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Research article

Effect of feeding *Moringa oleifera* dried leaves on growth performance, blood biochemical status and economy of production in Barbari goats

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Abstract

A three-months feeding trial was conducted to investigate the effect of feeding *Moringa oleifera* leaves as replacement to concentrate in the ration of growing goat. Eighteen female Barbari goats of uniform age and conformation (16.65 ± 1.20 kg; 11 to 13 months) were divided randomly into three groups. The animals in control group (T_1) were fed basal diet consisting of roughage and concentrate in equal proportion, whereas in treatment groups T_2 and T_3 the concentrate mixture was partially replaced with dried *Moringa oleifera* leaves at 05% and 10% levels, respectively. Significantly ($P<0.01$) higher average daily feed intake was recorded in T_3 group compared to T_1 and T_2 groups. Mean daily body weight gain was significantly ($P<0.01$) higher in T_3 group, than T_2 and T_1. The biochemical parameters showed significant ($P<0.01$) lowering in blood cholesterol in T_3 and a significant ($P<0.05$) elevation in total protein and globulin at the end of experiment. The cost-benefit analysis of dietary treatment showed that it was 0.79, 0.83 and 1.02 for T_1, T_2 and T_3, respectively. It was concluded that dried *Moringa oleifera* leaves could replace up to 10% of concentrate in growing goats without impairing their performance and health status, while reducing the cost of feed.

Keywords: Barbari goats, Feed efficiency, Feeing economics, Growth performance, *Moringa* leaf meal

Introduction

Goats are highly versatile animals and considered more resilient than other livestock species. They can thrive well on diverse types of grasses, legumes and tree leaves. Utilization of foliage from trees and shrubs could be a potential strategy for increasing the quality and availability of feeds for resource poor livestock farmers and producers round the year. The trees provide cheaper alternatives to protein and other micronutrients (Moyo *et al*., 2012; Sultana *et al*., 2015). Moringa tree leaves are superior to low quality roughages and grasses that are deficient in nitrogen with high ligno-cellulose content (Sultana *et al*., 2014). *Moringa* leaves are rich source of vitamins and minerals to complement deficiencies in basal feed resource (Gerbregiorgis *et al*., 2012). The intake and digestibility of poor quality roughages could be enhanced by supplementing concentrate diets along with leaf meal (Sultana *et al*., 2015). Moreover, conventional feed resources (grains, cereals, legumes, etc.) for animal production are scarce and highly expensive in many parts of the world (Babeker and Bdalbagi, 2015). This situation has led to consideration of other means of ration formulation considering alternative and less expensive feed ingredients with adequate protein content having balanced amino acid profile (Halmemies *et al*., 2018). In recent years, there has been increased research on alternative protein sources from forage trees and shrubs that can be fed to goat and sheep.

Moringa oleifera leaf meal is used as an alternative protein source and regular feed resource in animal production system especially goat rearing (Asaolu *et al*., 2010) and other ruminants (Halmemies *et al*., 2018). Moringa leaves contained between 25.7 to 26.1% crude protein (Sultana *et al*., 2014) and negligible amounts of anti-nutritive compound, such as phenols and tannins (Aye and Adegun, 2013; Parthiban *et al*., 2022). Conventional concentrate mixtures used for feeding livestock consist of grains, cereal by-products and oil seed cakes at variable ranges, depending on market prices which usually contain 16 to 20% CP. Moringa being rich source of protein may be one of the alternatives to conventionally mixed concentrates. This study was planned to investigate the feeding value of *Moringa*

oleifera leaves as alternative local feed resource in Barbari goats.

Materials and Methods

Experimental design and feed materials: The present study was conducted at Instructional Livestock Farm Complex, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India. Eighteen female Barbari goats (16.65 ± 1.20 kg) of age (11 to 13 months) were selected and divided in to three groups using completely randomized block design. Separate, well-ventilated stalls were provided to each group under uniform managemental practices. All the animals under experiment were de-wormed at the beginning of experiment using Fenbendazole bolus and were examined periodically for any parasitic infestation. The animals were allowed 10 days of adjustment period during which they were gradually introduced to the experimental diets. The study was carried out for a duration of 3 months (November 2020 to February 2021).

Moringa oleifera leaves were collected from ICAR-Indian Institute of Farming System Research, Meerut. The leaves were air dried in sun and mashed in powdered form. The balanced diet was formulated based on the body weight of experimental animals under different treatment groups on dry matter basis, according to ICAR (2013) and adjusted biweekly. Roughages included two parts of green fodder comprising of berseem and oat and one part of wheat straw. Commercially available high energy feed (CP: 21.04 ± 0.83%, CF; 8.92 ± 1.34%) was used as a concentrate feed and *Moringa oleifera* dried leaves (CP: 29.15 ± 0.55%; CF: 10.10 ± 0.30%) were used as experimental feed for replacing the conventional concentrate in feeding of Barbari goats. The control group T_1 was fed basal diet consisting of equal proportion of roughage and concentrate. The treatment group T_2 and T_3 were fed basal diet having partial replacement of concentrate with dried *Moringa oleifera* leaves at 5 and 10% levels, respectively. The chemical composition of different experimental feeds was also recorded (Table 1).

Growth performance and feeding economics: The individual animals were weighed on digital spring balance during morning hours before offering feed and water, and body condition score (BCS) was recorded on 1 to 5 scale (Ockert, 2015) with a panel of experts at fortnightly interval in 90 days feeding trial. During the entire experimental period, the measured quantity of respective experimental feed was provided to each group twice a day at 9 am and 3 pm in equal portions and the left over was weighed next morning to assess daily feed consumption. The average daily feed intake in all the groups was calculated. The chemical composition of feed ingredients and experimental diet were analyzed according to standard procedure of the AOAC (2005). The feed cost was calculated based on the actual cost of feed and fodder. The income from the gain in body weight was calculated from the market rate of goat based on live body weight and net profit/kg live body weight was estimated.

Statistical analyses*:* The generated data of the feed intake, growth performance, and feed efficiency were analyzed by a mixed model for repeated measurements (PROC MIXED) in Statistical Package for the Social Sciences (SPSS for windows, V20.0; SPSS Inc., Chicago, IL, USA) by using following model: $Y_{ij} = \mu + T_i + + e_{ij}$; where, Yij was the dependent variable; μ was the overall mean of a population; Ti was the effect of treatments; eij was the random error. Tukey multiple range test was applied to treatment means which showed a statistically significant variation in the samples. The difference was considered significant at $P<0.05$. The

Table 1. Chemical composition (% DM basis) of experimental diets

Attributes	T_1	T_2	T_3
Dry matter	65.55±0.27	65.58±0.24	65.61±0.28
Organic matter	89.74±0.04	89.74±0.05	89.74±0.07
Crude protein	14.89±0.10	15.25±0.22	15.61±0.24
Ether extract	2.52±0.02	2.94±0.02	3.35±0.02
Crude fibre	20.62±0.12	20.62±0.16	20.61±0.10
NFE	51.71±0.14	51.04±0.12	50.37±0.12
NDF	56.17±0.15	55.23±0.09	55.21±0.10
ADF	32.26±0.07	32.11±0.07	31.84±0.09
Ash	10.26±0.04	10.26±0.04	10.26±0.07

comparative economics of feeding dried moringa leaves to the experimental animals was calculated based on actual cost of feed and fodder.

Results and Discussion

Feed intake and growth performance: The average daily feed intake (DM basis) in Barbari goats fed dried moringa leaves was 609.26, 614.74, 637.47 g/d in T_1, T_2 and T_3 groups, respectively. The dry matter intake in goats in T_3 was significantly (P<0.01) higher than T_2 and T_1 (Table 2). The mean body weight at different fortnights showed a linear increase which did not differ at the end of experiment (P>0.05). Similary, BCS in animals increased linearly but did not differ significantly (Fig 1). The change in body weight at the end of trial was significantly (P<0.01) higher in T_3 than T_2 and T_1. The present findings were in line with the earlier works of Sultana *et al*. (2015), Kholif *et al*. (2016), Asaolu *et al*. (2012), and Meel *et al*. (2018) who reported increase in DM intake in goats fed with moringa leaf meal. Babiker *et al.* (2017), Choudhary *et al.* (2018) and Ahmed and Shaarawy (2019) reported that feeding of moringa leaves increased body weight changes in growing goat kids significantly without affecting DMI. In contrary to our findings, Tona *et al*. (2014), Moyo *et al*. (2012) and Damor *et al*. (2017) reported no change in dry matter intake in Moringa fed groups. Sonkar *et al.* (2021) reported no significant effect of supplementation of *M. oleifera* dried leaves up to the level of 20% replacement of concentrate on dry matter intake and milk composition in lactating Sahiwal cows. In present study, the body weight changes in Barbari goats were greater at 10% replacement of concentrate in daily diet. The marked variation in body weight gain by the animals fed experimental diets might be attributed to difference in protein quality, palatability of feed and proportion of bypass protein in *Moringa oleifera* leaves (Kholif *et al*., 2016). The superior body weight gains exhibited by animals in treatment groups might also be attributed to higher feed intake of animals on Moringa based experimental diet, since voluntary feed intake of an animal is directly related to the body weight changes. Abbas *et al.* (2018), and Su and Chen (2020) reported that *M. oleifera* leaves were rich in amino acids, vitamins and minerals particularly iron, which might be responsible for increase in the body weight of the goats in the current study.

Mean ADG revealed significant (P<0.01) effect of treatment T_3 than T_2 and T_1 (Table 2). The present findings were in agreement with the study of Moyo *et al.* (2012), Tona *et al.* (2014), Babiker *et al.* (2017) and Damor *et al.* (2017) who reported that feeding of *Moringa oleifera* leaves in goats had significant effect on average daily gain in body weight. In contrary, Ali *et al*. (2018) and Jiwuba *et al.* (2016a) reported no

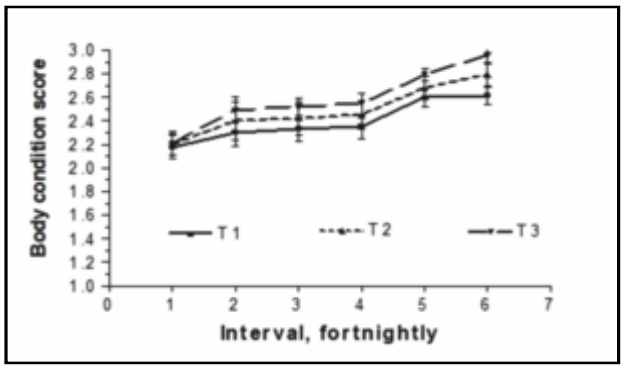

Fig 1. Effect of moringa feeding on body condition score (BCS) in Barbari goats

Table 2. Effect of feeding dried moringa leaves on weight gain, feed intake and feed conversion efficiency of Barbari goats (n=18)

Parameters	Treatments			SEM	P value
	T1	T2	T3		
Initial BW (kg)	16.70	16.53	16.73	1.20	0.992
Final BW (kg)	21.75	22.05	23.42	1.30	0.636
ΔBW (kg)	5.06[a]	5.52[a]	6.67[b]	0.16	0.000
ADFI (g DM)	609.26[a]	614.74[a]	637.47[b]	2.29	0.000
ADG (g/day)	56.18[a]	61.32[a]	74.10[b]	1.76	0.000
FCR	11.04[a]	10.09[ab]	8.80[b]	0.51	0.000

Means within row having different superscripts differed significantly (P<0.05); Treatments- T_1: Control diet; T_2: 5% replacement with moringa leaves; T_3: 10% replacement with moringa leaves; BW: Body weight; ADFI: Average daily feed intake; ADG: Average daily gain; DM: Dry matter; FCR: Feed conversion ratio; SEM: Standard error of mean

significant change in ADG amongst the treatment groups. The higher body weight gain in goats at 10% replacement of concentrate supported the earlier findings which stated that *M. oleifera* leaves in diet enriched the nutritional value and palatability of feed in ruminant diets. Su and Chen (2020) reported about 47% rumen bypass protein with a good amino acid profile in the diet of ruminants which resulted in faster body weight gains in livestock (Kholif *et al.,* 2022). The feed utilization in terms of FCR was significantly ($P<0.01$) improved in T_3 than T_2 and T_1. It was reported earlier that *Moringa oleifera* leaf meal contained high protein, essential vitamins, which could help in better utilization of feed in animals (Asaolu *et al*., 2012). Bharathidhasan (2021) reported high content of malic acid and fumaric acid in moringa which potentially reduced methane emission and increased productivity in ruminants. The results obtained in present study were also in agreement with Oyedel *et al.* (2016), Jiwuba *et al.* (2016a), Babiker *et al.* (2017) and Ali *et al*. (2018) reported that feeding of moringa leaves significantly increased feed efficiency in goat. In contrary, Adegun and Aye (2013) reported decrease in feed efficiency ($P<0.01$) among the treatment groups.

Blood biochemical parameters: The blood biochemical parameters were not affected by supplementation of *M. oleifera* dried leaves, except lowering ($P<0.01$) in mean blood cholesterol in T_3 compared to T_2 and T_1 groups (Table 3). The total protein and globulin levels at the end of experiment were significantly ($P<0.05$) higher in T_3 group than control (Fig 2). The findings of present study were in conformity with earlier reports of Yusuf *et al.* (2018), Kholif *et al.* (2018) and Meel *et al.* (2018) in goats fed moringa based ration. Sonkar *et al*. (2021) reported

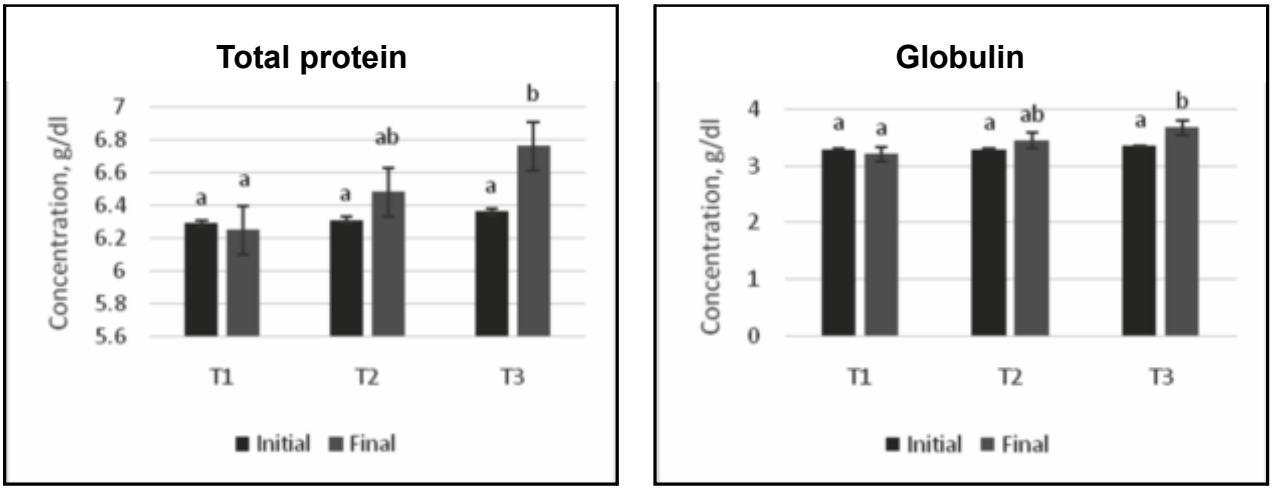

Fig 2. Concentrations of total protein and globulin in different treatments; Means bearing different superscripts with small letters a, b differed significantly ($P<0.05$); Treatments- T_1: Control diet; T_2: 5% replacement with moringa leaves; T_3: 10% replacement with moringa leaves

Table 3. Effect of feeding dried moringa leaves on blood biochemical parameters of Barbari goats (n=18)

Parameters	Treatments			SEM	P value
	T1	T2	T3		
Glucose (mg/dl)	49.02	51.70	52.38	1.31	0.065
Cholesterol (mg/dl)	123.33^{a}	114.64^{ab}	112.49^{b}	2.56	0.000
Protein (g/dl)	6.31^{a}	6.50^{ab}	6.59^{b}	0.08	0.001
Albumin (g/dl)	3.04	3.03	3.05	0.12	0.982
Globulin (g/dl)	3.26	3.47	3.54	0.16	0.182
A:G ratio	1.00	0.89	0.89	0.01	0.356
BUN (mg/dl)	26.74	24.15	26.23	2.98	0.542
SGOT (IU/L)	59.34	59.92	58.44	4.75	0.837
SGPT (IU/L)	27.31	28.42	25.79	1.40	0.122

Means within row having different superscripts differed significantly ($P<0.05$); Treatments- T_1: Control diet; T_2: 5% replacement with moringa leaves; T_3: 10% replacement with moringa leaves; SEM: Standard error of mean; BUN : Blood urea nitogen

Table 4. Economic analysis of treatment groups under study for three months

Particulars	Treatment groups		
	T_1	T_2	T_3
Average green (berseem+ oat) consumed/ goat (kg)	81.94	82.19	85.12
Average straw (wheat) consumed/ goat (kg)	10.77	10.81	11.19
Average concentrate feed consumed/ goat (kg)	32.68	31.14	30.56
Average dried *M. oleifera* leaves consumed/ goat (kg)	0.00	1.65	3.42
Cost of green fodder consumed/goat (Rs) @Rs 2/kg	163.88	164.37	170.24
Cost of wheat straw consumed/goat (Rs) @Rs 6/kg	64.64	64.83	67.15
Cost of concentrate feed consumed/ goat (Rs) @ Rs 19/kg	620.97	591.70	580.58
Cost of *M. oleifera* leaves consumed/ goat (Rs) @Rs 50/kg	0.00	82.45	170.80
Cost of feed /goat (Rs)	849.49	903.37	988.77
Average live body weight gain (kg)	5.06	5.52	6.67
Cost of feed/ kg live body weight gain (Rs)	167.88	163.65	148.24
Income from gain in body weight (Rs) @ Rs. 350/kg	1518.00	1656.00	2001.00
Net profit (Rs)	668.51	752.63	1012.23
Net profit/ kg live body weight gain (Rs)	132.12	136.35	151.76
Cost- benefit ratio	0.79	0.83	1.02
Input-output ratio	01:1.8	01:1.8	01:2.1

Treatments- T_1: Control diet; T_2: 5% replacement with moringa leaves; T_3: 10% replacement with moringa leaves

significantly (P<0.05) lower levels of total triglyceride concentration and higher levels of total serum protein and globulin in moringa fed group up to 20% replacement of concentrate mixture. There was no change in the albumin concentration in treatment and control groups which was in concurrence with the findings of Ali *et al.* (2018). However, Kholif *et al*. (2018) reported higher albumin values in Nubian goats fed moringa ration as substitute for berseem clover.

***Economic analysis*:** The economics of goat rearing was compared between the treatment groups under study for three months. Except dietary differences, other factors were similar for the groups, therefore, the economics of goat rearing was compared on the basis of cost of feed/kg live body weight gain (Rs.) (Table 4). The cost of feed per kg live body weight gain were Rs. 167.88, 163.65 and 148.24 for group T_1, T_2 and T_3, respectively. The feed cost per kg of live body weight gain was found lowest in group T_3 followed by group T_2 and T_1. The net profit per kg live body weight gain was Rs. 132.12, 136.35 and 151.76 for group T_1, T_2 and T_3, respectively. The cost- benefit ratio for groups was 0.79, 0.83 and 1.02, respectively. Hence, *Moringa oleifera* dried leaves might serve as a good and cheaper protein source for growing goats. The results obtained in the present study were in agreement with Ahmad *et al*. (2017) and Ali *et al.* (2018) who found significant reduction in cost of feed per kg live body weight gain in moringa treated groups at increasing levels of replacement. Similarly, Jiwuba *et al*. (2016b) reported that feeding of *Moringa oleifera* leaf meal was beneficial to west African dwarf goats at 10 and 15 percent levels of replacement.

Conclusion

The results indicated that feeding the growing goats, replacing concentrate feed with *Moringa oleifera* dried leaves up to 10% significantly improved feed intake and utilization, and body weight gain without any harmful effect. The cost benefit ratio was more at 10% replacement which could reduce the cost of concentrate feed in goats.

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