 1–5 (with 1=a very flat carcass, 2=a flat carcass, 3=medium carcass, 4=a round carcass, 5=very round carcass) was used. After 24 h of refrigeration at 0°C, weights were recorded to obtain cold carcass weights (CCW). These recordings were later used to calculate dressing percentage and chilling losses.

**Postmortem examination**

Three goats from each group were slaughtered to see if there were any pathological changes present on 90$^{th}$ day after treatment. After sacrifice of the animals, stomach and intestine were examined for gross pathological lesions. At necropsy, gross tissue changes were observed & recorded carefully & representative tissue samples were preserved in 10% buffered formalin for histopathological studies. Any types of abnormalities and lesions were also observed after slaughter of the goats during postmortem examination.

**Haematological parameters**

Blood samples were collected from jugular vein of goat of both control and treated groups at the end of feeding period of 90$^{th}$ days to study the effect of the MOL, and the following parameters were observed:

a) Total erythrocyte count (TEC)- Total erythrocyte count was done following the method described by Lamberg and Rothstein (1977).

b) Hemoglobin estimation (Hb)- The Hb estimation was followed from the procedure by the Hellige hemometer method as described by Lamberg and Rothstein (1977).

c) Packed cell volume (PCV)- The citrated well mixed blood sample was drawn into special loading pipette (Wintrobe pipette). Then, the hematocrite or PCV was recorded by reading the graduation mark; the percent volume occupied by the hematocrit was calculated by using the following formula as described by Lamberg and Rothstein (1977).

$$PCV\% = \frac{\text{Height of the red cell volume in cm}}{\text{Height of total blood in cm}} \times 100$$

d) Erythrocyte sedimentation rate (ESR)- The fresh anticoagulant blood was taken into the Wintrobe hematocrit tube by using special loading pipette exactly up to 0 marks. Excess blood above the mark will be wiped away by sterile cotton. The filled tube will be placed vertically undisturbed on the wooden rack for one hour. After one hour the ESR was recorded from the top of the pipette. The result was expressed in mm/in 1st hour.

e) Blood lipid profile - Blood samples were collected at 90$^{th}$ days of experiment for total serum cholesterol measurement.

f) Parasitic loads

Feces from the goat were sampled two times per month. About 10-20g fresh faecal samples were directly collected by inserting the hand into the animal's rectum: samples were put into polythene bags with 10% formalin solution and refrigerated until examination. The quantitative estimation of faecal eggs or cysts of *Balantidium coli*, ova of *Paramphistomum* and other parasites were done by employing 'Modified Stoll's Dilution Technique' as described by Soulsby (1982).

**Immunological profile**

Antibody titer for against PPR was done by competitive enzyme linked immunosorbent assay (C-ELISA). Antibody titer against PPR was worked out using ELISA Kit techniques as described by Synder *et al.* (1984).

**Statistical analyses**

Each nutrient analysis was done in triplicate. Data obtained was processed using SAS procedure means (2003) which computed the means and standard errors. The experimental data were analysed using the general linear model procedure of SAS (2003). Dietary treatments were considered as fixed effects and the residual as random effect. Each individual served as an experimental unit for all parameters assessed. Pairwise comparisons of the least square means were performed using the PDIFF procedure

of SAS (2003). The statistical model used was: Yijk ¼ m þ Ti þ eijk, where Yij is the dependant variable (average daily gain, EBW, dressing percentage); μ is the overall mean; Ti is the effect of supplement (i = MOL, Con); and Eijk is the random error. A chi-square test (SAS 2003) was used to test whether any associations existed between treatment, body condition score, carcass fatness and carcass conformation grades.

## RESULTS AND DISCUSSION

**Nutritive value of the experimental diets**

The nutritional composition of the MOL is summarized in Table 2. The dried leaves of Moringa had a CP content of 30.3%. Calcium had the highest value of 3.65% followed by potassium (1.5%). and phosphorus had the least value of 0.30% among the macro-elements. The highest value among the micro-minerals was Fe with 490 mg/kg followed by Se with 3.63 mg/kg. Copper had the least value of 8.25 mg/kg. The fiber content been NDF, ADF, ADL and ADC of the leaves were 11.4, 8.49, 1.8 and 4.01%, respectively. The condensed tannins had a value of 3.2%, while total polyphenols were 2.02%. The study showed that Moringa leaves contain nutritious compounds. Noteworthy is the crude protein content of 30.3% observed in this study, although lower than sunflower seed cake's CP of 35.88% which is mostly used as protein concentrate (Mapiye *et al.*, 2010). This makes the Moringa leaves to be a good potential source of supplementary protein in animal diets.

The values of NDF and ADF of 11.4 and 8.49% differed from that of the findings of Foidl *et al.* (2001) that showed NDF and ADF values of 21.9 and 11.4%, respectively, suggesting that the leaves used in this study were of high digestibility. The observed concentrations of acid detergent lignin (ADL) in this study were however, consistent with values reported by Foidl *et al.* (2001).

**Table 2. Chemical composition of dried leaves of Moringa (*M. oleifera* Lam.)**

| Nutrients | Nutritive value | Standard error |
|---|---|---|
| Moisture (%) | 9.533 | 0.194 |
| Crude protein (%) | 30.29 | 1.480 |
| Fat (%) | 6.50 | 1.042 |
| Ash (%) | 7.64 | 0.433 |
| Neutral detergent fibre (%) | 11.40 | 0.425 |
| Acid detergent fibre (%) | 8.49 | 0.348 |
| Acid detergent lignin (%) | 1.8 | 2.204 |
| Acid detergent cellulose (%) | 4.01 | 0.101 |
| Condensed tannins (mg/g) | 3.12 | 0.104 |
| Total polyphenols (%) | 2.02 | 0.390 |
| **Mineral:** Macro-elements (%) | | |
| Calcium % | 3.65 | 0.036 |
| Phosphorus % | 0.30 | 0.004 |
| Magnesium % | 0.50 | 0.005 |
| Potassium % | 1.50 | 0.019 |
| Sodium % | 0.164 | 0.017 |
| Sulphur % | 0.63 | 0.146 |
| **Micro-elements (mg/kg)** | | |
| Zinc (mg/kg) | 31.03 | 3.410 |
| Copper (mg/kg) | 8.25 | 0.143 |
| Manganese (mg/kg) | 86.8 | 3.940 |
| Iron (mg/kg) | 490 | 49.645 |
| Selenium (mg/kg) | 363.00 | 0.413 |
| Boron (mg/kg) | 49.9 | 3.02 |

Another interesting aspect of the results reported here is the low percentages of anti-nutritional factors in the leaves, which though present were negligible. The value of condensed tannins was 3.12%, while

Foidl *et al.* (2001) reported 1.4% of tannins and did not detect the condensed tannins. The content of total phenols (2.02%) in this study was lower than previously reported values of 2.7 and 4.3% ( Foidl *et al.*, 2001). At these concentrations, simple phenols do not produce any adverse effects when consumed by animals (Foidl *et al.*, 2001)

It is also of remarkable interest that the dried Moringa leaves have high deposit of mineral elements. Calcium was observed to be higher compared with other plant sources (Nkafamiya *et al.*, 2010. Interestingly, even Fe, which is commonly deficient in many plant-based diets, was found in abundance in this plant's leaves. Results from this study had higher levels of zinc (31.03 mg/kg) than the findings of Barminas *et al.* (1998) who reported 25.5 mg/kg in dried Moringa leaves. The Moringa dried leaves contained Cu, which is considered to have strong effects on the immune system (Anwar *et al.*, 2007). Copper in combination with Zn, plays a role in superoxide dismutase activity and the removal of oxygen free radicals. Moringa has sulphur that is necessary for efficiency of rumen microbial growth and activity (Brisibe *et al.*, 2009). Moringa mineral composition plays a significant role in nutritional, medicinal and thera-peutic values (Al-Kharusi *et al.*, 2009).

**Table 3. Effect of supplement on growth, carcass and non-carcass measurements**

| Performance (variable) | Treatment | | | Significance |
|---|---|---|---|---|
| | Con (n=12) | MOL2 (n=12) | MOL1 (n=12) | |
| Initial body weight | 7.86±0.80 | 7.68±0.80 | 7.35±0.80 | NS |
| Final body weight | 10.46±1.16a | 13.75±1.16b | 13.55±1.16b | * |
| Empty Body Wt. (EBW) | 7.61±1.19a | 12.10±1.19b | 11.40±1.19b | * |
| Hot Carcass Wt. (HCW) | 5.46±0.62a | 7.18±0.62b | 7.14±0.62b | * |
| Cold Carcass Wt. (CCW) | 5.08±0.60a | 7.05±0.60b | 6.90±0.60b | * |
| Chilling loss (%) | 5.32±0.36a | 4.07±0.36b | 4.29±0.36b | * |
| Dressing percentage | 44.9±0.63a | 50.8±0.63b | 50.0±0.63b | * |
| Average daily gain (g) | 43.3±7.85a | 101.3±7.85b | 103.3±7.85b | * |
| DM feed intake (g) | 404.5±1.00a | 491.5±1.00b | 490.75±1.00b | * |

Means in the same row with different letters differ significantly (P<0.05); NS not significant (P>0.05); *P<0.05

## Growth performance

Goats supplemented with MOL1 and MOL2 completely consumed the daily feed ration, which translated into daily dry matter intake of 490.75 and 491.5 g, respectively (P>0.05), as shown in Table 3. The Con group took in significantly lower dry matter compared with that of the treatment group (MOL). The effect of different diets on growth performance is shown in Table 3. The two diets, MOL1 and MOL2, led to similar daily body gain of goats. However, goats on both diets gained significantly (P<0.05) more weight than those on the Con diet. There was an association (P<0.001) between treatment, body condition score, carcass conformation and carcass fatness. The body condition score of goats supplemented with MOL1 and MOL2 was higher (P<0.05) and had a higher (P<0.001) frequency of body condition score 4 than Con at slaughter (Table 4). At the same time, the carcass conformation of the MOL1 and MOL2 groups was better (P<0.001) than the Con group (Table 5). The carcass fatness for the MOL1 and MOL2 groups was classified as 4 and better (P<0.001) than Con (Table 6). Goats on MOL1 and MOL2 diets were heavier at slaughter and had consequently higher EBW, warm carcass weight and dressing percentages than those on the con diet. The dietary treatments significantly influenced the weight and proportion (in per cent) of EBW of the fresh non-carcass organs such as the lung, heart, fat, blood empty digestive tract and liver (Table 7). The proportional weights of the liver of goats fed on MOL1 diet and MOL2 were almost similar, having 2.12% and 2.16%, respectively (P>0.05). However, they were significantly higher than that of the Con diet. The effect of diet on the weight of fresh non-carcass organs and their proportions of empty body weight are summarized in Table 7. The goats on the MOL1 and MOL2 diets had a similar feed intake, however higher (P<0.05)

than goats on the Con diet. This could be because the MOL diets contained more readily digestible NDF fractions and high amounts of crude protein, resulting in high nutrient digestibility (Babayemi, 2009). *M. oleifera* leaves have been reported to have a high mineral content (Sánchez-Machado *et al.*, 2010); as such, it influenced the mineral content of the MOL diet. No sign of toxicity was observed

**Table 4. Frequency of Body Score Condition (BSC) values in goats supplemented with MOL**

| Supplement | Frequency (%) body condition score | | | Total | P value |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | | |
| Con | 20.8 (5) | 12.5 (3) | 0.0 (0) | 33.3 (8) | 0.001 |
| MOL1 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| MOL2 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| Total | 20.8 (5) | 12.5 (3) | 66.7 (16) | 100 (24) | - |

Values in parentheses indicate the number of cases

**Table 5. Frequency of carcass conformation values in goats supplemented with Con, MOL1 and MOL2**

| Supplement | Frequency (%) carcass conformation value | | | Total | P value |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | | |
| Con | 16.7 (4) | 16.7 (4) | 0.0 (0) | 33.3 (8) | 0.001 |
| MOL1 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| MOL2 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| Total | 16.7 (4) | 16.7 (4) | 66.7 (16) | 100 (24) | - |

Values in parentheses indicate the number of cases

**Table 6. Frequency of carcass fatness values in goats supplemented with Con, MOL1 and MOL2**

| Supplement | Frequency (%) carcass fatness value | | | Total | P value |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | | |
| Con | 25.0 (6) | 8.3 (2) | 0.0 (0) | 33.3 (8) | 0.001 |
| MOL1 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| MOL2 | 0.0 (0) | 0.0 (0) | 33.3 (8) | 33.3 (8) | - |
| Total | 25.0 (6) | 8.3 (2) | 66.7 (16) | 100 (24) | - |

Values in parentheses indicate the number of cases

**Table 7. Effect of diet on weight of fresh non-carcass organs and proportion of empty body weight**

| Organ weight | Con (n=8) | MOL2 (n=8) | MOL1(n=8) | Significance |
|---|---|---|---|---|
| Lung–trachea–diaphragm (g) | 247.37±5.98 | 261±5.98 | 256±5.98 | NS |
| Heart (g) | 91±2.75 | 96.63±2.75 | 96.88±2.75 | NS |
| Omental and kidney fat (g) | 69.5±9.15a | 240±9.15b | 243±9.15b | NS |
| Liver (g) | 259.4±24.34a | 401.0±24.34b | 398.63±24.34b | * |
| Kidney (g) | 41.87±0.91a | 45.37±0.91b | 45.51±0.91b | * |
| Empty digestive tract (kg) | 2.89±0.08b | 1.81±0.08a | 1.94±0.08a | * |
| Gut content (kg) | 3.4±0.108c | 1.64±0.10a | 2.15±0.10b | * |
| In % of empty body weight (EBW) | | | | |
| Lung–trachea–diaphragm (%) | 1.66±0.08 | 1.41±0.08 | 1.43±0.08 | NS |
| Heart (%) | 0.60±0.03 | 0.53±0.03 | 0.54±0.03 | NS |
| Omental and kidney fats (%) | 0.45±0.08a | 1.30±0.08b | 1.36±0.08b | * |
| Liver (%) | 1.65±0.08a | 2.13±0.08b | 2.18±0.08b | * |
| Kidney (%) | 0.27±0.02 | 0.25±0.02 | 0.23±0.02 | NS |
| Empty digestive tract (%) | 18.82±0.92b | 10.01±0.92a | 10.76±0.92a | * |
| Gut content (%) | 22.27±1.29b | 9.06±1.29a | 12.10±1.29a | * |

Means in the same row with different letters differ significantly ($P<0.05$); NS not significant ($P>0.05$); *$P<0.05$

in the experimental goats, which could be attributed to the availability of minerals to the animal as a number of minerals interact with each other for them to be absorbed or utilized by the animal (McDonald *et al.*, 2002).

The EBW, warm carcass weight and dressing percentage depend on FLW at slaughter (Mushi *et al.*, 2009) and were consequently affected by treatments. This was expected since the CP (16.05%) content in the Con diet was higher than the maintenance requirement (9.2%) of goats (NRC 2007). Van Soest (1994) demonstrated that body weight gain is not impaired if the level of CP in a given diet is more than 8%. Similarly, the rumen function is impaired when the nitrogen content of the diet is <1.2% (Solomon *et al.*, 2008). The MOL diet had the highest polyphenols of 2.02%, which seemed not to have caused any side effects. It has previously been reported that diets containing <4.5% have no adverse effects on ruminants (Solomon *et al.*, 2008). The goats fed on MOL diets had similar average daily weight gain (ADG) and body condition scores, both of which were higher ($P<0.05$) than those on the Con diet. It has been reported that increment in protein intake increases the feed intake, digestibility and, consequently, growth rate (Gebregiorgis *et al.*, 2011). Mendieta-Araica *et al.* (2011) reported that inclusion of *M. oleifera* in the diet significantly increased the feed intake and NDF digestibility of poor quality feed.

The ADG values (103.3±7.85 g/day) of goats supplemented with MOL diets were higher than those obtained in previous studies in goats fed on different levels of *M. oleifera* leaf diets (Aregheore, 2002). The higher ADG and body condition scores of goats on the MOL diets were higher than those on the Con diet, which could be partly due to the higher fat content in the MOL diets. Fats have been reported to boost protein nutrition by coating proteins, thus preventing ruminal microbial degradation, thereby increasing post-ruminal protein supplies (Safari *et al.*, 2009). The findings that supplementation with *M. oleifera* increases slaughter and carcass weights of goats were consistent with the literature (Mushi *et al.*, 2009). Body condition scores and live weight of goats at the time of slaughter have been reported to influence carcass quality and yields (Mushi *et al.*, 2009). In the present study, chilling losses decreased with increasing carcass weight; carcasses from Con had higher ($P<0.05$) chilling losses than of MOL supplemented goats, which are comparable. Chilling loss was higher in goats fed the Con diet, probably due to their lower fat content. The amount of fat has a large impact on carcass chilling loss; it is reported that fat acts as an insulation which slows down moisture evaporation (Mushi *et al.*, 2009). This findings coincide with those of Mushi *et al.* (2009) who assessed the effect of concentrate levels on carcass attributes. Chilling losses ranging from 2.3% to 8.7% were reported for different goat genotypes and different feeds (Mushi *et al.*, 2009). The higher carcass conformation scores for goats on MOL diets than Con diets can be associated with higher intakes of DM, energy and protein, which could have led to increased muscle weight (Safari *et al.*, 2009). This also suggests that goats respond to nutritional treatment by accretion of more muscle protein and fat (Safari *et al.*, 2009). The minimal difference in carcass fatness among dietary groups could be attributed to the unique fattening pattern of goats; they deposit most of the fat around the viscera and less in the carcass (Casey and Webb, 2010). Omental and kidney fats were heavier and similar in goats fed on MOL diets compared with those fed on Con diet, and this could be attributed to the high energy and protein intakes from the MOL diet.

An association between supplementary diet, body condition score, carcass fatness and carcass conformation was expected because as the body condition score increases, it results in the increment of carcass fatness and conformation (Aumont *et al.*, 1994). Supplementation of goats with nutritive feeds results in the improvement of body condition score (Table 4), carcass conformation (Table 5) and carcass fatness (Table 6). The organ weights of the kidneys, liver, lung–trachea–diaphragm and heart in goats on MOL diets (MOL1 and MOL2) were not significantly different and were heavier ($P<0.05$) than those from goats fed the Con diet. This was in agreement with the results of Sanon *et al.* (2008) who found that such organs were heavier in animals fed high-energy and protein diet compared with those fed on low-quality diet.

**Gross and histological observation of tissues during Postmortem examination**

At the end of the experiment, the animals were killed and duodenum was examined for any gross or histological changes (Fig. 1, 2 and 3). But no lesion was observed in the tissues collected for gross and histological study. There were no significant pathological changes in any internal organs of the goats

of treatment group and no lesion has been identified in the gastrointestinal mucosa of the parasitized animals fed on MOL mixed diet.

**Fig. 1. Histopathological section of duodenum of goat (H&E x 85) showing no lesion in control animals**

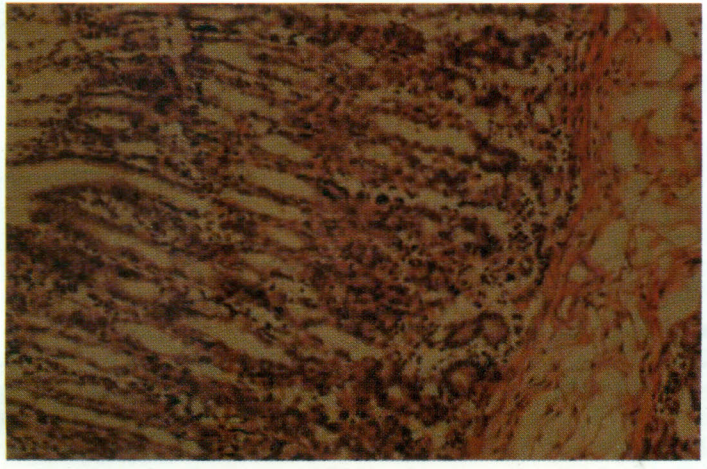

**Fig. 2. Histopathological section of duodenum of goat (H&E x 85) showing no lesion in MOL1 group animals**

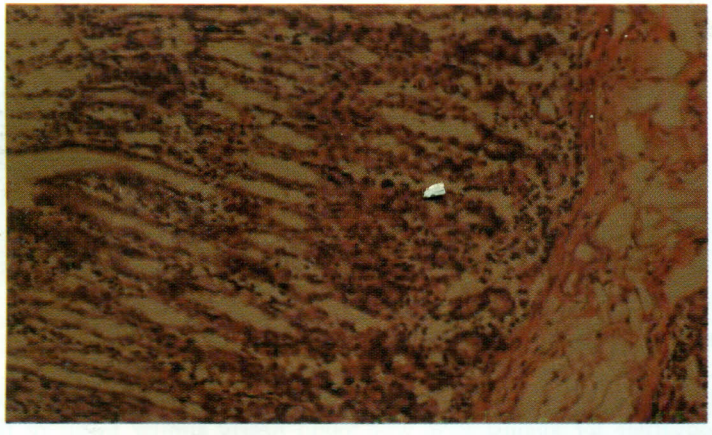

**Fig. 3. Histopathological section of duodenum of goat (H&E x 85) showing no lesion in MOL2 group animals**

**Moringa leaves on Haematological Parameter of goat**

Observation of haematological parameter (TEC, Hb, PCV, ESR) on the end of the experiment did not show any significant difference (P<0.05) between the control and MOL treated groups (Table-8). The haematological Parameter of goat supplemented with Moringa leaves showed no significant different result as compared to control group. The above parameter indicates that Moringa leaves have no adverse effect on goat production at haematological aspects.

**Table 8: Effect of Moringa leaves on Haematological parameter, blood cholesterol and antibody titer against PPR of goat**

| Experimental period | Parameters | Groups | Mean | Std. error Mean | Significance value |
|---|---|---|---|---|---|
| At the end of 90th day of experimental period | TEC | MOL1 | 15.5 million/cu.mm | 7.53 | NS |
| | | MOL2 | 16.1 million/cu.mm | 6.31 | |
| | | Con | 16.0million/cu.mm | | |
| | Hb | MOL1 | 11.49% | 0.06 | NS |
| | | MOL2 | 10.81% | 0.11 | |
| | | Con | 10.56% | | |
| | PCV | MOL1 | 34.10% | 0.57 | NS |
| | | MOL2 | 32.30% | 0.87 | |
| | | Con | 33.20% | | |
| | ESR | MOL1 | 59.16minitus/longer | 0.88 | NS |
| | | MOL2 | 58.23minitus/longer | | |
| | | Con | 56.63minitus/longer | 0.88 | |
| | Blood cholesterol | MOL1 | 100.3 mg/dl | 2.65 | * |
| | | MOL2 | 95.13 mg/dl | 2.24 | |
| | | Con | 108.2 mg/dl | 1.78 | |
| | Antibody titer against PPR | MOL1 | 74.86 | 1.98 | NS |
| | | MOL2 | 75.10 | 2.67 | |
| | | Con | 74.20 | 2.33 | |

NS not significant (P>0.05); *P<0.05

**Effects of MOL on serum cholesterol level of goat**

The effects of MOL on blood cholesterol level of goats are presented in the Table 8. During the starting of the experiment, it is exhibit that the serum cholesterol level of different groups of animals was same. With the advancement of age the serum cholesterol of control groups was increased. The highest serum cholesterol level (108.20 mg/dl) was found at the 90th day of the experiment, which was statistically significant (p<0.05) as compared to MOL groups. On the other hand with the time the serum cholesterol of the MOL1 treated animals decreased. The highest serum cholesterol level (110.3 mg/dl) was found on 1st day of the experiment. On the 90th day of the experiment the serum cholesterol level of MOL1 treated animals was 100.3 mg/dl which was the lowest and was statistically significant (p<0.05) as compared to Con. The experiment reveals that MOL has a cholesterol lowering effect. The decrease in serum cholesterol level of MOL treated animals was consistent with the authors (Park *et al.*, 2001; Choi *et al.*, 2004; ). With the advance of age the serum cholesterol of MOL2 treated animals was also decreased. The highest serum cholesterol (109.80 mg/dl) was found at first day of the experiment. At the last day of the experiment the serum cholesterol level of MOL2 treated animals was 95.13 mg/dl which was statistically significant (p<0.05) as compared to Con (Table 8). This result was consistent with a report suggested by Anderson *et al.* (1995). The decrease of serum cholesterol was due to the effect of some potent cholesterol lowering agents existing in MOL were suggested as the agent reducing serum cholesterol.

**Parasitic loads and Immunological profile**

There were not exceptional parasites shown in both of Con and MOL groups. All of the parasites found were as usual and no parasitic load was found nil in all of the goats feces collected from different groups. The antibody titer for against PPR was found nearly similar in all of the groups and no significance difference was shown in Table 8.

## CONCLUSION

In conclusion, the data derived from nutrient characterization of Moringa are clear indications that the plant leaves are rich in nutrients and has potential to be used as a feed additive with multiple purposes. High nutritional content found in the dried leaves are important nutritional indicators of the usefulness of the plant as a likely feed resource. The goats fed the MOL diet had improved growth rate and carcass measurements, and it compared well with goat performance fed with the known commercial diet. The experiment also reveals that MOL has a cholesterol lowering effect. As such, M. oleifera can be used as a supplement for feeding ruminants such as goat to improve the production performance.

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