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Effects of *Leptadenia reticulata* and *Moringa oleifera* feeding on hematological profile of lactating Sahiwal cattle under farm conditions

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Abstract
The present trial was conducted for 120 days on 28 lactating Sahiwal cattle (1st-4th parity) at the Instructional Dairy Farm, Nagla, GBPUA&T, Pantnagar. Animals were randomly divided into four groups: T_0 (control), T_1 (*Leptadenia reticulata* @ 90 g/day/animal), T_2 (*Moringa oleifera* @ 150 g/day/animal), and T_3 (combination of 45 g *L. reticulata* + 75 g *M. oleifera* per day/animal). All cows were maintained on a basal diet of concentrate mixture, green fodder, and wheat straw, while treatment groups received the respective herbal supplements in addition. Blood samples were collected monthly to evaluate hematological parameters, including hemoglobin (Hb), packed cell volume (PCV), total erythrocyte count (TEC), total leukocyte count (TLC), and differential leukocyte count (DLC). Results showed that Hb and most differential leukocyte counts remained unaffected by supplementation, except for neutrophils which were significantly ($p<0.05$) higher in the Moringa group (T_2). PCV was significantly ($p<0.05$) improved in both Leptadenia (T_1) and Moringa (T_2) groups, with T_2 recording the highest values. TEC and TLC were also significantly ($p<0.05$) elevated in the Moringa-fed cows. It may be concluded that supplementation of *Leptadenia reticulata* and *Moringa oleifera* along with the basal diet improved hematological health in lactating Sahiwal cows. While *Moringa oleifera* demonstrated stronger effects on erythropoietic and immune indices, *Leptadenia reticulata* contributed positively, particularly through improved PCV, thereby supporting their potential as safe and beneficial herbal feed supplements.

Keywords: Hematology, herbal supplementation, *Leptadenia reticulata*, *Moringa oleifera*, Sahiwal cattle

Introduction
The livestock sector constitutes an integral part of Indian agriculture and contributes significantly to the national economy, rural employment and nutritional security of millions of households. India possesses the largest livestock population in the world with 535.8 million heads, which includes 192.5 million cattle and 109.8 million buffaloes (DAHD, 2019) [4]. Indigenous dairy breeds such as Sahiwal cows are particularly valued for their adaptability to tropical climates, higher disease resistance and superior milk fat percentage, making them important contributors to the livelihood of small and marginal farmers.
Despite the enormous livestock resources, the productivity of animals in India remains much lower than the global average, primarily due to the shortage of good quality feed and fodder. Increasing pressure on cultivable land and the rising human population has widened the gap between the demand and supply of balanced livestock feed. Farmers generally rely on poor-quality crop residues and conventional roughages that are deficient in protein, minerals and vitamins. Prolonged feeding of such low nutritive value feedstuffs often results in poor digestibility, reduced voluntary intake, compromised reproductive efficiency, delayed maturity and low milk production (Gebregiorgis *et al.*, 2012) [5]. To overcome these constraints, researchers have been exploring cost effective feed supplements of herbal origin that are rich in nutrients and possess additional therapeutic properties. among these, *Leptadenia reticulata* (Jivanti) is a well-known medicinal plant in Ayurveda, traditionally used as a galactagogue and immunomodulator. It contains phytoconstituents such as alkaloids, flavonoids, tannins and saponins, which are reported to exert antioxidant,

hematopoietic and immunity-enhancing effects (Kumar *et al.*, 2012) [9]. Likewise, *Moringa oleifera*, popularly known as the "miracle tree," is recognized as a multipurpose plant that can be cultivated under diverse agro-climatic conditions. Its leaves are rich in crude protein (20-26%), essential amino acids, vitamins (A, B and C), calcium, potassium and iron, in addition to possessing antioxidant, antimicrobial, anti-inflammatory and anti-diabetic properties (Gopalakrishnan *et al.*, 2016) [6]. Thus, both *Leptadenia reticulata* and *Moringa oleifera* hold considerable promise as cost-effective and sustainable feed supplements for improving animal health and production.

Evaluation of hematological parameters provides a reliable tool for assessing the physiological status and overall health of animals. Important indices such as total erythrocyte count (TEC), hemoglobin concentration (Hb), packed cell volume (PCV) and total leukocyte count (TLC) indicate oxygen-carrying capacity, erythropoietic activity and immune competence. In addition, the differential leukocyte count (DLC), comprising neutrophils, lymphocytes, monocytes, eosinophils and basophils, serves as an indicator of immune response, disease resistance and general well-being of animals (Smith, 2002) [16]. Changes in these blood parameters due to dietary interventions can therefore reflect the impact of herbal feed supplementation on hematopoiesis and immunity.

Studies in dairy cattle have shown that *Moringa oleifera* supplementation has been shown to improve milk yield, antioxidant status, and hematological health in dairy cattle (Nouman *et al.*, 2013; Ashfaq *et al.*, 2012) [11, 1]. *Leptadenia reticulata*, traditionally used as a galactagogue and immunomodulator in Ayurveda, has also been reported to enhance hematological indices in livestock (Kumar *et al.*, 2012; Patel *et al.*, 2016; Sharma *et al.*, 2019) [9, 13, 14]. However, systematic evaluation of these herbs in indigenous dairy breeds like Sahiwal cows is limited, and evidence on their combined use is scarce. Hence, the present study aimed to evaluate the effect of *L. reticulata* and *M. oleifera*, alone and in combination, on hematological parameters of lactating Sahiwal cows under farm conditions

Materials and Methods

The present study was conducted at the Instructional Dairy Farm, Nagla, GBPUA&T, Pantnagar (Uttarakhand) for a period of 120 days on 28 lactating Sahiwal cows of 1st to 4th parity. The animals were selected on the basis of similarity in average milk yield and body weight and were randomly distributed into four groups of seven animals each. The control group (T_0) was provided with a basal diet consisting of concentrate mixture, green fodder and wheat straw offered *ad libitum*, while the treatment groups were fed the same basal diet along with herbal feed supplements. Group T_1 received basal diet supplemented with *Leptadenia reticulata* (Jivanti) root powder at 90 g/day/animal, group T_2 received basal diet supplemented with *Moringa oleifera* leaf powder at 150 g/day/animal and group T_3 received basal diet supplemented with a combination of *Leptadenia reticulata* (45 g) and *Moringa oleifera* (75 g) per day/animal. All animals were housed in a well-ventilated shed with concrete flooring and were managed under uniform feeding and managemental conditions throughout the experiment. Routine farm practices were followed for cleaning, feeding and watering, and all cows were dewormed before the commencement of the trial. Fresh and clean drinking water was made available ad libitum and general health care practices were ensured during the study period. Blood samples (approximately 5 ml) were collected aseptically from the jugular vein of each cow at 0, 30, 60, 90 and 120 days of the experiment using sterile syringes and transferred into EDTA-coated tubes to prevent coagulation. These samples were used for the study of hematological parameters which included hemoglobin (Hb, g/dl), packed cell volume (PCV%), total erythrocyte count (TEC, $\times 10^6$/mm^3), total leukocyte count (TLC, $\times 10^3$/mm^3) and differential leukocyte count (DLC,%) comprising neutrophils, lymphocytes, monocytes, eosinophils and basophils.

Statistical Analysis

The experimental data generated during the present study was subjected to statistical analysis using one-way analysis of variance (ANOVA) through SPSS software, following the method described by Snedecor and Cochran (1994) [19].

Results & discussion

This study evaluated the effects of *Leptadenia reticulata* and *Moringa oleifera* supplementation on the hematological profile of lactating Sahiwal cattle. The results are summarized in Table 1 and 2 and discussed below.

Hematological Parameters (Hb, PCV, TEC and TLC)

The hemoglobin (Hb) concentration recorded in different treatment groups during the experimental period is presented in Table 1. Statistical analysis revealed that there was no significant difference (p>0.05) in Hb levels among the groups throughout the trial. The overall mean values ranged from 11.97±0.13 g/dL in the control (T_0) to 12.07±0.12 g/dL in the Moringa-supplemented group (T_2). Although the values did not differ significantly, all treatment groups maintained Hb concentration within the normal physiological range of healthy lactating cattle, indicating that supplementation of *Leptadenia reticulata* and *Moringa oleifera* did not adversely affect the oxygen-carrying capacity of blood. These results are in agreement with Singh (2011) [15], who reported non-significant variation in Hb of goats fed herbal galactagogues containing *Leptadenia reticulata*, and Sonkar *et al.* (2020) [17], who observed similar non-significant changes in Hb concentration of lactating Sahiwal cows supplemented with Moringa leaf meal.

Packed cell volume (PCV) values at day 0 were comparable among all groups T_0 (control): 32.64±0.90%, T_1: 33.44±0.45%, T_2: 33.42±0.58%, and T_3: 33.66±0.90%. However, the overall mean (0-120 days) revealed significant differences (p<0.05). Both Leptadenia (T_1: 32.92±0.33%) and Moringa (T_2: 33.19±0.23%) supplemented groups exhibited higher PCV compared with the control (T_0: 32.04±0.33%), while the mixed group (T_3: 32.16±0.34%) remained statistically similar to control. The elevation in PCV indicates a stimulatory effect on erythropoiesis and consequently an improved oxygen-carrying capacity in the supplemented groups. Similar hematinic responses have been documented in ruminants, with improved PCV reported in buffaloes fed *Leptadenia reticulata* (Pathak, 2017) [12] and increased PCV, Hb, and RBC counts in goats supplemented with *Moringa oleifera* foliage (Zaher *et al.*, 2020) [18]. Although reports in dairy cattle are scarce, these findings from related ruminant models provide strong supportive evidence for the hematological benefits of these herbal feed supplements.

Table 1: Effect of herbal supplementation on hematological parameters (Hb, PCV, TEC and TLC) in Sahiwal cattle.

Parameter	Days	T_0	T_1	T_2	T_3
Hb (g/dL)	0 Day	11.83±0.30	12.10±0.12	11.83±0.33	11.79±0.21
	Overall mean	11.97±0.13	12.04±0.07	12.07±0.12	12.02±0.08
PCV (%)	0 Day	32.64±0.90	33.44±0.45	33.42±0.58	33.66±0.90
	Overall mean	32.04±0.33^a	32.92±0.33^b	33.19±0.23^b	32.16±0.34^a
TEC ($\times10^6$/µL)	0 Day	7.09±0.09	7.08±0.11	6.99±0.11	7.05±0.12
	Overall mean	7.07±0.04^a	7.18±0.03^a	7.31±0.04^b	7.10±0.04^a
TLC ($\times10^3$/µL)	0 Day	8.41±0.11	8.55±0.14	8.56±0.27	8.70±0.23
	Overall mean	8.48±0.08^a	8.58±0.07^a	8.86±0.06^b	8.65±0.05^a

T_0-Basal Diet (Control); T_1-Basal diet + Leptadenia reticulata root powder @ 90 g/day/animal orally; T_2-Basal diet + Moringa oleifera Leaf powder @ 150 g/day/animal orally; T_3-Basal diet+ Leptadenia reticulata root powder @ 45g + Moringa oleifera leaf powder @ 75g/day/animal orally

Means bearing different superscripts in a row differ significantly (p<0.05).

The overall mean TEC differed significantly (p<0.05) among treatments, with the Moringa-supplemented group (T_2: 7.31±0.04 $\times10^6$/µL) recording the highest value, significantly greater than control (T_0: 7.07±0.04 $\times10^6$/µL). Leptadenia (T_1: 7.18±0.03 $\times10^6$/µL) and the mixed group (T_3: 7.10±0.04 $\times10^6$/µL) remained statistically similar to control. The marked increase in TEC with Moringa supplementation is consistent with Jiwuba *et al.* (2016) [7], who reported significantly higher red blood cell indices in goats fed *Moringa oleifera* leaves. The significant rise in TEC observed here reflects enhanced erythropoiesis, thereby improving oxygen transport and overall physiological efficiency in lactating Sahiwal cows

The total leukocyte count (TLC) of different groups is presented in Table 1. At day 0, no significant differences were observed among treatments. However, at the overall mean level, significant (p<0.05) variation was evident, with the Moringa-supplemented group (T_2: 8.86±0.06 $\times10^3$/µL) showing higher values compared to the control (T_0: 8.48±0.08 $\times10^3$/µL). Increased leukocyte count indicates improved immune responsiveness, as WBCs are central to host defense. Similar immunomodulatory effects of *Moringa oleifera* have been reported in goats with significantly higher leukocyte counts (Babeker & Abdalbagi, 2015) [2], and improved hematological profiles in dairy cows supplemented with Moringa leaf meal (Kekana *et al.*, 2022) [8].

Differential leukocyte count (DLC)

Differential leukocyte count (DLC) parameters are presented in Table 2. The proportion of lymphocytes across all groups did not differ significantly (p>0.05), with overall values ranging from 64.94±0.64% in T_2 (Moringa-fed cows) to 66.63±0.53% in T_0 (control). Maintenance of lymphocyte count within the physiological range indicated that neither *Leptadenia reticulata* nor *Moringa oleifera* exerted any adverse effect on lymphocytic activity. Stable lymphocyte levels are crucial for adaptive immunity, ensuring effective antibody production and long-term disease resistance. Similar results were documented by Zaher *et al.* (2020) [18], who reported non-significant variation in lymphocyte concentration in goats supplemented with *Moringa oleifera* diets.

Neutrophil counts showed significant (p<0.05) variation among treatments, with the Moringa group (T_2: 28.37±0.39%) recording the highest percentage compared to control. Neutrophils represent the first line of defense against microbial invasion, and their elevation indicates enhanced innate immune responsiveness. The increase in neutrophils may also be associated with the overall rise in total leukocyte count observed in the Moringa-supplemented group. Similar immunostimulatory effects of *Moringa oleifera* on hematological and immune parameters have been reported earlier (Nkukwana *et al.*, 2014) [10].

Table 2: Effect of herbal supplementation on differential leukocyte count (%) in Sahiwal cattle.

Parameter	Days	T_0	T_1	T_2	T_3
Lymphocytes	0D	68.05±0.81	69.24±1.21	66.33±0.75	65.85±1.12
	Overall mean	66.63±0.53	66.11±0.49	64.94±0.64	65.66±0.72
Neutrophils	0D	25.09±1.14	26.45±0.88	25.80±1.15	26.86±0.75
	Overall mean	26.74±0.42^a	27.29±0.36^{ab}	28.37±0.39^b	27.65±0.35^{ab}
Monocytes	0D	3.13±0.18	3.09±0.15	3.06±0.11	3.05±0.09
	Overall mean	3.10±0.04	3.02±0.05	3.13±0.03	3.05±0.05
Eosinophils	0D	2.87±0.09	2.88±0.08	2.79±0.12	2.69±0.08
	Overall mean	2.72±0.03	2.81±0.04	2.77±0.07	2.62±0.04
Basophils	0D	0.56±0.10	0.66±0.12	0.53±0.11	0.70±0.10
	Overall mean	0.58±0.02	0.50±0.02	0.55±0.05	0.60±0.04

T_0-Basal Diet (Control); T_1-Basal diet + Leptadenia reticulata root powder @ 90 g/day/animal orally; T_2-Basal diet + Moringa oleifera Leaf powder @ 150 g/day/animal orally; T_3-Basal diet+ Leptadenia reticulata root powder 45g + Moringa oleifera leaf powder 75g/day/animal orally

Means bearing different superscripts in a row differ significantly (p<0.05).

Monocyte percentages did not differ significantly (p>0.05) among the treatment groups, with values ranging between 3.02±0.05% (T_1) and 3.13±0.03% (T_2). Monocytes function as antigen-presenting cells and precursors of macrophages; their stable levels indicate that herbal supplementation maintained normal immunological balance without inducing stress-related fluctuations. Similarly, eosinophil counts remained statistically comparable across groups, with overall mean values ranging from 2.62±0.04% in T_3 to 2.81±0.04% in T_1. As eosinophils are mainly associated

with allergic and parasitic responses, the absence of marked variation suggests that supplementation neither triggered hypersensitivity nor compromised parasite resistance. Basophil counts, though numerically variable, also did not differ significantly (p>0.05) among groups, with values lying between 0.50±0.02% (T_1) and 0.60±0.04% (T_3). Given their very low physiological abundance, this stability further supports the benign nature of both *Leptadenia reticulata* and *Moringa oleifera* as safe herbal feed supplements. These findings are in agreement with earlier reports in dairy cattle, where *Leptadenia reticulata* supplementation did not cause significant alterations in leukocyte profile (Dash *et al.*, 1972) [3]. Similar observations have also been reported with *Moringa oleifera* supplementation in goats and dairy animals, where differential leukocyte percentages (monocytes, eosinophils, basophils) largely remained unchanged (Nouman *et al.*, 2013; Babeker & Abdalbagi, 2015; Jiwuba *et al.*, 2016) [11, 2, 7].

Conclusion

The study showed that supplementation of *Leptadenia reticulata* (T_1) and *Moringa oleifera* (T_2) in lactating Sahiwal cows improved hematological traits compared to the control (T_0). Hemoglobin remained unaffected, while PCV increased significantly in both herbal groups. TEC, TLC, and neutrophil percentage were higher in the Moringa group (T_2), indicating enhanced erythropoiesis and immune response. The combined group (T_3) did not show additive benefits, likely due to dose dilution or phytochemical interactions. Overall, both herbs were safe, with *Moringa oleifera* (T_2) exerting stronger effects and *Leptadenia reticulata* (T_1) contributing positively, especially to PCV.

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