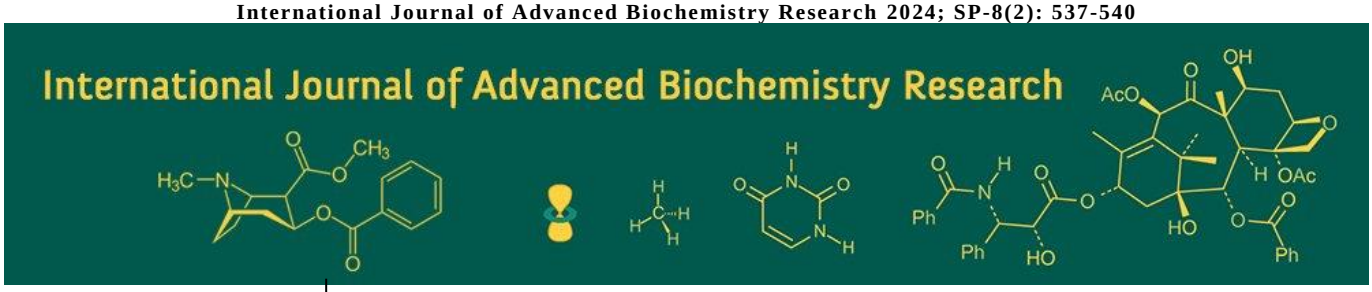

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(2): 537-540
www.biochemjournal.com
Received: 11-11-2023
Accepted: 20-01-2024

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Effect of dietary inclusion of *Moringa oleifera* leaf meal on and Hemato-biochemical profile of Sahiwal calves

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DOI: https://doi.org/10.33545/26174693.2024.v8.i2Sg.625

Abstract
This study was conducted to investigate the impact of dietary inclusion of *Moringa oleifera* leaf meal as a substitute for concentrate mixture on the growth performance and haemato-biochemical profile of Sahiwal calves. Twenty-four Sahiwal female calves, six to ten months of age, with an average body weight of approximately 77.41±0.93 kg, were randomly distributed through three equal dietary treatments. *Moringa oleifera* leaf meal inclusion replacing the concentrate mixture was made @ 0% (M_0), 10% (M_{10}), and 20% (M_{20}), respectively. The results indicated that dietary inclusion of 10 and 20% *Moringa oleifera* leaf meal significantly improved (p<0.001) final body weight, dry matter intake, daily weight gain, feed conversion efficiency, and haemo-biochemical profile as compared to control (M_0). It can be concluded that *Moringa oleifera* leaf meal is a source of nutritional and therapeutic advantages when replacing @ 10-20% of the concentrate mixture without any adverse effects on growing Sahiwal female calves.

Keywords: Growth performance, haemato-biochemical profile, *Moringa oleifera*, Sahiwal calves

Introduction
The necessity to implement cost-effective and easily accessible alternative feedstuffs to facilitate the advancement of livestock development has become imperative (Aye and Adegun, 2013) [5]. Leaf protein sources derived from the foliage of vegetables, legume trees, browse plants, fodder trees, and shrubs have emerged as highly nutritious feed options for all categories of livestock. These resources have garnered significant attention due to their immense potential (Asaolu *et al.*, 2011) [4]. *Moringa oleifera* is commonly used as animal feed, with its leaves being the preferred component for feeding animals in the form of leaf meal. *Moringa oleifera* is widespread and readily accessible in India. The tree is cultivated in India for both human food and animal feed (Anjorin *et al*., 2010) [3].
Leaves are often considered a protein source. The protein content of fodder varies from 15% to 30% on a dry matter basis, depending on the stage of maturity and the proportions of leaflets, petioles, and stems. Moreover, Moringa leaves possess a high biological value and show outstanding promise as a feed source for ruminant animals as it contain a wide range of essential nutrients such as protein, amino acids, fatty acids, minerals, vitamins, calcium, potassium, phenolics, and oxycarotenoids, which are fundamental components of the animal body (Pradhan, 2016) [17]. These nutrients play a crucial role in osmotic adjustment, enzyme activation, growth hormone regulation, and other organic processes that contribute to growth, functionality, and the overall maintenance of life (Anjorin *et al*., 2010) [3]. Numerous studies have examined the impact of Moringa leaves on the productivity of dairy cows (El-Esawy, 2015) [10], sheep and goats (Fayomi *et al*., 2015) [12], as well as the growth and carcass characteristics of rabbits (El-Badawi *et al*., 2014) [9] and the productivity of broilers and laying hens (Abbas, 2013) [1]. This study was aimed to assess the impact of feeding rations with varying levels of dry *Moringa oleifera* leaves on the feed intake, growth performance, and hemato-biochemical constituents of Sahiwal female calves.

Materials and Methods

Animals, Diets and Management

This study was conducted at the Livestock Farm Complex (LFC) of the College of Veterinary Science and Animal Husbandry, ANDUAT Kumarganj, Ayodhya (India). Twenty-four clinically healthy Sahiwal female calves, six to nine months old, with an average body weight of 77.41±0.93 kg, were randomly distributed into three equal groups, each of eight animals, for the four month experimental period.

Moringa leaves were obtained from the Moringa tree by cutting its branches, which contained leaves and soft twigs, at regular intervals of 45 days. The soft twigs were harvested and left to dry in the sun for 2-3 days. Afterwards, the partially dried leaves were removed by threshing. The twigs were then sun-dried again for approximately 48 hours on black plastic sheets. The dried leaves were ground in a hammer mill, then placed in sacks and stored in a well-ventilated store room.

The experimental diet contained a concentrate mixture and wheat straw. The experimental diets were designed in accordance with NRC guidelines (2001) to fulfill the nutritional needs of growing calves. The diet was prepared, combined daily, and given once a day for the entire experimental period. Fresh water was available *ad libitum*. Before the start of the experiment, calves were dewormed. The control group was fed a basal diet (concentrate mixture and wheat straw) without supplementation (M_0). The other treatment groups were fed the basal diet supplemented with dry Moringa leaf meal replacing concentrate mixture at @ 10% (M_{10}) and 20% (M_{20}), respectively. Each calf was housed in a separate pen with a concrete floor and fitted with a locally made feed manager. The body weight of calves was measured at the start of the experiment and every fortnight thereafter. Feed intake was also recorded for a fortnightly interval.

Blood Sampling

Blood samples were collected from the jugular vein during the early morning on days 0, 30, 60, 90, and 120 of the experiment. About 7 mL of blood was collected from each animal, of which 5 mL was kept for clotting and serum was separated for the estimation of biochemical parameters. Another 2 mL of blood was stored in an EDTA vial for haematological estimation. Blood metabolites (calcium, total protein, and albumin) were analyzed by an Automatic B^{200} Serum Analyzer using commercial test kits (Bonavera, Beacon, Gujrat, India) as described by the manufacturer.

The data were presented as the mean and standard error of the mean (SEM), and analyzed using one-way analysis of variance (ANOVA) with Graph Pad Prism 5 software.

Results and Discussion

Effect on Growth performance

The calves fed M_{10} and M_{20} (%) diets showed a significant increase (p<0.001) in final body weight, total weight gain, and daily weight gain compared to the calves fed the control diet (M_0) (Table 1). The total dietary intake of dry matter was significantly improved by 10% supplementation of *Moringa oleifera* leaf meal compared to the control group ($p < 0.001$). Moreover, the addition of both 10% and 20% Moringa leaf meal resulted in a significant decrease ($p < 0.001$) in the feed conversion ratio as compared to control (M_0).

Body weight during the early stages of life significantly influences the long-term performance, encompassing aspects such as growth, production, and reproduction. Body weights are frequently employed to assess the nutritional status and growth of animals (Chimonyo *et al*., 2000) [8]. The observed enhancements in the final body weight and average daily weight gain of calves due to the supplementation of Moringa leaf meal in their diet align with findings reported in prior investigations (Moyo *et al*., 2011; Babiker *et al*., 2017; Kholif *et al*., 2015) [15, 6, 14]. These studies demonstrated that incorporating *Moringa oleifera* leaves into farm animal diets enhanced growth performance and feed conversion rates. This finding supports the utilization of *Moringa oleifera* as a natural protein supplement to enhance ruminant production. Significant increase (p<0.001) in body weight gain can be attributed to the high nutrient content found in dry *Moringa oleifera* leaves, as well as the antimicrobial properties of *Moringa oleifera* leaf meal (Fahey *et al*., 2001) [11]. El-Badawi *et al*. (2014) [9] reported that Moringa leaf meal acts as natural growth promoter.

Table 1: Effect of dietary supplementation of *Moringa oleifera* leaf meal on performance of growing Sahiwal female calves

Items	Treatment groups		
	Control (M_0)	M_{10} (%)	M_{20} (%)
Initial body weight (kg)	77.41±0.93	77.30±1.15	77.22±0.91
Final body weight (kg)	102.3±1.11^a	112.1±1.16^c	109.8±1.04^b
Average body weight gain (kg)	3.11±0.03^a	3.64±0.04^b	3.82±0.03^c
Average daily weight gain (kg)	0.207±0.00^a	0.242±0.00^b	0.255±0.00^c
Total DM intake (kg/day)	2.273±0.01^a	2.47±0.01^c	2.396±0.01^b
Feed conversion ratio	11.05±0.04^c	10.26±0.04^b	9.458±0.04^a

Mean ± SE values bearing different superscript (a, b, c) in a row differ significantly (p<0.001). DM: Dry matter M_0, M_{10} and M_{20}, *Moringa oleifera* leaf meal at 0, 10 and 20% of the concentrate mixture.

Effect of *Moringa oleifera* leaves on Haemato-biochemical parameters

The haemato-biochemical parameters of growing calves were significantly influenced by the dietary supplementation of Moringa leaf meal (Table 2). The concentrations of serum calcium, total protein, albumin, and globulin in the calves of the M_{10} and M_{20} (%) groups were significantly higher (p<0.001) compared to the control group (M_0). Additionally, the blood parameters, including haemoglobin, erythrocyte, and leukocyte count, showed a significant increase (p<0.001) in calves that were supplemented with 10% and 20% Moringa leaf meal compared to the calves in the control group.

In general, haemato-biochemical parameters are used to assess the overall health and vitality of animals. In this study, there was an increase in Hb, TLC, and erythrocyte values in both treatment groups after 120 days of treatment. This might be due to the high levels of Fe, Cu, and

antioxidants such as ascorbic acids, polyphenols, flavonoids, and organosulfur compounds present in Moringa (Bharti *et al*., 2007) [7]. Supplementation of Moringa leaves resulted in a significant increase (p<0.001) in serum total protein, albumin, globulin, and calcium levels at 10% and 20% in M_{10} and M_{20}, respectively, than those of control group. Our results corroborated well with Aja *et al*. (2014) [2], who stated that Moringa contains various compounds those possess hepatoprotective effects due to their antioxidant properties. The addition of dried Moringa leaves to the diet of cattle calves resulted in a notable rise (p<0.001) in calcium levels, a finding that was also observed by Ranjan *et al*. (2009) [18] in their study on rabbits. The potential positive impact of Moringa could be attributed to its high calcium content, as suggested in previous studies (Kawo *et al*., 2009; Anjorin *et al*., 2010) [13, 3].

Table 2: Effect of dietary supplementation of *Moringa oleifera* leaf meal on haemato-biochemical parameters of growing Sahiwal female calves

Items	Treatment groups		
	Control (M_0)	M_{10} (%)	M_{20} (%)
Total protein (g/dL)	6.83±0.04^a	6.94±0.07^b	7.02±0.04^c
Albumin (g/dL)	3.42±0.02^a	3.52±0.01^b	3.64±0.01^c
Globulin (g/dL)	3.30±0.02^a	3.42±0.01^b	3.49±0.01^c
Calcium (mmol/L)	2.26±0.00^a	2.37±0.02^b	2.45±0.01^c
Leukocyte count (10^3/mm^3)	6.37±0.09 ^{a}	7.21±0.01^b	7.71±0.01^c
Erythrocyte (10^6/mm^3)	5.59±0.04^a	5.99±0.01^b	6.33±0.01^c
Haemoglobin (g/dL)	11.16±0.06^a	11.43±0.10^b	11.74±0.05^c

Mean ± SE values bearing different superscript (a, b, c) in a row differ significantly (p<0.001). M_0, M_{10} and M_{20}, *Moringa oleifera* leaf meal at 0, 10 and 20% of the concentrate mixture.

Conclusions

On the basis of the findings of the present investigation, it can be concluded that dry Moringa leaf meal can effectively replace a portion of the concentrate mixture. *Moringa oleifera* leaves can be used as a substitute for up to 10–20% of the concentrate mixture in Sahiwal female calves. This substitution has been found to enhance body weight gain, feed intake, and the blood profile of the calves. Due to its affordability and accessibility, the addition of Moringa leaf meal to the diet of Sahiwal calves is feasible.

Acknowledgements

The authors would like to express their gratitude to the Dean of the College of Veterinary Science and Animal Husbandry, ANDUAT, Kumarganj, Ayodhya, India, for their valuable support and provision of necessary resources.

Conflict of Interest: None

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