Indian J Dairy Sci 79(3): 275-283
https://doi.org/10.33785/IJDS.2026.v79i03.011

RESEARCH ARTICLE

Assessment of plasma mineral- biochemical profiles, milk composition and nutrient status of feeds for dairy cattle in cold arid Kargil, Ladakh

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Received: 14 August 2025 / Accepted: 21 March 2026 / Published online: 23 July 2026

Abstract: To address deficiencies impacting productivity, it is important to evaluate the regional mineral status of livestock by assessing mineral content in local feedstuffs alongside physiological states (pregnancy, lactation) and production levels (milk yield). This study was conducted with the aim to determine the mineral profiles of key feedstuffs and dairy cattle plasma, their metabolic parameters, and milk composition under farmers' field condition in district Kargil. A total of 129 blood and 102 milk samples were collected randomly from dairy cattle in 6 blocks (Zanskar, Sankoo, TSG, Kargil, Drass and Chiktan) of the district. These samples were divided into three groups based on milk yield of animals as cattle yielding milk 5-10 kg/day, upto 5 kg/day and dry pregnant. Also, samples of feeds and fodders most commonly offered to livestock by the dairy farmers were collected separately, pooled block wise and analysed. The chemical composition of the feedstuffs were within prescribed normal ranges except wild grass hay in which content of most of the minerals were below the critical levels. The concentrate feeds contained adequate levels of all the nutrients and minerals with low P and Mn contents in apricot oilcake. All plasma macro-minerals and only Fe and Co among micro-minerals were above the critical levels across all the milk yield groups of dairy cattle throughout the district. Overall deficiency of Ca, P and Na among macro- and Cu, Zn and Mn among micro-minerals exists among 45.73, 31.78, 44.96, 64.34, 86.04, 72.86%, respectively in blood plasma of dairy cattle in the district with higher ($p<0.01$) deficiency prevalence in dry pregnant compared to lactating animals. Plasma biochemicals were within normal reference ranges across all groups of dairy cattle except for total protein. The key milk components varied between the groups with higher ($p<0.05$) levels of fat and total solids but lower ($p<0.05$) levels of protein and MUN contents in cows yielding milk upto 5 kg/day compared to those producing 5-10 kg/day. It is concluded that milk yield varied the plasma mineral status, metabolic profiles as well as milk composition in dairy cows with dry pregnant cows exhibited higher deficiency prevalences, reflecting the need of targeted mineral supplementation for cost effective enhancement of milk productivity in the region.

Keywords: Blood biochemicals, Cold arid, Dairy cattle, Feeds, Mineral status, Milk

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Introduction

In developing nation like India, most of the feedstuffs offered to the livestock do not meet the optimum requirements of nutrients including mineral elements. Continued ingestion of feeds that are deficient or excessively high in minerals induce biochemical or physiological dysfunctions and nutritional disorders that ultimately affects animal performances like production and composition of milk in dairy animals (Fadlalla 2022). The process of milk production requires the mobilization of minerals, fats and proteins from body reserves to cope up with the high nutrient demands during milk production (Alemu et al. 2023). Assessment of mineral profile of blood and constituents of milk serve as indicators of cows' nutritional status and metabolic health (Andjelic et al. 2022). Biochemical profile reflects the health status of dairy animals and is highly correlated with milk production (Coroian et al. 2017). Such analysis is generally performed to estimate the prevalence and risk levels of specific metabolic disorders in the herd (Calamari et al. 2016).

Mineral elements are essential to satisfy the normal physiological requirements of dairy animal, as they play crucial role in health, reproduction, and production of animal (Pal et al. 2024). The level of milk production in dairy cattle is known to influence their overall metabolic balance and nutrient requirements (Gross 2022).

Many environmental and biological conditions like lactation stages, milk yield, parity etc. affect mineral and biochemical concentration in blood (Spears et al. 2022) and milk composition (Huhtanen and Rinne 2007), but the results are inconsistent probably due to differences in breed, production system, regional feeding practices, environment factors, and physiological conditions. Healthy cows can have different milk production levels even when they are fed the same diet and managed under the similar conditions (Kim et al. 2017); however, scanty information is available on the degree of variation in blood mineral and biochemical levels, as well as milk constituents among them. In this context, the present study was conducted to determine the plasma mineral- biochemical profiles, milk composition across different yield groups, and nutrient status of key feeds/fodders fed to dairy cattle in district Kargil of Ladhak to evaluate physiological health, pinpoint nutrient deficiencies (if any) for enhance regional productivity.

Materials and Methods

The study area

The study was carried out in Kargil district of Union Territory of Ladakh, located at 75.08° East longitudes and 34.33° North latitude in the north-west of the Great Himalayan Range encompassing majority of the Zanskar range. The region has mostly hilly terrain with a typical cold-arid harsh climate enjoying wide diurnal and seasonal fluctuations in temperature from ‹ 40 °C in winter to +35 °C in summer. The distinctive agro-climatic conditions of this cold desert has led to the development of traditional animal farming practices and survival-oriented adaptations. The district has administratively 9 blocks out of which six blocks *viz*. Zanskar, Sankoo, TSG, Kargil, Drass and Chiktan were selected for the study based on highest number of breedable cattle population as per the 20th Livestock census.

Sampling

A total of 129 blood samples were collected from dairy cattle selected randomly in six blocks. Milk samples of 102 in total number were also collected from the same cattle from which blood samples were taken. Moreover, samples of feeds and fodders commonly offered to cattle by dairy farmers were collected separately. The number of blood, milk and feed/fodder samples collected from different blocks in district Kargil are presented in Table 1. Since majority of the cattle being reared by dairy farmers were cross-bred Jersey with an average daily milk productivity of 4-6 litres per cow (Singh 2014), the blood samples collected were divided into three groups based on the milk yield of respective cattle as animals yielding milk 5-10 kg/day, upto 5 kg/ day and dry pregnant. Accordingly, milk samples were divided into two groups for cattle yielding milk 5-10 kg/day and upto 5 kg/day.

Sample processing and analysis

Approximately 10-15 ml of blood was drawn aseptically from jugular vein of each dairy animals into capped collection vials containing ethylene diamine tetra acetic acid at 1.5 mg per ml of blood as anti-coagulant, and the samples were gently shaken to mix thorough with the anti-coagulant. Besides, 10 ml milk sample was also collected from the dairy animals during the morning milking on the same day the blood sample was collected. The collected samples were placed between ice packs and transported to the laboratory for analysis in vaccine carriers. The feed/fodder samples were pooled block wise to get the uniform representative sample for each type of feed/fodder.

The blood samples were centrifuged at 3000 rpm for 10 minutes to obtain plasma which was then stored in deep freezer at -20°C in two sets for further analysis of mineral and biochemical estimation. The plasma samples with equal volume of concentrated nitric acid were kept for overnight in digestion tubes followed by low heat (70-80°C) digestion with di-acid mixture (70% Perchloric acid : conc. Nitric acid in 1: 3 ratio). The final content was filtered through Whatman's filter paper No.1 (Kolmer et al. 1951). The concentration of calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), cobalt (Co) and manganese (Mn) in blood plasma were estimated using Atomic Absorption Spectrophotometer (GBC SensAA, Sr. no. A7156, GBC Scientific Equipment, Inc, Australia). Phosphorus was determined colorimetrically in blood plasma (Fiske and Subbarow 1925) using Autozyme Phosphorus kit (ACCUREX Biomedical Pvt. Ltd.). Sodium (Na), potassium (K) and chlorine (Cl) were estimated in blood plasma using flame photometer (Systronics, Mediflame 127). Also, the glucose level was estimated at the time of blood collection by using SD-Codefree Blood Glucose Meter (SD Biosensor Healthcare Pvt. Ltd., Gurgaon, Haryana, India). Another set of stored plasma samples were analysed for contents of biochemicals like cholesterol (Chol), triglycerides (TG), total proteins (TP), albumin (Alb), and urea-N (PUN) through standard methods using commercial diagnostic kits (Diasys Diagnostics Private Limited, India) on Photometer 5010V5$^+$ semi-auto biochem analyzer (Robert Riele INC, Berlin, Germany).

The milk samples collected were heated to 40±2°C for homogenization and then analysed for composition using automatic milk analyzer (Speedy Lab, Astori Technica s.r.l, Italy) based on Fourier-transform infrared spectroscopy. The collected and pooled feed/fodder samples were dried at 80°C, ground, labelled and properly stored in airtight polythene bags for laboratory analysis. The samples were analyzed for proximate composition including dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fibre (CF), non-structural carbohydrates (NSC) following standard procedures as per AOAC (2019). Also, the feed/fodder samples were subjected to wet digestion with di-acid mixture (Trolson 1969), diluted with triple glass distilled water to prepare extractable aliquots, analysed for estimation of macro- and micro- minerals using the same procedures as done for blood plasma.

Statistical analysis

The data generated were subjected to statistical analysis for mean, standard error and test of significance through one-way ANOVA using SPSS (2011) statistical software program for Windows. Significant differences among treatment means was determined as per Duncan's multiple range test. These tests were one sided and were referenced for p value for their significance. Any p value less than 0.05 (pÂ0.05) was taken to be statistically significant.

Results and Discussion

Feeding system and composition of available feeds/fodders

The dairy farmers were following complete stall feeding of their livestock during winter season while semi-stall along with grazing was practiced during summer season. The dry fodders for dairy cattle included mainly barley straw, alfalfa hay and wild grass hay stored during summers to be offered in winters. Dairy farmers practiced to feed concentrates only to their high yielders based on the milk production. Mostly the farmers were preparing concentrate feed at home using locally available ingredients of barley grains, apricot oilcake and other agro-residues. Only 33.70% of the farmers particularly in Kargil, Sankoo and TSG use to supplement the dairy animals with mineral mixtures.

The chemical composition of any feed is considered as the preliminary index for the assessment of its quality. Proximate and mineral composition (on %DM basis) of the feeds and fodders most commonly fed to dairy cattle in Kargil district are presented in Table 2. The chemical composition of all the feeds and fodders in surveyed blocks of the district were in normal ranges as prescribed for Indian feeds and fodders (ICAR 2013) with little variations which might be due to difference in herbage plant species, cultivar differences, soil/geographical area, climatic conditions, irrigation and fertilizer uses (Teka et al. 2012). The chemical composition of roughages fed to dairy cattle in the study areas of district Kargil are in close agreement with the values reported by Bharti et al. (2016), while composition of concentrate feeds are in line with the findings of Sheikh et al. (2011).

Adequate content of all macro-minerals was present in the analyzed composite samples of the fodders except wild grass hay in which the minerals were below critical levels barring Ca and Cl. Low precipitation in cold desert Ladhak prevents leaching of minerals from the soils in general, as such the crops grown over them contain adequate plant minerals. Temperate forages especially legumes like alfalfa generally contain more Ca than those grown in the tropics (McDowell and Valle 2000). Also, lower temperature in cold-arid Ladhak region might have favored the accumulation of Ca in plant tissues (Waraich et al. 2012). These forages had higher levels of Ca than dietary requirement of dairy cows; however, efficiency of Ca utilization from these forages, and thus its bioavailability in ruminants would depend on presence of adequate level of P, active form of vitamin D, and levels of calcitonin and parathyroid hormone (Veum 2010).

Content of analysed micro-minerals except Fe were below the critical levels prescribed by McDowell and Conrad (1977) and NRC (1984) in all the available fodders barring Cu and Co in alfalfa hay. Cu deficiency in fodders under the present study may be attributed to the typical soil condition that might be restricting its accumulation and availability in plants (Xu et al. 2024). Looseness of soil and lower values of soil Cu and Zn, and/ or higher concentration of soil molybdenum and Fe in Kargil reflected as such in the forages grown over it (Mandal et al. 2004). The concentrate feeds contained adequate levels of all the nutrients and minerals with low P and Mn contents in apricot oilcake. Similar results were also found in the study conducted by Malsawmthangi and Samanta (2017) in temperate sub-alpine zone of Mizorum.

Plasma macro-mineral and deficiency prevalence profiles of dairy cattle

The overall average of all the plasma macro-minerals were found above the critical levels throughout the district (Table 3) with significant ($p<0.05$) influence of milk yield on Mg and Cl levels in dairy cattle. The normal range for Ca, P, Mg, Na, K and Cl in dairy

Table 1: Samples of blood and milk from dairy cattle, and available feed/fodder collected in different blocks of district Kargil, Ladhak

S No.	Surveyed Blocks	Total cattle population	Breedable cattle population	Number of blood samples collected	Number of milk samples collected	Number of feed/fodder samples collected
1	Zanskar	12059	6029	27	20	24
2	Sankoo	6181	3090	31	25	98
3	TSG	3773	1915	17	14	65
4	Kargil	10899	4589	21	19	70
5	Drass	5016	2508	21	15	63
6	Chiktan	2182	1206	12	9	107
			Total	129	102	427

cattle has been reported to be 9 to 12, 4 to 7, 1.7 to 2.5 mg/dL, and 134 to 144, 4 to 5.9, 92 to 99 mEq/L, respectively (Radostits et al. 2000).

The mean plasma Ca concentration in dairy cattle of all the blocks of district Kargil was within the normal range with marginal higher values ($p>0.05$) in lactating compared to dry animals which might be due to extra care regarding feeding of concentrates and/or supplements to milch cows. Moreover, lactating cows mobilize large amounts of Ca from their body reserves (Djokovic et al. 2014). The overall prevalence of hypocalcaemia in the district was 45.73% with numerically higher ($p>0.01$) values in dry pregnant animals. Workers have reported varying percentage prevalence of hypocalcemia in cattle; however, the results of present study corroborates well with the reports from various agro-climatic zones of North-West Himalayan region of Jammu division (Singh et al. 2016).

The mean plasma P concentration was similar among different groups of dairy cattle with slightly higher ($p>0.05$) values in milch compared to dry pregnant animals; however, the values were within the normal range for all groups of dairy animals in all blocks of the district. Some studies have reported significantly higher level of P in crossbred cows (Siddique 2011), while other have outlined the level below the normal range (Singh et al. 2016). The differences observed in the level of blood P in various studies could be due to difference in their dietary level, breed, season and other factors like sample preparation, temperature, duration of sample collection and plasma preparation time (McDowell 2003). The overall prevalence of hypophosphataemia in dairy cattle was 31.78% in the district with higher ($p>0.05$) values in dry pregnant animals. Goklaney et al. (2019) also reported higher prevalence of P deficiency in pregnant goats followed by dry and lactating goats. In contrast, Singh et al. (2016) reported widespread P deficiency among crossbred cattle of hilly areas of Jammu division.

Plasma Mg concentration was higher ($p<0.05$) in low milk yielding and least in animals yielding milk 5-10 kg/day but within the normal range, with a negligible (0.77%) overall prevalence of

Table 2: Composition (on %DM basis) of most available feeds and fodders fed to dairy cattle in district Kargil, Ladhak

Attribute	Critical level	Barley straw (n=104)	Alfalfa hay (n= 104)	Wild grass hay (n=100)	Apricot oil cake (n=32)	Home-made concentrate (n=56)	Commercial compound feed (n=31)
Proximate composition							
Dry matter	-	91.88±2.36	93.30±4.62	92.63±3.92	88.10±4.62	91.50±3.21	92.67±2.59
Organic matter	-	91.03±3.71	87.97±3.52	90.66±3.04	96.33±4.91	91.93±2.64	90.78±3.74
Crude protein	-	3.41±0.11	15.94±2.01	5.17±0.27	31.19±3.21	14.61±1.21	11.33±1.03
Ether extract	-	0.91±0.02	1.45±0.02	1.25±0.01	7.25±1.01	3.82±0.08	2.95±0.04
Crude fibre	-	48.75±3.21	28.57±1.90	31.40±2.73	7.08±0.95	5.82±0.72	7.55±0.84
Non-structural carbohydrates	-	37.96±2.79	42.01±2.32	52.83±2.88	50.68±3.15	67.69±4.13	67.96±3.52
Mineral composition							
Calcium	<0.30 %	0.29±0.02	1.95±0.05	0.45±0.01	0.36±0.04	1.01±0.04	1.29±0.02
Phosphorous	<0.25 %	0.25±0.01	0.31±0.03	0.22±0.02	0.15±0.00	0.33±0.02	0.87±0.04
Magnesium	<0.20 %	0.22±0.01	0.32±0.05	0.19±0.01	0.30±0.03	0.38±0.04	0.61±0.04
Sodium	<0.08 %	0.17±0.00	0.08±0.00	0.02±0.00	0.08±0.01	0.21±0.01	0.58±0.03
Potassium	<0.25 %	2.27±0.21	2.35±0.11	0.18±0.06	1.15±0.15	0.95±0.09	1.13±0.14
Chlorine	<0.10 %	0.69±0.04	0.39±0.05	0.46±0.02	0.13±0.00	0.21±0.01	0.32±0.01
Copper	<8.00 ppm	5.07±0.11	10.76±1.02	4.21±0.58	10.29±1.04	12.53±1.16	25.68±2.04
Zinc	<30.0 ppm	6.16±0.21	22.25±3.12	22.61±2.23	38.35±3.02	36.15±2.94	66.64±4.07
Iron	<50.0 ppm	209.67±21.43	204.17±18.56	561.00±37.23	319.60±25.53	243.83±18.67	762.50±52.67
Cobalt	<0.10 ppm	0.08±0.00	0.18±0.01	0.09±0.00	0.29±0.02	0.11±0.00	1.02±0.02
Manganese	<40.0 ppm	15.85±1.13	32.81±3.89	61.78±6.23	37.43±4.25	47.73±5.23	69.41±6.21

hypomagnesaemia in dairy cattle throughout the district. Mg deficiency is rare under normal conditions as it is generally present in appreciable quantity in fodders (Greene et al. 1983). In the present study also, Mg was in adequate amounts in the feed and fodder samples which might be responsible for normal Mg levels in the animals under study. Likewise, Singh et al. (2016) also reported a nominal 3.50% incidence of hypomagnesamia in crossbred cows with higher prevalence in Kathua followed by Jammu district.

The plasma Na, K and Cl levels in all the milk yield groups of dairy cattle throughout the district were found within the normal ranges with significant (p=0.01) difference among the different milk-yield groups for plasma Cl. The average plasma concentrations of these minerals were lowest in dry pregnant compared to the lactating animals with overall deficiency prevalence of 44.96% and 21.70% for Na and K, respectively. The content of Na in most of the feed and fodder samples collected from the study areas were also close to the critical value (Table 1) which could be related to their low levels in blood plasma of livestock in the district. Further, low level of these minerals in blood plasma might be due to non-inclusion of salts supplements in the diets of dairy cattle in the region. Higher prevalences of Na and K deficiency among cattle from various agro-climatic zones of North-West Himalayan region of Jammu division has been reported by Singh et al. (2016).

Plasma micro-mineral and deficiency prevalence profile of dairy cattle

The overall district averages as well as the means across different milk yield groups of dairy cattle in Kargil were below the critical levels for Cu, Zn and Mn among the analysed plasma micro-minerals with the highest (p<0.01) values for Cu and the lowest (p<0.01) values for Zn, Co and Mn in dry pregnant animals. The mean plasma Cu level in the district was below the critical level probably due to lesser content of Cu in the most common fodder resources (barley straw and wild grass hay), and low availability of Cu from feeds because of high Fe which interferes in Cu bioavailability in the body (Bremner and Price 1985). Adelstein and Vallee (1962) also reported lower serum Cu levels in lactating animals. Higher mean plasma Cu level in dry pregnant than lactating cattle might be attributed to higher progesterone level and/or to the increased fetal demands and utilization of maternal Cu for development of fetal nervous system (Elnageeb and Abdelatif 2010). Moreover, pregnancy is usually associated with an increase in plasma Cu levels in the form of ceruloplasmin due to increase in oestrogen levels during late pregnancy (Howell et al. 1968). Prevalence of hypocupraemia was recorded in 64.34% dairy cattle in the district with higher (p<0.01) value in lactating animals compared to dry animals. The finding corroborates with the report of Kumar et al. (2008) for livestock of Shivalik hill zone of Himachal Pradesh.

Average plasma Zn concentration was higher (p<0.01) in cows yielding milk 5-10 kg/day with an overall mean concentration below the critical level for the district which might be due to its lesser content in fodders available to the dairy animals and/or increased intake of Fe in diet which might have interfered in normal absorption of Zn (McDowell 2003). The results of the present study are in accordance with the reports of Hamid (1997) who reported higher levels of Zn in serum of high yielding animals than in the lower yielding animals. Ghedalia et al. (1996) also reported higher and consistent apparent absorption of Zn in lactating ruminants than non-lactating ones. Overall prevalence of Zn deficiency in the district was 86.04% with lowest (p<0.01) values in higher milk yielding animals. Masters and Fels (1980) reported decreased serum Zn level in desert ewes during late gestation as a result of hemodilution.

Table 3: Plasma macro- mineral and deficiency prevalence profiles of different milk yield groups of dairy cattle in district Kargil, Ladhak

Plasma macro-mineral	Critical level	Dry pregnant (n = 27)	Upto 5 kg (n = 52)	5 - 10 kg (n = 50)	Pooled district mean (n = 129)	p value
Macro- mineral profile						
Calcium	< 8.00 mg/dl	7.92±0.24	8.79±0.41	8.32±0.22	8.42±0.19	0.222
Phosphorous	< 3.50 mg/dl	3.67±0.11	4.17±0.17	3.91±0.10	3.97±0.09	0.088
Magnesium	< 1.20 mg/dl	2.74^{ab} ±0.12	2.99^{b} ±0.12	2.60^{a} ±0.07	2.78±0.06	0.019
Sodium	< 132 mEq/l	126.07±2.79	134.24±2.79	131.48±1.79	131.44±1.45	0.114
Potassium	< 3.00 meq/l	3.77±0.16	4.13±0.20	3.98±0.19	3.99±0.11	0.464
Chlorine	< 80.0 mEq/l	100.82^{a}±2.02	109.51^{b}±1.82	107.85^{b}±1.51	106.99±1.05	0.010
Macro-mineral deficiency prevalence						
Calcium		55.55 (15/27)	40.38 (21/52)	46.00 (23/50)	45.73 (59/129)	0.073
Phosphorous		40.74 (11/27)	28.54 (15/52)	30.00 (15/50)	31.78 (41/129)	0.136
Magnesium		0.00 (0/27)	1.92 (1/52)	0.00 (0/50)	0.77 (1/129)	0.134
Sodium		77.77^{b} (21/27)	28.84^{a} (15/52)	44.00^{a} (22/50)	44.96 (58/129)	0.000
Potassium		18.51 (5/27)	21.15 (11/52)	24.00 (12/50)	21.70 (28/129)	0.686

Means bearing different lowercase superscripts differ significantly among the different milk yield groups

The mean plasma Fe concentration was above the critical level in all the groups of animals across the district with marginal higher ($p>0.05$) values in lactating compared to dry pregnant animals. Kaneko et al. (1999) reported elevated Fe level in plasma could be due to refractory anaemia, haemolytic iron overload and liver disease. Thus, elevated level of plasma Fe recorded in present study could be either due to widely prevalent anaemia among the animals or it could also be due to excessive level of Fe in the available feed resources as soil of hilly areas have higher levels of Fe content. Fe deficiency is rarely observed in adult cattle because it is quite abundant in all feeds (Hidiroglou 1979). These results are in agreement with the findings of other workers who also reported either negligible or no Fe deficiencies in adult cattle in different parts of the country (Singh et al. 2016).

The overall mean value for plasma Co in the district was below the critical level with higher ($p<0.01$) values in low milk yielding animals. No adequate literature is available to infer the effect of milk yield on plasma Co concentration in dairy animals. Shekhar et al. (2017) reported that plasma Co concentration in crossbred cattle varied from 0.01 to 0.27 µg/dl in different districts of Bihar against their critical levels of 0.05 to 0.07 ppm as suggested by McDowell (2003). Likewise, mean plasma Mn concentration was higher in lactating cattle with the overall mean value of the district below the critical level. This might be due to the antagonistic effect of other minerals like Ca, P and Fe on Mn concentration in animal body as reported by Furll et al. (2004). Overall prevalence of Mn deficiency was 72.86% with the highest value in dry pregnant compared to lactating animals in the district.

Blood metabolic profile of dairy cattle

Blood metabolic profile is an important indicator of the metabolic activities in dairy animals (Thakur et al. 2024), and lactation is one such a physiological stage which alters the metabolism in animals affecting health and subsequent performance of dairy cattle. The key indicators of energy profile in ruminants are glucose, cholesterol and triglycerides (Kaniamuthan et al. 2025).

Table 4: Plasma micro- mineral and deficiency prevalence profiles of different milk yield groups of dairy cattle in district Kargil, Ladhak

Plasma mineral	Critical level	Dry pregnant (n = 27)	Upto 5 kg (n = 52)	5 - 10 kg (n = 50)	Pooled district mean (n = 129)	p value
Micro- mineral profile						
Copper	< 65 µg/dl	$66.44^{c}\pm0.83$	$62.38^{b}\pm0.51$	$58.48^{a}\pm0.60$	61.72±0.44	0.000
Zinc	< 50 µg/dl	$39.37^{a}\pm1.03$	$41.05^{a}\pm0.74$	$44.84^{b}\pm0.68$	42.17±0.49	0.000
Iron	< 100 µg/dl	139.00±4.16	145.36±3.44	144.30±2.87	143.62±1.98	0.476
Cobalt	<1.0 µg/dl	$1.49^{a}\pm0.06$	$1.68^{b}\pm0.04$	$1.47^{a}\pm0.04$	1.57±0.02	0.000
Manganese	< 20 µg/dl	$13.70^{a}\pm0.67$	$16.46^{b}\pm0.46$	$16.12^{b}\pm0.56$	15.75±0.33	0.005
Micro-mineral deficiency prevalence						
Copper		22.22^{a} (6/27)	63.64^{b} (33/52)	88.00^{b} (44/50)	64.34 (83/129)	0.000
Zinc		96.29^{b} (26/27)	90.34^{b} (47/52)	76.00^{a} (38/50)	86.04 (111/129)	0.000
Manganese		92.59^{b} (25/27)	76.92^{a} (40/52)	64.00^{a} (29/50)	72.86 (94/129)	0.000

Means bearing different lowercase superscripts differ significantly among the different milk yield groups

Table 5: Plasma metabolic profile of different milk yield groups of dairy cattle in district Kargil, Ladhak

Parameter	Reference value*	Dry pregnant (n = 27)	Upto 5 kg (n = 52)	5 - 10 kg (n = 50)	Pooled district mean (n = 140)	p value
Energy profile						
Glucose	45-75 mg/dL	$54.83^{ab}\pm1.53$	$56.77^{b}\pm0.91$	$52.40^{a}\pm0.91$	54.61±0.63	0.009
Cholesterol	65-220 mg/dL	110.55±4.94	113.11±3.24	120.18±3.45	115.27±2.15	0.178
Triglycerides	0-14 mg/dL	5.93±0.40	6.30±0.33	6.19±0.33	6.18±0.20	0.792
Protein profile						
Total proteins	5.7-8.1 mg/dL	5.76±0.16	5.49±0.16	5.25±0.14	5.45±0.09	0.112
Albumin	2.1-3.6 mg/dL	3.06±0.09	2.98±0.07	2.94±0.07	2.98±0.04	0.600
Globulin	2.8-5.0 mg/dL	3.21±0.27	2.92±0.20	2.44±0.19	2.82±0.12	0.052
Plasma urea nitrogen	6-27 mg/dL	$13.21^{a}\pm1.16$	$14.81^{ab}\pm0.92$	$16.65^{b}\pm0.74$	15.10±0.54	0.049

Table 6: Milk composition profile of different milk yield groups of dairy cattle in district Kargil, Ladhak

Parameter	Reference value*	Upto 5 kg (n = 52)	5 - 10 kg (n = 50)	Pooled district mean (n = 102)	p value
Fat (%)	3.5-4.5	4.32±0.61	4.01±0.52	4.17±0.56	0.031
Lactose (%)	4.6-4.9	4.52±0.05	4.65±0.08	4.59±0.06	0.128
Protein (%)	3.0-3.5	2.68±0.03	3.04±0.05	2.86±0.04	0.047
Solid not-fat (%)	8.5-9.0	8.14±0.42	7.85±0.35	7.99±0.22	0.061
Total solids (%)	12.5-14.5	12.14±1.04	11.32±0.91	11.73±0.98	0.041
Urea N (mg/dL)	10-16	9.32±1.04	11.03±0.95	10.18±1.01	0.021

* Kalyankar et al. (2016)

All energy parameters across different groups of dairy cattle in district Kargil were within the normal ranges with difference ($p<0.01$) observed among the different milk yield groups for blood glucose only (Table 5). The average blood glucose level was lower in lactating animals yielding milk 5-10 kg/day which might be due to high demand of glucose during lactation for milk sugar synthesis. Blood glucose level remained within normal reference range before calving but declined drastically after parturition (Yousuf et al. 2016). Average plasma cholesterol and triglycerides concentrations were statistically similar among different groups though marginally ($p>0.05$) higher in lactating compared to dry pregnant animals but all within the normal reference range (Kaneko et al. 1999) probably due to high energy demand for milk synthesis than supplied by the offered diet (Cavestany et al. 2005). These results are in accordance with the findings of Naser et al. (2014) who reported significantly higher levels of triglycerides in dairy animals during late stage of lactation.

Overall plasma protein profile parameters (Alb, Glb, and PUN) in dairy cattle of Kargil district (Table 5) were within the normal ranges except TP which was marginally below the reference range quoted by Kaneko et al. (1999) indicating that protein deficiency was nominally prevalent among dairy cattle across the district. Livestock in the study areas were being mainly offered fodder like barley straw that has a low protein value, which might be the reason for low plasma TP in dairy cattle of the district. Singh et al. (2016) reported that the cattle from subtropical and intermediate zones of Jammu division were having significantly lower levels of plasma proteins. Mean plasma concentrations were numerically ($p>0.05$) higher for TP and Alb, while lower for PUN in dry pregnant animals. In contrast to the results of the present study, Yousuf et al. (2016) reported significantly higher levels of serum TP in cows after two months of parturition. Naser et al. (2014) reported lower (25.85±8.91 mg/dL) levels of serum urea nitrogen in early stage lactation as compared to mid stage and late stage of lactation (29.85±9.6 g/dL).

Milk composition profile of dairy cattle

Composition evaluation of milk from different yield groups of dairy cattle across the district Kargil revealed significant differences for multiple parameters (Table 6). Milk fat content decreased ($p<0.05$) with increase in yield from 4.32% in low-milk yield to 4.01% in moderate yielding cows, though the overall district mean milk fat content remained within the reference range. This could be attributed to the dilution effect of increased volume of milk on fat content in cows yielding 5-10 kg per day, even though total fat yield was more. A similar pattern was observed for total solids ($p<0.05$) as well as solid-not-fat ($p>0.05$) contents which decreased with milk yield, consistent with the fall in fat content. Increase in milk yield result in proportionally lower contents of solids, particularly fat due to the dilution effect.

Although milk lactose content increased numerically ($p>0.05$) with yield, the values remained within the normal reference range. Milk protein content also increased ($p<0.05$) with increase in yield from 2.68% in low-yielding to 3.04% in moderate yielding cows. This increase might be linked to the greater supply of metabolizable protein in cows yielding 5-10 kg per day due to extra care in terms of higher concentrate feed intake and/or improved rumen microbial protein synthesis. These results are in line with the findings of Huhtanen and Rinne (2007) who also reported that higher milk yield was positively associated with milk protein and lactose concentrations but negatively associated with milk fat contents. Milk urea nitrogen (MUN) level increased ($p<0.05$) with increase in milk yield from 9.32 mg/dl in cows yielding upto 5 kg/day to 11.03 mg/dl in cows yielding 5-10 kg per day. Although the MUN values in both the groups were within the normal reference range, the increase possibly could be due to increased consumption of concentrate feeds to support greater milk production, higher degradability of dietary proteins and/or imbalanced nutritive ratio in the diets reducing the nitrogen utilization efficiency. These results are in agreement with the findings of Yoon et al. (2004) who also reported positive correlation of MUN concentration with yield in Holstein dairy cows.

Conclusion

Milk yield significantly influenced plasma minerals, metabolic profiles, and milk components in Kargil dairy cattle, where Ca (45.73%), P (31.78%), Na (44.96%), K (21.70%), Cu (64.34%), Zn (86.04%), and Mn (72.86%) deficiencies prevailed, more pronounced in dry pregnant compared to lactating cows. Mg, Cl, Fe, and Co levels remained adequate across milk yield groups, with metabolic parameters normal except marginally low total protein. Milk fat and total solids declined while protein and urea N increased with yield. Supplementation of area-specific mineral mixtures offer a targeted, cost-effective solution over general supplements to enhance milk productivity in the region.

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