



Effect of Partial Replacement of Concentrate with *Moringa oleifera* Dried Leaves on Nutrient Utilization, Blood Biochemical Profile and Health Status of Growing Barbari Goats

Rajbir Singh¹, Ahmad Fahim², Vaibhav Arya³, Deepak Singh⁴, Kartik Tomar⁵,
Manoj Kumar Bansala⁶, Deepak Kumar Verma¹

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ABSTRACT

Background: The present study was conducted to evaluate the effect of partial replacement of concentrate mixture with dried *Moringa oleifera* leaves on nutrient intake, digestibility, blood biochemical and haematological attributes in growing Barbari goats.

Methods: Twenty female Barbari goat kids were randomly allotted to four dietary treatments with five animals in each group. The control group (C) was fed with basal diet comprising equal proportions of roughage and concentrate. In treatment groups T1, T2 and T3, the concentrate mixture was partially replaced with dried *M. oleifera* leaves at 20, 30 and 40 per cent levels on dry matter basis, respectively. A preliminary period of 14 days was given, followed by 90 days feeding trial and a collection period of 7 days for the conduct of digestibility trial.

Result: Significantly ($P<0.01$) higher dry matter intake was observed in kids fed with moringa leaves. The intake of CP and DCP was also higher ($P<0.01$) in treatment groups compared to control group, highest intake recorded in group T3. Digestibility coefficients of nutrients except crude fibre was not affected with the inclusion of moringa leaves in the diet. Based on nitrogen balance study, it was found that nitrogen intake and nitrogen retention was significantly ($P<0.05$) higher in moringa-fed goats. Glucose, total protein and globulin concentrations were significantly ($P<0.05$) higher and cholesterol reduced ($P<0.01$) in all the treatment groups. Haemoglobin, PCV and TEC concentration showed significant ($P<0.01$) rise, values remaining within normal physiological limits.

Key words: Barbari goats, Blood biochemical profile, Digestibility, *Moringa oleifera*, Nutrient utilization.

INTRODUCTION

Goat production is an important source of livelihood for small farmers and producers in tropics. These animals are often fed on low quality roughage and generally suffer deficiency of protein in their diet which adversely affects their growth and production. It is therefore important to identify such feed resources that are rich in protein content and may be used as alternative feed resource without impairing animal health.

In recent times, the non-conventional feed and fodder resources such as tree leaves from neem, pakar, subabul, etc. represent a good part of small ruminant diet, especially in goats. Goats have natural tendency of browsing, relishing preferably on top feed when left free for grazing in pastures and open vegetation. Now a days, *Moringa oleifera* has emerged as a possible substitute in goat diet due to high content of crude protein and rich source of vitamins, minerals and other bioactive metabolites (Kashyap *et al.*, 2022; Islam *et al.*, 2021). It can provide round the year supply of green fodder once planted in areas where no other alternative is available. *Moringa oleifera* leaves in ration of goat has been found to enhance growth, milk production, nutrient utilization and reduced enteric methane emissions, suggesting manifold benefits of moringa inclusion in goat as well as ruminant diets (Leitanthem *et al.*, 2023, Bashar *et al.*, 2020).

¹Department of Animal Husbandry, IIMT University, Meerut-250 001, Uttar Pradesh, India.

²Department of Livestock Production Management, College of Veterinary and Animal Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250 110, Uttar Pradesh, India.

³Department of Animal Husbandry, Government of Uttar Pradesh, Uttar Pradesh, India.

⁴Faculty of Agriculture, Guru Kashi University, Bathinda-151 302, Punjab, India.

⁵Department of Agriculture Science, Dr. Bhimrao Ambedkar University, Agra-282 003, Uttar Pradesh, India.

⁶Department of Agriculture, Dolphin (PG) Institute of Biomedical and Natural Sciences, Dehradun-248 007, Uttarakhand, India.

Corresponding Author: Rajbir Singh, Animal Husbandry, IIMT University, Meerut-250 001, Uttar Pradesh, India.

Email: dean_agrisc@iimtindia.net

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Feeding of moringa leaves in ruminants have been found to exhibit beneficial effect on health and production

(Sultana, 2020; Rizwan *et al.*, 2024; Saini *et al.*, 2024). It has been associated with better organ function and metabolic activity in goats and could potentially improve the efficiency of production due to its antioxidant and immune-modulating properties (Sultana, 2020; Sayed-Ahmed *et al.*, 2019). Keeping these benefits under consideration, the present study was conducted to assess the effects of partial inclusion of dried *Moringa oleifera* leaves as replacement for concentrate in ration of growing Barbari goats on their nutrient intake, digestibility, blood-biochemical profiles.

MATERIALS AND METHODS

The study was approved by Committee for the Control and Supervision of Experiments on Animals (CCSEA) rules laid down by the Government of India. (Approval no. V-11011(13)/3/2022-CPCSEA-DADF).

Collection and preparation of dried *Moringa* leaves

Fresh *Moringa oleifera* leaves were harvested manually from the *Moringa* plots at ICAR-Indian Institute of Farming System Research, Modipuram, Meerut. After collection, only tender leaflets were separated from petioles and stems to ensure uniformity and to minimize fibre content. The harvested leaves were dried in thin layers on clean plastic sheets under well-ventilated conditions at ambient temperature (28-32°C) for 5-7 days and turned twice daily to ensure uniform drying and prevent fungal growth. Direct exposure to sunlight was avoided to minimize losses of heat-labile nutrients, pigments and bioactive compounds. After complete drying, the leaves were ground to fine powder using hammer mill. The ground material was stored in airtight polyethylene containers at room temperature in a dry place until further use in diet formulation and chemical analysis.

Experimental animals and design

The study was conducted on twenty female Barbari goat kids aged 8 to 12 months (initial mean body weight 11.25 ± 1.43 kg), of uniform age and conformation. The animals were clinically checked for any signs of illness or disease. A randomized block design was used to divide the selected animals into four dietary treatment groups with five animals per treatment. A graded levels of dried moringa leaves was provided as partial replacement of concentrate to prepare a balanced diets that were iso-nitrogenous and iso-caloric-control group and treatment groups T1, T2 and T3 having 0, 20, 30 and 40% of moringa leaves on dry matter basis. The proximate values of dried moringa are given in Table 1. A preliminary period of 14 days was given, followed by 90 days feeding trail and a collection period of 7 days for the conduct of digestibility trial. During the feeding trial, the animals were kept in half-wall partitioned stalls each of dimension 10 × 12 sq ft, in a well-ventilated and protected shed under uniform managemental practices at the goat farm. A measured quantity of experimental feed was offered twice (morning and evening) to each group as per feeding regimen based on NRC (2007) guidelines.

Digestibility trial and analysis of sample

A six days digestion trial was conducted at the end of 90 days of feeding trial in specially designed metabolic cages having provision for individual feeding of animals and collection of urine and faeces separately. During this period, daily feed and fodder offered, residue left and faeces voided were recorded and samples were processed for further analysis. The feed samples and left over feed from each animal were collected and kept in aluminum trays which were placed overnight in a hot air oven at 60°C. The faeces voided by individual animal in 24 hours were collected manually and stored in properly labeled plastic bags individually animal wise. Every day at 9.00 A.M., the faeces voided during past 24 hours were collected, weighed for individual animals and thereafter spread on clean concrete floor. These were thoroughly mixed by hand and approximately 1.0-1.5 kg of faeces samples were drawn from 5-6 different places. The selected samples so obtained from each animal separately were brought to laboratory and thoroughly mixed before placing in clean dry tin tray for dry matter estimation. A 1/200th part of total faeces voided was weighed in a pre-weighed tray for dry matter estimation. After completion of drying, the six day samples were pooled together for each animal and then allowed to air dry for about a week. These were ground well using a laboratory grinder and kept in cleaned, well labeled polythene bags for determination of moisture, ash, ether extract, crude fibre, nitrogen-free extract, neutral detergent fibre and acid detergent fibre. Simultaneously, samples of 1/100th part of total faeces voided daily were also weighed accurately and transferred to pre-weighed wide mouth plastic bottles daily and 10 mL of 1:4 sulphuric acid were poured into the faeces to prevent fungal growth as well as decomposition of faeces and preserved as wet faeces for nitrogen estimation. The six day samples were pooled and mixed homogeneously before nitrogen estimation. 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.

Blood sampling and health monitoring

Blood samples were collected from jugular vein of individual animal first at the start (day 1) and then at the end of the experiment (day 90) before morning feeding hours. The samples were collected in heparin coated vacutainer tubes. The sample was centrifuged at 3000 rpm for 15 minutes to separate plasma which was stored at -20°C until analysis. Serum biochemical parameters included glucose, total protein, albumin, globulin, urea, creatinine, cholesterol and triglycerides were estimated using diagnostic kits (ERBA, Mannheim, Germany) as per manufacturer's guidelines in semi-automatic biochemistry analyzer. Haematological indices in study included

haemoglobin concentration, packed cell volume, total erythrocyte count and total leukocyte count were determined using auto-hematoanalyzer (Mindray BC 30 Vet).

Statistical analysis

Data generated on nutrient intake, digestibility coefficients, blood biochemical parameters and haematological indices were subjected to one-way analysis of variance (ANOVA) using SPSS statistical software (version 20.0; SPSS Inc., Chicago, IL, USA). The statistical model used was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where

Y_{ij} = Dependent variable,

μ = Overall mean,

T_i = Effect of treatments,

e_{ij} = Random error.

Duncan multiple range test was applied to treatment means which showed a statistically significant variation in samples.

RESULTS AND DISCUSSION

The results of the different experimental groups have been presented and discussed under the following subheadings.

Nutrient intake and digestibility

The effect of partial replacement of concentrate with dried *Moringa oleifera* leaves on nutrient intake, digestibility and nitrogen balance in growing goats is presented in Table 2. The dry matter intake (DMI) (kg/d and % BW basis) differed significantly ($P < 0.01$) among the treatment groups, the moringa supplemented group showed higher values compared to control group. There was significant ($P < 0.01$) difference in crude protein (CP) intake which increased with increasing level of dried moringa leaves inclusion. Similar trend was observed for digestible crude protein (DCP) intake, which was significantly ($P < 0.01$) higher in T3 group followed by other treatment groups and control group. The total digestible nutrient (TDN) intake was also superior in treatment group as compared to control group. There was no significant difference in the digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), nitrogen-free extract (NFE), neutral detergent fibre (NDF) and acid detergent fibre (ADF) values in goats fed dried moringa leaves at different inclusion levels as well as the control group. However, digestibility of crude fibre (CF) differed significantly ($P < 0.05$) and was higher in treatment groups.

A significantly higher dry matter intake was observed in goats fed with moringa leaves which indicates improved palatability of diet. It has been reported that moringa leaves are more preferable compared to other tree leaves in ruminant diet due to its soft texture, better nutrient density and presence of certain bioactive compounds that is associated to stimulate voluntary intake (Selmi *et al.*, 2020; Sultana *et al.*, 2015; Sanchez *et al.*, 2006). The higher DMI

in moringa-fed groups may also be attributed to enhanced microbial activity due to improved rumen function and lower lignin content (Sanchez *et al.*, 2006; Kumar and Gupta, 2025). Significantly higher crude protein and digestible crude protein intake in moringa-fed groups can be attributed to high protein content in moringa leaves (25-30%) and superior amino acid profile of *M. oleifera* leaves (Nyobe *et al.*, 2025; Teixeira *et al.*, 2014). In addition, moringa has been reported to possess a higher rumen bypass protein, resulting in improved efficiency of nitrogen utilization (Kholif *et al.*, 2018). The observed increase in TDN intake with increase in the level of moringa inclusion in treatment group is suggestive of improved availability of dietary nutrients (Kumar, 2023). The digestibility coefficients of nutrients except crude fibre did not differ significantly which suggest that inclusion of dried moringa leaves had no adverse effect on rumen function. Significant improvement in crude fibre digestibility in moringa fed group may be due to enhanced rumen activity facilitated by certain bioactive compounds present in moringa leaves and moderate fibre fraction (Kumar and Gupta, 2025). Bioactive compounds in moringa leaves are responsible for enhanced activity of fibrolytic enzyme due to altered rumen microbial populations (El-Nile *et al.*, 2025).

Nitrogen balance

Nitrogen balance parameters were markedly influenced by dietary treatment having inclusion of moringa leaves. It was observed that nitrogen intake was significantly ($P < 0.01$) higher in moringa-fed group, reflecting higher proportion of dietary protein intake with increasing level of inclusion. The faecal and urinary nitrogen excretion values were also significantly ($P < 0.05$) higher in treatment groups compared to control group. Based on the values of nitrogen absorbed and nitrogen balance in goats fed moringa-based diets, maximum values were observed in T3 group. The N balance expressed in terms of percentage nitrogen intake and nitrogen absorbed, did not show any significant difference, however numerically the values were higher with increasing moringa inclusion, suggesting an improved trend of nitrogen utilization efficiency in moringa-fed goats.

Table 1: Proximate composition (% DM basis) of dried moringa leaves.

Parameter	Proximate values
Dry matter	88.75
Organic matter	87.70
Crude protein	29.15
Ether extract	9.90
Crude fibre	10.10
NFE	38.55
NDF	16.00
ADF	9.35
Hemicellulose	6.65
ADL	2.45
Cellulose	6.90
Ash	12.30

The study resulted in increased excretion of faecal and urinary nitrogen in metabolic trial conducted which proportionally increased with the level of inclusion of moringa leaves. The overall nitrogen retention was higher in treatment group T3. This means that moringa leaves were efficiently utilized for anabolic processes rather than being excreted out of the body. The positive nitrogen retention values for all treatments showed that the protein in the diets was adequate to meet the requirement for maintenance and growth of experimental goats (Sultana *et al.*, 2015; Fadiyimu *et al.*, 2010). The improved nitrogen use efficiency is likely due to better synchronization of rumen-degradable protein and fermentable energy, which enhances microbial protein synthesis (Kumar and Gupta, 2025; Babiker *et al.*, 2017). Similar improvements were recorded in other ruminant species in terms of nitrogen retention due to moringa leaves supplementation, signifying its role as an efficient source of protein (Babiker *et al.*, 2017; Bennour *et al.*, 2020).

Blood biochemical parameters

Blood biochemical parameters are indicative of metabolic health in livestock. The effect of partial replacement of concentrate with dried *Moringa oleifera* leaves on blood biochemical parameters in growing Barbari goats is presented in Table 3. Plasma glucose concentration showed significant ($P<0.05$) increase in goats fed moringa-based diets compared to the control group. The concentration of total protein and globulin was significantly ($P<0.01$) higher in treatment groups as compared to control, however albumin remained unaffected in all groups. There was significant decrease in albumin globulin ratio ($P<0.01$) in goats fed with moringa. There was no change in urea and creatinine concentrations among the treatment groups. Significant ($P<0.01$) decrease in plasma cholesterol level was observed in goats of treatment group, indicating beneficial effects of diets containing dried moringa leaves. A significant increase in concentration of blood glucose level in goats fed with moringa leaves suggest improved

Table 2: Effect of dietary treatment on nutrient intake, digestibility and nitrogen balance in growing Barbari goats.

Attributes	C	T1	T2	T3	SEM	P value
Body weight						
BW (kg)	15.70	16.92	17.10	17.12	0.44	0.11
BW ^{0.75} (kg)	7.88	8.34	8.41	8.42	0.17	0.10
DM intake						
kg/day	0.46 ^a	0.54 ^b	0.56 ^b	0.56 ^b	0.01	0.00
% BW	2.96 ^a	3.20 ^b	3.24 ^b	3.26 ^b	0.04	0.00
CP intake						
g/day	60.36 ^a	73.12 ^b	82.14 ^c	86.04 ^c	1.86	0.00
DCP intake						
g/day	41.97 ^a	51.36 ^b	58.03 ^c	62.18 ^d	1.24	0.00
%	9.05 ^a	9.48 ^b	10.46 ^c	11.34 ^d	0.11	0.00
TDN intake						
g/day	273.20 ^a	320.50 ^b	331.45 ^b	333.43 ^b	8.65	0.00
%	58.81	59.16	59.75	59.69	0.62	0.67
Digestibility coefficient (%)						
Dry matter (DM)	58.80	60.60	61.82	61.32	0.88	0.12
Organic matter (OM)	60.82	62.00	63.62	64.74	1.06	0.08
Crude protein (CP)	69.63	70.24	70.66	72.29	0.84	0.18
Ether extract (EE)	65.10	67.32	67.54	68.16	1.47	0.50
Crude fibre (CF)	49.38 ^a	49.62 ^{ab}	50.80 ^{ab}	51.48 ^b	0.52	0.04
Nitrogen-free extract (NFE)	63.64	65.08	66.30	65.70	1.11	0.40
Neutral detergent fibre (NDF)	54.46	55.62	57.74	56.94	0.82	0.06
Acid detergent fibre (ADF)	49.76	50.60	51.68	51.92	0.63	0.09
N balance						
N intake (g/day)	9.68 ^a	10.57 ^b	10.81 ^b	11.41 ^b	0.29	0.01
N excretion in faeces (g/day)	2.92 ^a	3.14 ^b	3.17 ^b	3.16 ^b	0.06	0.03
N excretion in urine (g/day)	2.02 ^a	2.06 ^a	2.14 ^{ab}	2.26 ^b	0.05	0.03
Total N excretion (g/day)	4.94 ^a	5.20 ^b	5.31 ^b	5.42 ^b	0.09	0.01
N absorbed (g/day)	6.76 ^a	7.43 ^{ab}	7.64 ^b	8.25 ^b	0.27	0.01
N balance (g/day)	4.74 ^a	5.37 ^{ab}	5.50 ^{ab}	5.99 ^b	0.28	0.04
N balance (% of N intake)	48.61	50.71	50.83	52.46	1.44	0.34
N balance (% of N absorbed)	69.67	72.17	71.92	72.56	1.33	0.44

SEM Standard error of mean; BW^{0.75} Metabolic body weight. Means within a row bearing different superscripts differ significantly.

Table 3: Effect of dietary treatment on blood biochemical parameters of growing Barbari goats.

Parameter	C	T1	T2	T3	SEM	P value
Glucose (mg/dL)	49.66 ^a	53.04 ^{ab}	56.88 ^b	56.64 ^b	1.72	0.03
Total protein (g/dL)	6.21 ^a	6.78 ^b	7.12 ^c	7.35 ^d	0.03	0.00
Albumin (g/dL)	3.11	3.12	3.15	3.15	0.02	0.14
Globulin (g/dL)	3.10 ^a	3.66 ^b	3.97 ^c	4.20 ^d	0.04	0.00
A:G ratio	1.00 ^a	0.85 ^b	0.79 ^c	0.75 ^d	0.01	0.00
Urea (mg/dL)	32.60	31.96	34.78	35.00	1.72	0.52
Creatinine (mg/dL)	0.92	0.93	0.93	0.90	0.01	0.40
Cholesterol (mg/dL)	71.40 ^a	69.20 ^b	67.38 ^c	67.80 ^c	0.38	0.00

Means within a row bearing different superscripts differ significantly (P<0.05).

SEM = Standard error of mean.

Table 4: Effect of dietary treatment on haematology of growing Barbari goats.

Parameter	C	T1	T2	T3	SEM	P value
Haemoglobin (g/dL)	9.70 ^a	10.40 ^b	10.90 ^c	11.30 ^d	0.07	0.00
Packed cell volume (%)	29.78 ^a	31.94 ^b	33.48 ^c	34.64 ^d	0.18	0.00
TEC (×10 ⁶ /μL)	12.50 ^a	13.18 ^b	13.80 ^c	14.30 ^d	0.07	0.00
TLC (×10 ³ /μL)	9.50	9.84	10.10	10.22	0.25	0.21

Means within a row bearing different superscripts differ significantly (P<0.05).

SEM = Standard error of mean.

energy utilization, which may be due to enhanced propionate production in rumen (Van Soest *et al.*, 1991; Moyo *et al.*, 2012). Higher total protein and globulin concentrations in treatment groups reflect improved protein status and immune competence in treated animals. Increased globulin level is associated with enhanced immune competence in moringa-fed group (Pareek *et al.*, 2023; Bennour *et al.*, 2020). The albumin concentration did not change across treatment groups which is suggestive of lower nutritional stress in animals. There was significant reduction in albumin globulin ratio observed in treatment groups fed with moringa leaves which further supports our findings at higher level of inclusion. Sheep and goat fed moringa diet exhibited similar trends compared to our study (Zinder *et al.*, 2025; Kholif *et al.*, 2022). Blood urea and creatinine concentrations did not differ in the present study, indicating efficient nitrogen utilization and normal body function (Sultana *et al.*, 2021). There was a marked reduction in cholesterol concentrations due to feeding of moringa leaves which is consistent with the hypolipidemic properties of *M. oleifera* as reported in previous studies (Ferreira *et al.*, 2008; Liu *et al.*, 2023).

Haematological parameters

The effect of moringa leaves inclusion in diet of Barbari goats on the haematological profile has been presented in Table 4. The concentration of hemoglobin, packed cell volume and total erythrocytic count showed a significant increase in treatment groups which were within the normal physiological limits in comparison to animals of control group. The total leukocytic count showed a little variation among the groups. Significant improvement in haemoglobin concentration, packed cell volume and total erythrocytic

count in treatment groups indicates superior health status as compared to control. These effects may be attributed to the high iron, folic acid and vitamin content of moringa leaves (Rotella *et al.*, 2023). The absence of significant differences in total leukocyte count among treatments suggests that moringa inclusion did not induce inflammatory responses in animals (Singh *et al.*, 2010). Sagaf *et al.*, 2025 reported similar findings on leukocyte values, however, other parameters differed from the result of present study. This difference might be attributed to variation in composition of concentrate mixture, level of inclusion of moringa leaves and local conditions.

CONCLUSION

The findings of the present study suggest that dried *Moringa oleifera* leaves can be safely used to replace concentrate diet in growing Barbari goats up to a level of 40%. The improved nutrient intake and digestibility are indicative that moringa can potentially be used as an alternative feeding strategy to economize goat rearing. In addition, there was improvement in goat health and immunity reflected by haemato-biochemical parameters. Thus, moringa plantation along with goat rearing may be adopted as sustainable feed resource for small holder production system, especially in tropics.

Conflict of interest

The authors declare no conflict of interest.

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