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Exploration of Mineral and Biochemical Status of Dairy Cattle in Pir Panjal Range of North-Western Himalayas, Kashmir

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ABSTRACT

Mineral deficiency is an area specific problem with marked effect on productivity and can only be corrected by suitable supplementation of specific minerals. This requires careful assessment of the mineral status of livestock in specific regions that depends upon the mineral content of available feedstuffs offered to them. The present study was conducted to find out the mineral profile of some important feedstuffs and plasma of dairy cattle along with their metabolic parameters in different milk yield groups (yielding milk >10 kg/day, 5-10 kg/day, upto 5 kg/day and dry pregnant) under farmers' field condition in Shopian district of Kashmir division. A total of 201 blood plasma samples were collected from dairy cattle, selected randomly from 6 different tehsils of two veterinary blocks (Shopian and Keegam) of the district. Also, samples of feeds and fodders most commonly offered to cattle by the dairy farmers were collected separately, pooled tehsil wise and analysed. The chemical composition of the feedstuffs were within prescribed normal ranges, but available fodders contained low P, Mg, Cu and Zn while all the concentrate feed resources were adequate in all the analysed macro- and micro-minerals. All plasma macro-minerals and only Fe among micro-minerals were above the critical levels, while all plasma biochemical profiles were within normal reference ranges except total protein in all groups of dairy cattle throughout the district. Overall deficiency of Ca, Cu, Mn and Zn exists among 41.56, 80.00, 89.50 and 89.67%, respectively in blood plasma of dairy cattle in the district with higher deficiency prevalence figures for dry pregnant compared to lactating animals. It is concluded that dietary strategy through formulation and supplementation of area specific mineral mixtures to different classes of dairy animals for overcoming the mineral deficiencies could be a suitable approach for cost effective enhancement of milk productivity in the region.

KEYWORDS: Biochemistry, Blood plasma, Dairy cattle, Feedstuffs, Jammu & Kashmir, Mineral status

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INTRODUCTION

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 milk production in dairy animals (Fadlalla, 2022). The process of milk production requires the mobilization of minerals, fat and protein from body reserves to cope up with the high nutrient demands during milk production (Alemu et al., 2023). Assessment of blood constituents are used as indicators of the nutritional status and metabolic health of cows, and these constituents can be monitored through analysis of the blood mineral and biochemical profiles (Puppel and Kuczyńska, 2016). 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 concentration in blood (Spears et al., 2022), 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, it is unknown to what extent the blood mineral and biochemical levels differ among them. Establishing further knowledge in this context may help to evaluate the physiological state of dairy cows for overcoming nutrient deficiencies (if any) to improve the productivity. In this regard, the present study aimed to determine the plasma mineral and biochemical concentrations of different milk yield groups of dairy cattle and most available feeds and fodders fed to them in district Shopian of Jammu and Kashmir.

MATERIALS AND METHODS

The study area

The study was carried out in one of the Southern districts of Kashmir Division, the district Shopian situated in the foothills of Himalayan Pir-Panjal range on the ancient imperial road "*The Mughal Road*" which connects Kashmir valley with Rajouri and Poonch districts of Jammu. The district's cattle population stands at 0.70 lakh, comprising 6.20% of Kashmir Division's total cattle and 36.85% of the district's overall livestock population. The district has mostly hilly terrain, enjoys predominantly dry temperate climate, and is located at a latitude of 330 72' N and a longitude of 74° 53 E with an average elevation of 2057m above mean sea level. The district has vast area under apple orchards and play important role in fruit industry in the region, thus commonly called "*the apple bowl of Kashmir*". The district is administratively divided into two veterinary blocks *viz*. Shopian and Keller.

Sampling

One-time sampling was conducted during the study to establish baseline values for key nutritional contents of available feedstuffs, plasma biochemical parameters, and mineral profile in dairy cattle. A total of 201 blood samples were collected from dairy animals selected randomly in which 165 were collected from the Shopian block and 36 from the Keller block based on breedable cattle population. The number of blood samples collected from tehsils of Shopian, Imam Sahib, Herman, Zainapora and Chitragam were 28, 36, 41, 30, 30, respectively in block Shopian, and 36 from Keegam in block Keller. The samples were divided into four groups based on the milk yield of respective cattle as animals yielding milk >10 kg/day, 5-10 kg/day, upto 5 kg/day and dry pregnant. Moreover, samples of feeds and fodders commonly offered to the cattle by dairy farmers were collected separately, pooled for various villages of each tehsil to get the uniform representative sample for the respective feed/fodder.

Sample processing and analysis

About 10-15 mL of blood was collected aseptically in capped collection vials containing anti-coagulant ethylene diamine tetra acetic acid (EDTA @1.5 mg/mL blood) from jugular vein of dairy animals and transported and stored under frozen conditions. 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). Plasma concentrations of calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn) and iron (Fe) were estimated using the flame mode, while cobalt (Co) and manganese (Mn) were estimated using the graphite furnace mode of 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 collected feed/fodder samples were dried at 80°C, pooled tehsil wise, 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) following standard procedures of AOAC (2019). Also, the feed/fodder samples were subjected to 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 on mineral contents were subjected to statistical analysis for mean, standard error and test of significance (one-way ANOVA). The statistical software program SPSS (2011) was used for analysis of the data. These tests were two sided and were referenced for *P* value for their significance. Any *P* value less than 0.05 ($P<0.05$) was taken to be statistically significant.

RESULT AND DISCUSSION

Composition of available feeds/fodders

The chemical composition (% DMB) of the most common feeds and fodders fed to dairy cattle in all surveyed tehsils of the district (Table 1) 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 (Garg et al., 2005). The composite fodder samples analyzed contained low P, Cu and Zn, while the Ca, Fe and Co concentrations were higher than the critical levels as prescribed by McDowell and Conrad (1977) and NRC (1984). The soils of hilly region like Jammu and Kashmir, Himachal, Uttarkhand and North-Eastern states are acidic in reaction due to leaching of the bases under the influence of high precipitation. High levels of Ca in soil is essential to reduce its acidity and may increase Ca concentration in fodders grown in it (Adams and Hartzog, 1960). 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 (Underwood, 1977). The concentrate rations contained adequate levels of all the nutrients and minerals with low Zn content in home-made concentrate mixture probably due to less Zn content in constituent ingredients and little or no use of mineral mixture in its formulation by the dairy farmers of district Shopian. These results were in close agreement with the reports of feeds and fodders from other districts of Kashmir (Bhat et al., 2011; Sheikh et al., 2019); however, the values for CP and NSC for maize stover analysed in the present study were less than those reported by Bhat et al. (2021).

Table 1. Composition (on %DM basis) of most available feeds and fodders fed to dairy cattle in district Shopian, Kashmir

Attribute	Critical level*	Home-made concentrate (n=17)	Commercial compound feed (n=95)	Maize stover (n=116)	Orchard grass hay (n= 115)
Proximate composition					
Dry matter	-	91.14±0.39	90.83±0.18	86.97±0.15	92.52±0.14
Organic matter	-	91.58±0.28	90.36±0.16	89.33±0.29	86.23±0.36
Crude protein	-	14.35±0.48	15.61±0.14	3.70±0.02	8.77±0.05
Ether extract	-	2.35±0.08	2.27±0.01	0.78±0.01	2.56±0.07
Mineral composition					
Calcium	<0.30 %	1.25±0.05	1.49±0.02	0.38±0.00	0.45±0.01
Phosphorous	<0.25 %	0.33±0.01	1.00±0.01	0.23±0.01	0.23±0.00
Magnesium	<0.20 %	0.35±0.01	0.59±0.01	0.15±0.01	0.20±0.01
Sodium	<0.08 %	0.31±0.01	0.60±0.01	0.45±0.01	0.04±0.00
Potassium	<0.25 %	0.99±0.03	1.07±0.03	0.70±0.02	0.23±0.01
Chlorine	<0.10 %	0.20±0.01	0.24±0.00	0.78±0.01	0.49±0.02
Copper	<8.00 ppm	9.63±0.62	14.76±0.75	4.82±0.11	4.14±0.14
Zinc	<30.0 ppm	26.40±1.59	76.62±1.79	12.32±0.94	20.72±0.87
Iron	<50.0 ppm	229.03±6.85	734.58±11.06	371.23±10.07	537.11±6.97
Cobalt	<0.10 ppm	0.11±0.00	1.01±0.02	0.19±0.01	0.33±0.01
Manganese	<40.0 ppm	46.73±1.97	59.19±1.88	40.04±1.51	45.04±1.12

* McDowell and Conrad (1977), NRC (1984)

Plasma macro- mineral profile of dairy cattle

The macro-mineral levels in blood plasma of dairy cattle are given in Table 2 with the prevalence of their deficiencies in Table 3. All the estimated plasma minerals contents were significantly (P<0.01) influenced by milk yield. The overall average of all the plasma macro-minerals were found above the critical levels throughout the district. The normal range for Ca, P, Mg, Na, K and Cl in dairy 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).

Table 3. Prevalence (%) of plasma mineral deficiency profile in different milk yield groups of dairy cattle in district Shopian, Kashmir

Plasma mineral	>10 kg/day	5 - 10 kg/day	Upto 5 kg/day	Dry pregnant	Pooled district mean	P value
Macro-mineral deficiency prevalence						
Calcium	$24.00^{A}\pm0.84$ (12/50)	$38.89^{B}\pm0.64$ (14/36)	$55.00^{C}\pm0.68$ (22/40)	$57.14^{C}\pm1.62$ (16/28)	41.56±0.89 (64/154)	0.001
Phosphorous	$3.57^{AB}\pm2.78$ (1/28)	$0.00^{A}\pm0.00$ (0/30)	$7.14^{B}\pm3.69$ (2/28)	$3.57^{AB}\pm3.33$ (1/28)	3.51±1.18 (4/114)	0.000
Chlorine	$0.00^{A}\pm0.00$ (0/39)	$3.03^{B}\pm2.78$ (1/33)	$0.00^{A}\pm0.00$ (0/36)	$3.70^{B}\pm4.17$ (1/27)	1.48±1.92 (2/134)	0.00
Macro-mineral deficiency prevalence						
Copper	$81.48^{B}\pm0.57$ (44/54)	$85.42^{BC}\pm0.84$ (41/48)	$87.27^{C}\pm0.59$ (48/55)	$53.57^{A}\pm0.77$ (15/28)	80.00±0.44 (148/185)	<0.001
Manganese	$97.10^{B}\pm0.17$ (67/69)	$83.67^{AB}\pm0.56$ (41/49)	$79.63^{A}\pm0.85$ (43/54)	$100.00^{C}\pm0.00$ (28/28)	89.50±0.27 (179/201)	<0.001
Zinc	$81.48^{A}\pm0.81$ (44/54)	$89.58^{AB}\pm0.68$ (43/48)	$94.44^{B}\pm0.36$ (51/54)	$96.43^{B}\pm0.29$ (27/28)	89.67±0.29 (165/184)	0.000

The means across the rows with different upper case superscript differ significantly among the milk yield groups

The mean plasma Ca concentration in dairy cattle of all the tehsils of district Shopian was within the normal range with higher values (P<0.01) in animals yielding milk >10 kg/day compared to other groups of dairy animals which might be due to extra care regarding feeding and/or supplementation of Ca rich mineral mixtures to high yielding cows. Moreover, high-yielding cows mobilize large amounts of Ca from their body reserves (Djokovic et al., 2014). The overall prevalence of hypocalcaemia in the district was 41.56% with higher values (P<0.01) in dry pregnant and animals yielding upto 5 kg/day of milk. 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 higher (P<0.05) in animals yielding milk >10 kg and 5-10 kg per day compared to those yielding upto 5 kg/day and dry pregnant animals; however, the values were within the normal range for all groups of dairy animals in all tehsils 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). Prevalence of hypophosphataemia in dairy cattle was very less in the district (3.51%) with higher values in low milk yielding and 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<0.01) in dry pregnant and least in animals yielding milk >10 kg/day but within the normal range, with no prevalence of hypomagnesaemia in any animal group of 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 (except maize stover) which might be responsible for normal Mg levels in the animals under study. In contrast, Singh et al. (2016) reported 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 Shopian were found to be higher than normal ranges with significant (*P*<0.01) differences among the groups. The average plasma concentrations of these minerals were lowest in dry pregnant animals compared to the other groups with overall prevalence of 1.48% for Cl deficiency only. The content of these minerals in the feed and fodder samples collected from the study areas were also higher which could be related to their high levels in blood plasma of livestock in the district. Further, high level of these minerals in blood plasma might be due to feeding of salt to the dairy cattle (at 100-150 g of salt/cow/day) as a routine practice in this region. Comparatively higher prevalence of Na and K deficiency among cattle from various agro-climatic zones of North-West Himalayan region of Jammu division was reported by Singh et al. (2016).

Plasma micro- mineral profile of dairy cattle

The results of plasma micro-mineral levels in dairy cattle of district Shopian, Kashmir are presented in Table 2 with the prevalence of their deficiencies in Table 3. The overall average of all the micro-minerals were below the critical levels except for Fe. Among micro-minerals, average plasma Cu, Co, Fe and Mn concentrations were higher (*P*<0.01) in less milk yielding animals compared to those yielding milk >10 kg/day, and the opposite was true for Zn concentration.

Table 2. Macro- and micro- mineral profile in blood plasma of different milk yield groups of dairy cattle in district Shopian, Kashmir

Plasma mineral	Critical level*	>10 kg/day	5 - 10 kg/day	Upto 5 kg/day	Dry pregnant	Pooled district mean	P value
Macro- mineral profile							
Calcium	< 8.00 mg/dL	9.05^{B}±0.19 (n = 50)	8.34^{A}±0.25 (n = 36)	8.07^{A}±0.23 (n = 40)	7.69^{A}±0.18 (n = 28)	8.38±0.12 (n=154)	<0.000
Phosphorous	<3.50 mg/dL	6.02^{B} ±0.23 (n = 28)	5.79^{B} ±0.17 (n = 30)	4.83^{A} ±0.17 (n = 28)	4.45^{A} ±0.10 (n = 29)	5.28±0.10 (n = 114)	<0.000
Magnesium	< 1.20 mg/dL	3.15^{A}±0.24 (n = 38)	3.43^{A}±0.24 (n = 39)	3.89^{A}±0.23 (n = 43)	5.03^{B}±0.35 (n = 33)	3.84±0.14 (n = 153)	<0.000
Sodium	< 132 mEq/L	161.6^{AB}±0.30 (n = 39)	162.4^{BC}±0.50 (n = 34)	163.4^{C}±0.49 (n = 39)	160.3^{A}±0.50 (n = 30)	162.01±0.23 (n = 143)	<0.000
Potassium	< 3.00 meq/L	6.12^{B}±0.26 (n = 42)	6.15^{B}±0.19 (n = 39)	6.51^{B}±0.24 (n = 45)	4.99^{A}±0.16 (n = 30)	6.02±0.12 (n = 156)	<0.000
Chlorine	< 80.0 mEq/L	98.60^{AB}±1.05 (n = 39)	100.03^{AB}±1.26 (n = 32)	102.37^{B}±0.77 (n = 36)	96.42^{A}±1.38 (n = 27)	99.51±0.57 (n = 134)	0.003
Chlorine	< 80.0 mEq/L	98.60^{AB}±1.05 (n = 39)	100.03^{AB}±1.26 (n = 32)	102.37^{B}±0.77 (n = 36)	96.42^{A}±1.38 (n = 27)	99.51±0.57 (n = 134)	0.003
Macro- mineral profile							
Copper	< 0.65 µg/dL	0.56^{A}±0.01 (n=54)	0.59^{A}±0.01 (n=48)	0.59^{A}±0.01 (n=55)	0.64^{B}±0.01 (n=28)	0.59±0.00 (n=185)	<0.000
Iron	< 100 µg/dL	593.95^{AB}±35.17 (n=29)	648.67^{AB}±35.73 (n=25)	720.74^{B}±17.10 (n=31)	539.30^{A}±24.84 (n=28)	627.30±20.13 (n=113)	0.007
Cobalt	< 0.10 µg/dL	0.01^{A}±0.00 (n=55)	0.02^{B}±0.00 (n=51)	0.02^{B}±0.00 (n=58)	0.01^{A}±0.00 (n=28)	0.02±0.00 (n=192)	<0.000
Manganese	< 2.00 µg/dL	0.13^{A}±0.00 (n=70)	0.16^{B}±0.01 (n=49)	0.16^{B}±0.00 (n=54)	0.12^{A}±0.00 (n=28)	0.15±0.00 (n=201)	<0.000
Zinc	< 0.50 µg/dL	0.44^{C}±0.01 (n=54)	0.42^{BC}±0.01 (n=48)	0.41^{AB}±0.01 (n=54)	0.38^{A}±0.01 (n=28)	0.42±0.00 (n=184)	<0.000

The means across the rows with different upper case superscript differ significantly among the milk yield groups* McDowell (1987)

The overall mean plasma Cu level in the district was below the critical level probably due to lesser content of Cu in fodder resources, low availability of Cu from feeds because of high Fe which interferes in Cu bioavailability in the body (Bremner and Price, 1985), and drainage through milk. Adelstein and Vallee (1962) also reported lower serum Cu levels in lactating animals. Among the milk yield groups, the mean plasma Cu level was higher ($P<0.01$) in dry pregnant than lactating cattle and was near the normal critical range. This 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 80.0% 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.

The mean plasma Fe concentration was much above the critical level in all the groups of animals throughout the district with higher ($P<0.01$) values in lactating compared to dry pregnant animals. Kaneko et al. (1999) reported that 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. Shekher et al. (2017) reported that plasma Co concentration in crossbred cattle varied from 0.01 to 0.27µg/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 low milk yielding animals 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 in the district was 89.50% with the highest value for dry pregnant compared to lactating animals in which least incidence was in low yielding animals.

Average plasma Zn concentration was higher ($P<0.01$) in high (>10 kg/d) milk yielding animals with the overall mean concentration below the critical level for the district which might be due to its lesser content in feeds and 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 et al. (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 89.67% with lowest ($P<0.01$) values in high milk yielding animals. Masters and Fels (1980) reported decreased serum Zn level in desert ewes during late gestation as a result of hemo dilution.

Blood metabolic profile of dairy cattle

Serum biochemical parameters are the important indicators of the metabolic activities in lactating animals (Paiano et al., 2020). The important indicators of energy profile in ruminants are glucose, cholesterol and triglycerides (Pechova and Pavlata, 2005). All energy parameters in dairy cattle of the district Shopian were within the normal ranges with difference observed among the different milk yield groups for plasma cholesterol ($P<0.01$) and triglycerides ($P<0.05$) only (Table 4). The average blood glucose level was numerically ($P>0.05$) lower in lactating animals, 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 higher in animals yielding milk >5 kg/day compared to dry pregnant animals though 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 parameters (Alb, Glb, and PUN) in dairy cattle of Shopian district (Table 4) 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 in the district. Livestock in the district were mainly offered fodder like maize stover 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) also reported that the cattle from subtropical and intermediate zones of Jammu division were having significantly lower levels of plasma proteins. Mean plasma TP and Alb concentrations were higher (*P*<0.01) in dry pregnant animals, while PUN was higher (*P*<0.05) in animals yielding milk >10 kg/day. 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).

Table 4. Plasma metabolic profile of different milk yield groups of dairy cattle in district Shopian, Kashmir

Parameter	Reference value*	>10 kg/day	5 - 10 kg	Up to 5 kg	Dry pregnant	Pooled district mean	P value
				Energy profile			
Glucose	45-75 mg/dL	55.03±1.55 (n=31)	55.08±1.24 (n=36)	57.06±1.08 (n=44)	57.71±1.18 (n=55)	56.54±0.63 (n=166)	0.379
Cholesterol	65-220 mg/dL	126.18^{B}±2.17 (n=58)	122.72^{B}±3.01 (n=47)	121.13^{AB}±2.42 (n=35)	112.27^{A}±3.30 (n=32)	121.26±1.39 (n=172)	0.006
Triglycerides	0-14 mg/dL	6.49^{B}±0.25 (n=60)	6.41^{B}±0.30 (n=46)	5.76^{A}±0.32 (n=38)	5.98^{A}±0.28 (n=33)	6.23±0.14 (n=179)	0.039
				Protein profile			
Total proteins	5.7-8.1 mg/dL	5.16^{A}±0.13 (n=33)	5.51^{AB}±0.10 (n=38)	5.78^{B}±0.14 (n=45)	5.94^{B}±0.15 (n=49)	5.64±0.70 (n=165)	0.001
Albumin	2.1-3.6 mg/dL	2.92^{A}±0.09 (n=36)	2.99^{AB}±0.09 (n=39)	3.18^{AB}±0.08 (n=46)	3.30^{B}±0.07 (n=49)	3.12±0.04 (n=170)	0.005
Globulin	2.8-5.0 mg/dL	2.58±0.19 (n=36)	2.74±0.19 (n=37)	3.16±0.21 (n=45)	3.19±0.21 (n=42)	2.94±0.10 (n=160)	0.101
Plasma urea nitrogen	6-27 mg/dL	16.61^{B}±0.65 (n=51)	15.15^{AB}±0.84 (n=26)	14.56^{AB}±0.88 (n=49)	12.83^{A}±0.88 (n=34)	14.95±0.42 (n=160)	0.013

The means across the rows with different upper case superscript differ significantly among the milk yield groups
* Kaneko et al. (1999)

CONCLUSION

Plasma analysis revealed deficiency of Ca, Cu, Mn and Zn among 41.56, 80.00, 89.50 and 89.67%, respectively of dairy cattle in district Shopian of Kashmir with higher deficiency prevalence figures for dry pregnant compared to lactating animals. The Mg, Na, K, Fe and Co levels in plasma of these animals were adequate. All the metabolic profile parameters were within the normal physiological ranges for dairy cattle except total protein which was marginally low throughout the district. Supplementing concentrate rations, legume or cultivated green fodders and tree foliages which are good sources of the nutrients and minerals could be a suitable approach. However, to overcome the deficiency, area specific mineral mixtures need to be framed and supplemented for enhancing the milk productivity cost effectively.

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