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Effect of *Leptadenia reticulata* and *Moringa oleifera* supplementation on physico-chemical properties and mineral composition of milk in lactating Sahiwal cattle

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Abstract

The present study was conducted to evaluate the effect of herbal feed supplementation with *Leptadenia reticulata* and *Moringa oleifera* on the physico-chemical properties and mineral profile of milk in lactating Sahiwal cattle under farm conditions. A total of 28 healthy lactating Sahiwal cows were randomly divided into four treatment groups comprising seven animals each. The control group (T₀) was maintained on a basal diet, while treatment groups received basal diet supplemented with *Leptadenia reticulata* root powder @ 90 g/day/animal (T₁), *Moringa oleifera* leaf powder @ 150 g/day/animal (T₂) and a combination of *Leptadenia reticulata* (45 g) and *Moringa oleifera* (75 g) per day per animal (T₃) for a period of 120 days. Milk samples were collected at fortnightly intervals and analyzed for physico-chemical parameters including specific gravity, titratable acidity and milk pH, along with mineral constituents such as calcium, phosphorus, magnesium and zinc. The results revealed that supplementation of *Leptadenia reticulata* and *Moringa oleifera*, either individually or in combination, did not exert any significant ($p > 0.05$) effect on milk physico-chemical parameters. Similarly, milk mineral constituents including calcium, phosphorus, magnesium and zinc did not differ significantly ($p > 0.05$) among treatment groups, although numerically higher values of calcium and phosphorus were observed in the *Moringa oleifera* supplemented group. All physico-chemical parameters and mineral concentrations remained within the normal physiological range throughout the study. Supplementation of *Leptadenia reticulata* and *Moringa oleifera* was found to be nutritionally safe and did not adversely affect milk quality in lactating Sahiwal cattle.

Keywords: *Leptadenia reticulata*, *Moringa oleifera*, Sahiwal cattle, milk physico-chemical properties, milk mineral profile

Introduction

Milk is a vital component of human nutrition and is regarded as a complete food due to its balanced composition of proteins, fats, carbohydrates, minerals and vitamins. The quality of milk plays a crucial role in determining its nutritional value, processing suitability and consumer acceptability. Physico-chemical properties such as specific gravity, titratable acidity and pH serve as important indicators of milk quality, freshness and compositional integrity, while mineral constituents like calcium, phosphorus, magnesium and zinc are essential for metabolic activities, bone development and enzymatic functions (Walstra *et al.*, 2006; Fox and McSweeney, 2015) [25, 12].

India is the largest milk producer in the world, owing largely to its vast livestock population. Indigenous cattle breeds such as Sahiwal are well known for their adaptability to tropical climates, disease resistance and ability to produce milk with higher fat content. Despite these advantages, the productivity and milk quality of indigenous cattle often remain suboptimal due to inadequate nutrition, poor quality feed resources and imbalanced feeding practices (DAHD, 2019) [7]. The increasing cost of conventional feed ingredients and shrinking availability of quality fodder have further necessitated the exploration of alternative, economical and sustainable feed resources for dairy animals.

In recent years, herbal feed additives have gained considerable attention as natural growth promoters owing to their safety, eco-friendly nature and wide range of biological activities.

Medicinal plants contain bioactive compounds such as flavonoids, alkaloids, tannins, saponins and phenolic compounds, which possess antioxidant, antimicrobial and immunomodulatory properties and can positively influence animal health and productivity (Kumar *et al.*, 2012; Patra, 2011) [16, 21]. Among these, *Leptadenia reticulata* and *Moringa oleifera* have been widely recognized for their nutritional and therapeutic potential in livestock feeding.

Leptadenia reticulata, commonly known as Jivanti, is an important medicinal plant used extensively in Ayurvedic formulations as a galactagogue, rejuvenator and tonic. It is rich in phytochemicals such as flavonoids, sterols, glycosides and alkaloids, which are reported to enhance lactation, improve blood profile and support immune function (Kumar *et al.*, 2012; Patel *et al.*, 2016) [16, 19]. Previous studies have indicated that supplementation of *Leptadenia reticulata* improves milk yield and certain hematological parameters in dairy animals; however, limited information is available regarding its effect on milk physico-chemical characteristics and mineral composition (Dash *et al.*, 1972; Pathak, 2017) [8, 20].

Moringa oleifera, popularly known as the “miracle tree,” is another promising plant widely used in animal nutrition due to its high protein content (20-26%), rich mineral profile and abundance of vitamins and antioxidants. The leaves of *Moringa* are particularly rich in calcium, potassium, iron and essential amino acids, making them an excellent nutritional supplement for dairy animals (Gopalakrishnan *et al.*, 2016) [13]. Several studies have reported that *Moringa* supplementation improves milk yield, feed efficiency and antioxidant status in dairy cattle and small ruminants (Nouman *et al.*, 2013; Ashfaq *et al.*, 2012) [18, 3]. However, its influence on milk physico-chemical properties and mineral composition remains inadequately documented, especially under Indian field conditions.

Milk physico-chemical parameters such as specific gravity, pH and titratable acidity are considered reliable indicators of milk quality and udder health. These parameters are generally stable but may be influenced by dietary manipulation, stage of lactation and physiological status of animals (Fox and McSweeney, 2015) [12]. Similarly, milk minerals like calcium and phosphorus play a key role in milk coagulation, bone metabolism and enzyme activity, while magnesium and zinc are involved in metabolic and immune functions. Any alteration in these components may affect both the nutritive value and technological properties of milk (Walstra *et al.*, 2006) [25].

Although several studies have evaluated the effect of herbal supplements on milk yield and hematological parameters, systematic information on the combined effect of *Leptadenia reticulata* and *Moringa oleifera* on milk physico-chemical properties and mineral profile in indigenous cattle is scarce. Moreover, comparative data under controlled farm conditions are limited. Therefore, the present study was undertaken to evaluate the effect of dietary supplementation of *Leptadenia reticulata* and *Moringa oleifera*, individually and in combination, on milk quality and mineral composition of lactating Sahiwal cattle under farm conditions.

Materials and Methods

The present investigation was conducted at the Instructional Dairy Farm, Nagla, Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Pantnagar,

Uttarakhand, for a period of 120 days. A total of twenty-eight healthy lactating Sahiwal cows belonging to first to fourth parity were selected for the study. The animals were chosen on the basis of similarity in body weight, stage of lactation and average milk yield in order to minimize individual variation. The selected cows were randomly allocated into four experimental groups, each consisting of seven animals. The control group (To) was maintained on a basal diet comprising concentrate mixture, green fodder and wheat straw offered as per standard farm practice. The treatment groups were fed the same basal diet along with herbal supplementation. Group T₁ received *Leptadenia reticulata* root powder at the rate of 90 g per animal per day, group T₂ received *Moringa oleifera* leaf powder at 150 g per animal per day, while group T₃ received a combination of *Leptadenia reticulata* (45 g) and *Moringa oleifera* (75 g) per animal per day.

All animals were housed in a well-ventilated shed with concrete flooring and were managed under uniform feeding and management conditions throughout the experimental period. Standard management practices such as regular cleaning, proper sanitation and routine health care were followed. The animals were dewormed prior to the commencement of the experiment and were continuously monitored for health status during the study. Clean and fresh drinking water was provided ad libitum to all experimental animals.

Milk samples were collected from each animal at fortnightly intervals, namely on day 0, 15, 30, 45, 60, 75, 90, 105 and 120 of the experimental period. Sampling was carried out during morning milking under hygienic conditions using clean and sterilized containers. The collected milk samples were immediately transferred to the laboratory for analysis of physico-chemical properties and mineral composition. The parameters analyzed included specific gravity, titratable acidity and milk pH as indicators of milk quality, while mineral estimation comprised calcium, phosphorus, magnesium and zinc content. All analyses were performed using standard procedures as described in AOAC (2016) [2].

Statistical Analysis

The experimental data generated were subjected to statistical analysis using one-way analysis of variance (ANOVA) following a completely randomized design. The significance of differences among treatment means was tested at the 5 percent level of significance ($p < 0.05$). Statistical analysis was carried out using SPSS software in accordance with the methods described by Snedecor and Cochran (1994) [23].

Results and Discussion

The results of the present investigation on the effect of *Leptadenia reticulata* and *Moringa oleifera* supplementation on milk physico-chemical properties and mineral composition in lactating Sahiwal cattle are presented in Tables 1 and 2.

Physico-chemical Properties of Milk

The specific gravity of milk recorded at different intervals during the experimental period is presented in Table 1. Statistical analysis revealed that supplementation of *Leptadenia reticulata* and *Moringa oleifera*, either individually or in combination, did not exert any significant ($p > 0.05$) effect on milk specific gravity. The overall mean

values ranged from 1.028 ± 0.001 in the control, T₂ and T₃ group to 1.029 ± 0.001 in the *Leptadenia*-supplemented group. Throughout the study period, the values remained within the normal physiological range of cow milk, indicating that the density and compositional integrity of milk were not altered by herbal supplementation.

Table 1: Effect of *Leptadenia reticulata* and *Moringa oleifera* supplementation on overall mean physico-chemical properties of milk in Sahiwal cattle

Parameter	T ₀	T ₁	T ₂	T ₃
Specific gravity	1.028 ± 0.001	1.029 ± 0.001	1.028 ± 0.001	1.028 ± 0.001
Titrateable acidity (%)	0.134 ± 0.00	0.133 ± 0.00	0.135 ± 0.00	0.134 ± 0.00
Milk pH	6.54 ± 0.01	6.56 ± 0.01	6.56 ± 0.01	6.57 ± 0.01

T₀-Basal Diet (Control); T₁-Basal diet + *Leptadenia reticulata* root powder @ 90 g/day/animal orally; T₂-Basal diet + *Moringa oleifera* Leaf powder @ 150 g/day/animal orally; T₃-Basal diet + *Leptadenia reticulata* root powder @ 45 g + *Moringa oleifera* leaf powder @ 75 g/day/animal orally

Minor fluctuations observed at different sampling intervals may be attributed to natural variations associated with stage of lactation and physiological status of animals rather than dietary influence. Similar findings were reported by Jain and Basant (2015) [14], who observed no significant change in milk specific gravity following supplementation of herbal galactagogues. Likewise, Dong *et al.* (2019) [9] and Amad and Zentek (2023) [1] also reported that *Moringa* supplementation did not significantly influence milk density, supporting the present findings.

Titrateable acidity of milk remained stable throughout the experimental period, with values ranging between 0.129 and 0.137 percent across all treatment groups. Statistical analysis indicated no significant differences among treatments. The overall mean titrateable acidity was comparable among the groups, suggesting that herbal supplementation did not influence milk freshness or acid-base balance. The stability of titrateable acidity reflects the absence of any adverse effect of the experimental diets on milk quality and microbial status. Similar observations were recorded by Baig and Bhagwat (2009) [5], who reported non-significant variation in milk acidity following herbal supplementation, and by Shankhpal *et al.* (2019) [22], who observed no alteration in acidity of milk from cows fed *Moringa*-based diets.

Milk pH also remained within the normal physiological range (6.50-6.62) throughout the study, and no significant differences were observed among treatment groups. The overall mean pH values were 6.54, 6.56, 6.56 and 6.57 for T₀, T₁, T₂ and T₃, respectively. These results indicate that dietary inclusion of *Leptadenia reticulata* and *Moringa oleifera* did not disturb the acid-base equilibrium of milk. The maintenance of stable pH values suggests healthy udder condition and absence of subclinical mastitis. Similar findings were reported by Baig and Bhagwat (2009) [5], Tadeo *et al.* (2019) [24] and Bashar *et al.* (2020) [6], who also observed no significant influence of herbal supplementation on milk pH.

Milk Mineral Profile

The effect of dietary supplementation on milk calcium content is presented in Table 2. The overall mean calcium concentration ranged from 118.10 ± 1.86 mg/dL in the control group to 122.81 ± 1.64 mg/dL in the *Moringa*-

supplemented group. Although numerically higher values were recorded in the *Moringa*-fed cows, the differences among treatment groups were statistically non-significant. The higher calcium content observed in the *Moringa* group may be attributed to the rich mineral composition of *Moringa* leaves; however, the lack of statistical significance suggests that homeostatic regulation of calcium in milk remained largely unaffected. Similar findings were reported by Babiker *et al.* (2016) [4] and El-Esawy *et al.* (2018) [11], who observed no significant change in milk calcium content following dietary inclusion of *Moringa*.

Table 2: Effect of *Leptadenia reticulata* and *Moringa oleifera* supplementation on overall mean mineral composition of milk in Sahiwal cattle

Parameter (mg/dL)	T ₀	T ₁	T ₂	T ₃
Calcium	118.10 ± 1.86	121.44 ± 1.31	122.81 ± 1.64	119.99 ± 2.13
Phosphorus	89.93 ± 1.03	92.18 ± 1.27	94.87 ± 0.82	91.51 ± 1.95
Magnesium	10.92 ± 0.50	10.50 ± 0.45	11.36 ± 0.22	10.47 ± 0.32
Zinc	0.55 ± 0.02	0.54 ± 0.02	0.53 ± 0.02	0.55 ± 0.02

T₀-Basal Diet (Control); T₁-Basal diet + *Leptadenia reticulata* root powder @ 90 g/day/animal orally; T₂-Basal diet + *Moringa oleifera* Leaf powder @ 150 g/day/animal orally; T₃-Basal diet + *Leptadenia reticulata* root powder @ 45 g + *Moringa oleifera* leaf powder @ 75 g/day/animal orally

Milk phosphorus content followed a similar trend, with values ranging from 89.93 ± 1.03 to 94.87 ± 0.82 mg/dL across treatment groups. Although the *Moringa*-supplemented group showed slightly higher phosphorus levels, the differences were not statistically significant. This indicates that dietary supplementation did not significantly alter phosphorus metabolism or secretion into milk. These findings are in agreement with those of Zeng *et al.* (2017) and Tadeo *et al.* (2019) [24], who reported that *Moringa* supplementation had no significant effect on milk phosphorus concentration.

The magnesium content of milk also remained unaffected by dietary treatments, with overall mean values ranging from 10.47 ± 0.32 to 11.36 ± 0.22 mg/dL. The absence of significant variation among groups indicates that magnesium homeostasis was well maintained irrespective of dietary supplementation. Similar observations were reported by Kekana *et al.* (2020) and Liu *et al.* (2023), who found no significant effect of herbal supplementation on milk magnesium concentration.

Milk zinc concentration showed minimal variation among treatment groups, with overall mean values ranging from 0.53 ± 0.02 to 0.55 ± 0.02 mg/dL. Statistical analysis revealed no significant differences among treatments, indicating that supplementation of *Leptadenia reticulata* and *Moringa oleifera* did not influence zinc secretion in milk. These results are in agreement with the findings of Dash *et al.* (1972) [8] and El-Badawi *et al.* (2023), who also reported non-significant effects of herbal supplementation on milk zinc content.

Overall, the results of the present study clearly demonstrate that supplementation of *Leptadenia reticulata* and *Moringa oleifera*, either alone or in combination, did not adversely affect milk physico-chemical properties or mineral composition. The stability of these parameters suggests that the herbal supplements are nutritionally safe and do not compromise milk quality. Although slight numerical improvements were observed in certain mineral

components, particularly in the *Moringa*-supplemented group, these changes were not statistically significant. The findings support the use of these herbal feed additives as safe nutritional supplements in lactating Sahiwal cattle without altering milk quality.

Conclusion

The present investigation demonstrated that dietary supplementation of *Leptadenia reticulata* and *Moringa oleifera*, either individually or in combination, had no adverse effect on the physico-chemical properties and mineral composition of milk in lactating Sahiwal cattle. Parameters such as specific gravity, titratable acidity and milk pH remained within the normal physiological range throughout the experimental period, indicating maintenance of milk quality and udder health.

Similarly, milk mineral constituents including calcium, phosphorus, magnesium and zinc were not significantly influenced by herbal supplementation, although slight numerical improvements were observed in the *Moringa*-supplemented group. The stability of these parameters suggests that the experimental supplements did not disturb mineral metabolism or milk compositional integrity.

Based on the findings of the present study, it may be concluded that *Leptadenia reticulata* and *Moringa oleifera* can be safely used as natural herbal feed supplements in lactating Sahiwal cattle without negatively affecting milk quality or mineral profile. Furthermore, the slight improvement observed in certain mineral parameters indicates their potential as sustainable and eco-friendly nutritional supplements for dairy animals. Future studies with larger sample size and longer duration may further elucidate their beneficial effects on milk nutritional quality and animal productivity.

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