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Evaluation of Moringa (*Moringa olifera*) and other tree leaves based complete pellet on growth, nutrient utilization and serum metabolites in growing Barbari goats

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ABSTRACT

Moringa (*Moringa olifera*), subabul (*Leucaena leucocephala*) and mulberry (*Morus alba*) based complete pellets were formulated and comparatively evaluated in growing male Barbari goats (age 3-4 months with a mean body weight of 9.3 kg). Twelve goats were divided into three groups (Gr M, Gr S1 and Gr S2) of 4 each as per a completely randomized design. Gr M was fed with moringa based complete pellet while Gr S1 and S2 were fed with subabul and mulberry based complete pellet feed. Experimental feeding cum growth trial duration was 52 days. Weekly body weight changes and effect on serum attributes were recorded. A metabolic trial of six days duration was conducted after six weeks of experimental feeding to study different nutrients digestibility, nitrogen utilization, and balance. The daily live weight gain (g) was statistically similar in Gr M (48.07), Gr S1 (46.15) and Gr S2 (42.78). Daily dry matter intake (g) was statistically more in Gr M as compared to Gr S1 and Gr S2 in which it was statistically similar. The dry matter intake (% BW) was 5.46, 3.68 and 4.38 in Gr M, Gr S1, and Gr S2 respectively, showing better palatability of moringa based pellet feed. There was no significant difference in digestibility of dry matter, organic matter, ether extract, total carbohydrate, and neutral detergent fibre between the three groups. Crude protein and acid detergent fibre digestibility was statistically higher in Moringa fed group (Gr M). Nitrogen balance (g/day) was statistically higher in Gr M and Gr S2 in comparison to Gr S1. Nitrogen absorbed (g/day) was significantly lower in Gr S1 (4.57) as compared to Gr M (10.13) and Gr S2 (8.17), which were statistically similar. The N balance (%) of N intake (g/day) and N absorbed (g/day) followed the same pattern. Total protein, globulin, and serum urea nitrogen were significantly higher in Gr S1 fed with *Leucaena* based complete pellet as compared to Gr M and Gr S2. From the present study it can be concluded that overall performance of growing goats is better on moringa and mulberry based complete pellet feeding than subabul based complete pellet feeding. However, intake and digestibility of nutrients were better with moringa based complete pellet as compared to Mulberry based complete pellets in goats.

Keywords: Complete pellet feed, Goats, Growth, Moringa, Nutrient utilization, Serum metabolites

Tree fodder represents a sizable portion of the diet of small ruminants. Naturally, goats utilize more than 90% of their grazing time in browsing on top feed and hardly 10% on surface vegetation, that too, when top feed is scarce (Acharya 1992). Tree fodder also acts as emergency fodder or scarcity fodder when green fodder is not available during the lean period in all the livestock species. Trees lopping from neem, pakar, subabul, etc. can be used as a source of fodder for up to 30% of total dry matter intake in case of small ruminants, particularly goats (Dutta 2009). The leaves of tree fodders are considered nutritious feed due to their high proteins, vitamins and minerals (Baumer 1992, Rana *et al*. 1999). They are also a source of plant secondary metabolites having many health benefits. They can provide fodder around the year once planted. Tree leaves play an important role in the nutrition of grazing animals in areas where few or no alternatives are available. Nowadays, the traditional grazing based system of goat farming is transforming into a stall-fed system due to reduced availability of pasture or grazing resources. Commercial goat farms are coming up to cater to the increased demand for goat meat and a better business opportunity. Feeding stall goats with tree leaves based on complete feed is a good choice. At ICAR-CIRG, Makhdoom, moringa fodder is being cultivated and utilized as a feed resource for goats. *M. oleifera* leaf is high in nutritive value and a green biomass production of up to 100 tons/hectare has been reported in the semi-arid region of India (Kumar 2023). Moringa varieties like PKM-1, PKM-2 have been developed to grow Moringa for its green biomass as foliage. Inclusion of Moringa in the ration of goats has been found to improve growth, milk production and nutrient utilization (Kumar *et al*. 2024, Babiker *et al*. 2017, Kholif *et al*. 2018). Moringa due to its high biomass production and high

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nutritive value can be justified as a potential feed resource in the diet of ruminants, particularly goats. Tree leaves like *M. azedarach, M. alba* and *Leucaena* proved to be excellent un-convention feedstuffs for small ruminants on the basis of chemical composition, digestibility of nutrients and efficiency of utilization of nutrients (Bakshi and Wadhwa 2007). Keeping in view these facts in background, the present study was conducted to evaluate Moringa based complete pellet with commonly available tree leaves like subabul and mulberry in growing goats for its potential as a component of complete pellet feed.

MATERIALS AND METHODS

Animal management and rations: Experimental feeding cum growth trial was conducted in the animal shed of the Animal Nutrition Management and Products Technology Division of ICAR-CIRG, Makhdoom. Geographically, the institute is located at 27° N latitude, and 78° N E longitude on 176 m above sea level. Twelve Barbari male goats, approximately 3–4 months of age with a mean body weight of 9.3 ±0.49 kg were divided into three groups (Gr M, Gr S1 and Gr S2) of four each as per a completely randomized design. The ration of Gr M was moringa (*Moringa olifera*) based complete pellet while for Gr S1 and S2 was subabul (*Leucaena leucocephala*) and mulberry (*Morus alba*) based complete pellet feed. All three complete pellet feeds were prepared in the Experimental feed unit of the division. The leaves of moringa, subabul and mulberry were collected from the agriculture farm of institute and sun-dried. Sundried leaves biomass was mixed with other ingredients such as crushed barley, mineral mixture and salt as per composition in Table 1. Mixed biomass was put in pellet making machine and complete pellets were prepared. These three complete pellets were iso nitrogenous and were fed to goats to meet their nutrient requirement as per NRC (2007). Goats of different groups were housed in well ventilated single shed having individual cage with facilities for feeding, watering and other management. Goats of different groups were fed with respective pellet and water was made available round the clock.

Experimental procedure: The duration of the experimental feeding cum growth trial was fifty two days. During the trial daily calculated quantities of respective pellets were offered to all the three groups of goats at two times: morning (08:00AM) (half of amount) and afternoon (2.00 PM) (half of amount). *Ad libitum* clean and wholesome drinking water was provided during the trial. To determine dry matter (DM) intake, weekly sampling of offered and residues pellets were sampled and subsequently analyzed for dry matter. Live weight changes were determined by recording body weight of each goat at 0 hr post feeding using a digital weighing machine at a weekly interval. The average growth rate was calculated on the basis of live weight changes during the feeding cum growth trial. To study the effect on blood metabolites after pellet feeding blood was collected in last week of trial by jugular vein puncture from the animals of different group. The blood was allowed to clot, and extraction of serum was done. Extracted serum was kept at –4°C. Different serum metabolites like glucose, protein, its fractions, triglycerides; cholesterol etc was estimated from this serum. Metabolism trial of six days duration was conducted after 6 weeks of feeding trial for estimation of digestibility of different nutrients and utilization of nitrogen. Metabolism trial was done in metabolic cages in which individual feeding and separate collection of urine and faeces was feasible. For dry matter estimation, feed pellet samples along with their residue from each animal were taken daily in previously tared trays and kept at 100±2°C in a hot air oven for 10-12 hr. Amount of faeces voided by the individual animal in 24 h was collected in a previously weighed container and weighed. Then faeces were properly mixed and a representative sample was kept in a properly labeled plastic bag individually animal wise. A 10% aliquot of individual goat faeces was taken. The fecal aliquot was used for dry matter estimation by drying at 100±2°C in a hot air oven. The dried material (offered and leftover complete pellet, and feces) obtained during the trial period was pooled individually and later on used for nutrient composition analysis after grinding. Estimation of proximate and fibre was done from these samples of complete pellet, residue and feces. For nitrogen estimation in feces, an aliquot (1% of fresh faeces) was properly mixed with 10 mL of 1:4 sulphuric acid and preserved in a glass bottle. For assessment of daily output of urine, collected urine during the 24 h period was measured using a measuring cylinder. Out of this urine, about 2% v/v (aliquot) of daily urine from each animal was taken and mixed with 40 mL of laboratory grade sulphuric acid (98.0%) in Kjeldahl flasks. Later on, this was used for nitrogen estimation in urine.

Laboratory and statistical analysis: Analysis of nutrient composition of offered and residue feed, urine, and faeces was done using the standard protocol as per AOAC (1995). Dry matter of feed sample was estimated by drying in a hot air oven at 100 ± 1°C until a constant dry weight was achieved. Organic matter (OM) was determined by de carbonization and then ashing at 550°C for 5 h in a muffle furnace. Crude protein (CP) was measured as nitrogen content (N × 6.25). Ether extract (EE) was estimated using Soxhlet apparatus. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were discerned as per Van Soest *et al*. (1991) and expressed inclusive of ash. The stored serum was used for analysis of different metabolites using diagnostic kits. Glucose was estimated by the glucose oxidase (GOD) method. Total protein in serum was measured by the Biuret method (Wotton 1964). Albumin content in serum was estimated using bromocresol green dye (BCG), as per the method of Doumas *et al*. (1971). Globulin content in serum was calculated by subtracting the albumin concentration from the total protein concentration of serum. Analysis of triglycerides and cholesterol were done by GPO-PAP endpoint assay and CHOD-PAP enzymatic method respectively.

The data obtained during the experimental trial on body

weight changes, nutrient digestibility, nitrogen balance and serum metabolites was statistically analysed for their significance using one–way ANOVA as per Snedecor and Cochran (1989) using SPSS software. Group means were compared and studied using Duncan's multiple range test (DMRT) and significance was declared at a 5% level of confidence.

RESULTS AND DISCUSSION

Composition of complete pellet feed: The ingredient and nutrient composition of the complete pellet formulated and used during the feeding cum growth trial is given in Table 1. The ratio of roughage and concentrate portion was approximately 70:30. All the pellets were made iso-nitrogenous containing around 16% crude protein. Among fibre fractions NDF and ADF were higher in moringa based complete pellet as compared to subabul based complete pellet and mulberry based complete pellet feed.

Growth and feed intake: There was no significant (p>0.05) difference in live body weight gain in different groups of goats (Table 2). Total body weight gain (kg) of goats was 2.50 for Gr M, followed by Gr S1 (2.40) and Gr S2 (2.22) without any significant difference (p>0.05) between the growing goat groups during 52 days of experimental feeding. Average daily gain (g) was statistically similar between groups, being 48.07 for Gr M followed by Gr S1 (46.15) and Gr S2 (42.78). Though statistically similar body weight gain was reported during the study period, in Gr S1, it was found that after 3 weeks of experimental feeding on subabul containing complete pellet, there is decline the body weight gain and daily dry matter intake (Fig. 1, 2).

Singh *et al*. (2010) also reported no significant change in the body weight gain of the goat when the concentrate mixture was 50% replaced with a leaf meal mixture having equal proportions of *Leucaena leucocephala*– *Melia azedarach*– *Morus alba*. Kumar *et al* (2015) reported similar average daily body weight gain by feeding goats on azolla containing (10% on weight basis) complete pellet feed. Since all the pellets were made iso- nitrogenous having around 16% CP, similar body weight gain was reported between groups. Dry matter intake (g/day) during the whole of trial and overall FCR were 497.76; 10.35 and 420.32 and 9.10 and 530.21 and 12.39 for moringa, subabul and mulberry based complete pellet fed groups respectively. Kearl (1982) stated that voluntary feed intake varied from 1.1 to 4.1% of live weight for goats in the tropical environment. In the present study, the daily total dry matter intake of goats was about 4.29–4.90% of the body weight of the goats, irrespective of type of pellet feed. Intake data reflected that all three complete pellets formulated using tree leaves had good palatability with no bitter taste or smell. However, Kumar *et al*. (2022) studied the effect of subabul based complete ration on growth and

Table 1. Ingredient and chemical composition of different complete pellet feeds and tree leaves

Ingredients (%)	Moringa (*Moringa olifera*) based complete pellet	Subabul (*Leucaena leucocephala*) based complete pellet	Mulberry (*Morus alba*) based complete pellet	Moringa (*Moringa olifera*) leaf	Subabul (*Leucaena leucocephala*) leaf	Mulberry (*Morus alba*) leaf
Dried leaves	70	70	70			
Barley grain	27	27	23			
Linseed cake	0	0	4			
Mineral mixture	2	2	2			
Salt	1	1	1			
Chemical composition (% DM)						
Organic matter	88.28	88.18	84.15	87.51	90.56	86.67
Crude protein	16.15	16.32	16.02	20.52	20.05	17.98
Ether extract	6.45	8.09	5.13	7.41	8.23	6.12
Total ash	11.72	11.82	15.85	12.49	9.44	13.33
Acid insoluble ash	0.92	1.48	0.40	1.05	1.25	1.89
Total carbohydrate	65.68	63.77	63.00	59.58	62.28	62.57
Neutral detergent fibre	37.55	31.11	27.19	27.12	28.58	29.76
Acid detergent fibre	27.60	18.15	14.97	18.12	18.23	21.71

Table 2. Effect of feeding different complete pellet on growth, feed intake and feed conversion ratio in growing goats

Attribute	Gr M	Gr S1	Gr S2	Sig
Initial Body weight (kg)	9.25±0.99	9.00±0.65	9.65±1.01	0.882
Final body weight (kg)	11.75±0.88	10.53±1.36	11.87±0.73	0.679
Total body weight gain (kg)	2.5±0.26	2.4±0.64	2.22±0.54	0.579
Average daily gain (g)	48.07±5.15	46.15±2.24	42.78±10.39	0.579
Feed intake (g)	497.76±13.35	420.32±13.39	530.21±12.26	0.543
Feed conversion ratio	10.35	9.10	12.39	

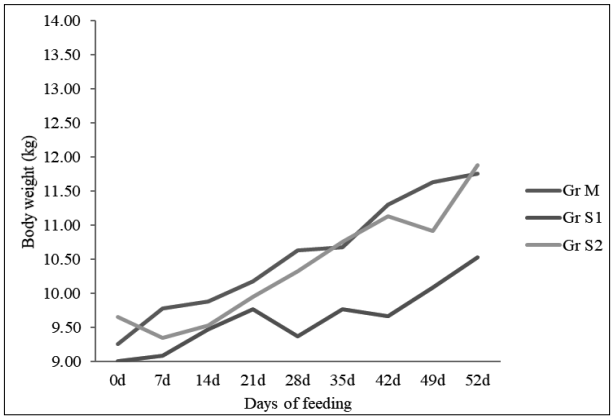

Fig. 1. Body weight changes in different groups of growing goats

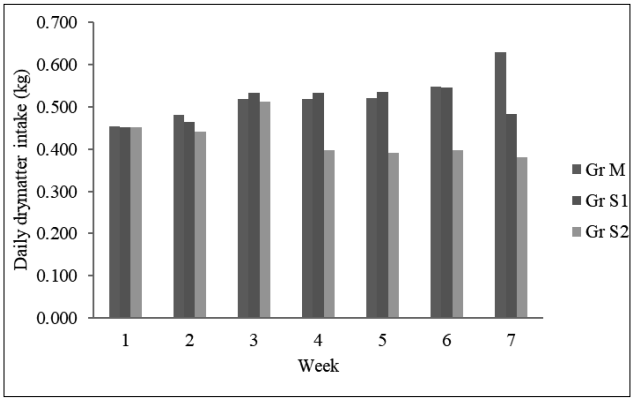

Fig. 2. Daily dry matter intake in different groups of growing goats

carcass characteristics in non-descript goats and reported lower body weight gain in kids fed 30 and 40% subabul leaves as compared to the control group of kids. In present experiment, complete pellet contained around 70 % dried leaves of different trees and 30% grain along with other ingredients. The overall body weight gain and FCR were statistically similar within all three groups of goats. The difference may be due to content of mimosine and other anti-nutritional metabolites in the *Leucenea* leaves and adoptability of rumen microbes for their degradation.

Nutrient digestibility and balance of nitrogen: The intake of dry matter (g/d and g/% BW) was significantly (p<0.05) higher in moringa complete pellet group (Gr M) in comparison to subabul (Gr S1) and mulberry (Gr S2) complete pellet groups indicating better palpability of Moringa pellets on long-term feeding in growing kids (Table 3). Similar pattern was observed with TDN and DCP intake. TDN (%) was similar in all three pellets, but DCP

Table 3. Effect of feeding different complete pellet on intake, digestibility and nitrogen balance in growing goats

Attribute	Gr M	Gr S1	Gr S2	Sig
Body weight (kg)	11.46±0.87	9.79±1.59	11.01±0.86	0.576
Metabolic body size ($BW^{0.75}$) kg	6.21±0.35	5.50±0.66	6.03±0.36	0.559
Dry matter intake (g/day)	618.30^{a}±43.68	348.98^{b}±23.76	476.21^{b}±40.66	0.005
Dry matter intake (% body weight)	5.46^{a}±0.48	3.68^{b}±0.42	$4.38a^{b}$±0.42	0.05
TDN Intake (g/day)	346.97^{a}±41.26	176.86^{b}±3.14	264.54^{ab}±42.44	0.044
DCP Intake (g/day)	63.32^{a}±5.71	28.57^{c}±2.45	51.06^{b}±7.24	0.005
TDN (%)	55.55±2.77	51.17±3.59	54.63±4.46	0.718
DCP%	10.21^{a}±0.30	8.26^{b}±0.83	10.58^{a}±0.61	0.05
Digestibility %				
Dry matter	54.55±3.39	46.24±3.23	57.95±5.23	0.203
Organic matter	58.81±2.44	52.38±3.35	61.77±4.67	0.273
Crude protein	63.23^{a}±1.89	50.61^{b}±5.13	66.06^{a}±3.86	0.045
Ether extract	45.44±9.63	49.33±6.44	41.55±9.22	0.842
Total carbohydrate	59.01±2.42	53.22±2.84	62.32±4.73	0.285
Neutral detergent fibre	37.36±3.36	32.66±3.1	33.39±8.97	0.851
Acid detergent fibre	45.13^{a}±2.87	21.59^{b}±2.32	22.58^{b}±8.21	0.029
N balance				
N intake (g/day)	15.97^{a}±1.12	9.11^{b}±0.62	12.2^{b}±1.04	0.005
N excretion in faeces (g/day)	5.84^{a}±0.37	4.54^{ab}±0.71	4.03^{b}±0.199	0.034
N excretion in urine (g/day)	1.34±0.11	1.8±0.146	1.51±0.25	0.309
Total N excretion (g/day)	7.18±0.37	6.34±0.82	5.54±0.30	0.098
N balance (g/day)	8.78^{a}±0.83	2.76^{b}±0.38	6.65^{a}±1.18	0.007
N absorbed (g/day)	10.13^{a}±0.91	4.57^{b}±0.39	8.17^{a}±1.15	0.013
N balance (%) of N intake (g/day)	54.76^{a}±1.62	30.85^{b}±5.10	53.44^{a}±4.96	0.007
N balance (%) of N absorbed (g/day)	86.63^{a}±0.96	60.07^{b}±4.44	80.55^{a}±3.74	0.001

Gr M: fed with moringa (*Moringa olifera*) based complete pellet, Gr S1:fed with mulberry (*Morus alba*) based complete pellet, Gr S2: fed with subabul (*Leucaena leucocephala*) based complete pellet *mean with different superscript in a row differ significantly (p<0.05)

(%) was significantly (p<0.05) higher in Gr M (10.21) and Gr S2 (10.58) and least in Gr S1 (8.26). These indicated that the effect of the antinutritional factor mimosine present in *L. leucocephala* is shown after 40 days of feeding. Feeding of subabul in goat kids can lead to chronic toxicity leading to inappetence, skin loss, etc. (Hatzade *et al*. 2020). There was no significant difference in the digestibility of dry matter and organic matter among groups. However, lower value of digestibility in dry matter and organic matter was reported in goats fed on subabul based complete feed. Ether extract, total carbohydrate, and neutral detergent fibre (NDF) digestibility were also similar among groups. Crude protein digestibility (%) was significantly (p<0.05) lower in Gr S1 (50.61) as compared to Gr M (63.23) and Gr S2 (66.06). Acid detergent fibre (ADF) digestibility (%) was statistically higher (p<0.05) in Gr M (45.13) as compared to Gr S1 (21.59) and Gr S2 (22.58). The difference may be due to the effect of anti-nutritional factors present in tree leaves like tannins which have adversely affected the fibre-degrading microbes and protein degradation in the rumen. Wang *et al*. (2022) also reported that tannic acid reduced apparent protein digestibility without altering the growth performance and ruminal microbiota diversity of Xiangdong black goats. The inclusion of *Leucaena* as a replacement for conventional protein supplements in the ration of goats has been found to reduce the crude protein digestibility by other workers also (Srivastava and Sharma 1998, Singh *et al*. 2010). The reason for the reduction in crude protein digestibility has been assigned to phenolics (tannins), plant secondary metabolites which form a rumen non-degradable material with proteins fraction of feed (Rittner and Reed 1992, Bonsi *et al*. 1994). In the present experiment about 70% of dry biomass of feed is coming from tree leaves, but in moringa and mulberry-based complete pellet feed negative effect on nutrient digestibility is less as compared to subabul, indicating the higher level and long-term inclusion of these tree leaves in the feed of goats with no negative effect on nutrient utilization. Nitrogen intake (g/day) was significantly less in Gr S1, which may be due to lower intake of dry matter. All three dietary groups of goats had positive nitrogen balance. This clearly indicated that the nutritional level of all the goats given different complete pellet feed ration was adequate and sufficient for proper growth. Among nitrogen utilization, nitrogen balance (%) with respect to N intake and N absorbed (g/day) was significantly lower in Gr S1 fed with *Leucaena* based complete pellet feed. This might be due to secondary metabolites present in leaves that have been discussed above. Result indicated better nitrogen utilization in goats fed with moringa and mulberry leaf based complete pellets as compared to goats fed with subabul based complete pellets.

Serum metabolites: Serum glucose level (mg/dl) was 71.63 in Gr M, 69.79 in Gr S2 and 60.67 in Gr S1 being the lowest in goats fed with subabul based complete pellet, though statistically similar. Serum glucose concentration in the goats of all three groups was in between 50–75mg/dl (normal range of goats as per Kaneko 1997). Akbar and Gupta (1985) also reported a significant decrease in the blood glucose level of goats fed with diets containing 50% CP replaced by *Leucaena*, indicating hypoglycemic effect of mimosine. In present study, around 85% of crude protein was provided by *Leucaena* leaves. Singh *et al*. (2010) reported no hypoglycemic effect of mimosine when *Leucaena* leaf was lower in amount (around 7% of ration) and a mixture of different tree leaves was used in the formulation of ration. Mean serum albumin, cholesterol and triglyceride levels in different groups of growing goats were statistically similar (Table 4). However, significantly (p<0.05) higher levels of total protein, globulin, and urea were found in the subabul pellet fed group (S1) as compared to Gr M and Gr S2. Total serum protein (g/dL) was 6.44, 7.50, and 5.99 in Gr M, Gr S1, and Gr S2, respectively being significantly higher in Gr S1 fed with *Leucaena* based complete pellet feed. Proteins concentration in serum mainly depends on the liver status of the animal, its function ability, and any disorder if present. The type, extent, and inflammation of hepatic cell disorder as well as other organ disorders can also modulate the protein serum concentration. Kaneko (1997) had suggested normal total serum protein ranges from 6–7.5 g/dL. In the present experiment, serum protein concentration was in normal range. Serum albumin and globulin levels of goats were also within the normal range as suggested by Kaneko (1997) during the experiment without any treatment effect. The higher protein level in Gr S1 is due to a significantly higher level of serum globulin. Prolonged feeding on ration with *Leucaena* in lambs led to no change in total protein (Mahanta *et al*. 1999). The serum urea nitrogen was higher than the normal range (10–20 mg/dl)

Table 4. Effect of feeding different complete pellets on serum metabolites in growing goats

Parameter	Gr M	Gr S1	Gr S2	Sig
Glucose (mg/dL)	71.63±0.98	60.67 ±2.60	69.79±3.29	0.566
Total protein (g/dL)	6.44^{b}±0.22	7.50^{a}±0.49	5.99^{b}±0.08	0.015
Albumin (g/dL)	4.55±0.21	4.01±0.079	4.62±0.12	0.074
Globulin (g/dL)	1.89^{b}±0.39	3.48^{a}±0.42	1.36^{b}±0.21	0.008
Serum urea (mg/dL)	24.10^{b}±1.66	31.25^{a}±0.62	22.85^{b}±0.92	0.004
Cholesterol (mg/dL)	77.93±1.30	79.08±4.74	75.89±0.67	0.646
Triglycerides (mg/dL)	110.55±2.74	96.29±6.25	102.77±3.01	0.091

Gr M: fed with moringa (*Moringa olifera*) based complete pellet, Gr S1: fed with mulberry (*Morus alba*) based complete pellet, Gr S2: fed with subabul (*Leucaena leucocephala*) based complete pellet, *mean with different superscript in a row differ significantly (p<0.05)

as suggested by Kaneko (1997) indicating a higher level on the feeding of tree leaves based diet. Adelusi *et al*. (2016) also reported a sharp increase in the BUN of goats fed tree leaves from 0 to 6 h post-feeding compared to goats fed the control diet. They attributed this to an increase in rumen NH_3-N concentration. Lewis (1975) affirmed that the concentration of plasma urea N is highly correlated with the concentration of ammonia production in rumen.

From the present study, it can be concluded that the overall performance of growing goats is better on Moringa (*Moringa olifera*), and mulberry (*Morus alba*) based complete pellet feeding than subabul (*Leucaena leucocephala*) based complete pellet feeding. However, intake and digestibility of nutrients were significantly higher in moringa (*Moringa olifera*) as compared to mulberry (*Morus alba*) based complete pellet feeding. So dried moringa biomass can be better utilized in the form of complete pellet feed in the growing goat ration.

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