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MINERAL STATUS OF FORAGE AND ITS RELATIONSHIP WITH THAT OF PLASMA OF FARM ANIMALS IN SOUTHERN PUNJAB, PAKISTAN

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Abstract

This study shows seasonal effect on Ca, Mg, Na and K status in both plants and goats at a particular Livestock Experimental Station in the Punjab province of Pakistan. The mean concentration of these metals in the forage was high in summer while low in winter. Plasma contained higher concentration of Mg both in lactating and dry classes during winter than those during summer; however, a reverse trend was found for most groups during both the seasons. Plasma K concentration was non-homogenous in all the classes with higher concentration in males followed by dry goats. Both seasons affected plasma Na concentration with higher concentration in summer than that in winter among all the groups of goats under investigation.

Introduction

An organism needs the optimum concentrations of the both of macro-and micro-elements to maintain its life (Avitzhun *et al*., 1991; Littledike & Goff, 1987). The quantitative control of mineral elements in animals depends directly on their concentrations in various environmental factors such as soil, water and plants. The chemical composition of forages varies from region to regions of the world (Chicco, 1972). Although hand plucked forage pasture samples are not representative what an animal actually grazes, it can serve as a vital diagnostic aid when sample collection by oesophageal fistula is not convenient. Undoubtedly forage analysis is a potential indicator of mineral status for ruminants as compared to that of soil. Similarly, animal tissue or fluid mineral concentrations reflect better availability of minerals than the forage mineral analyses (McDowell, 1985). Furthermore, blood is considered as the most important bio-substrate for the estimation of mineral status of an animal (McDowell, 1985; Merkel *et al*., 1990; Khan *et al*., 2006).

In Pakistan, the data on the element composition of the whole blood of various livestock classes are just fragmentary. The extent of macro-mineral deficiency and borderline deficiency is not known in most of the livestock farms. Under such situation it is difficult to suggest some preventive measures to overcome the deficiencies or excess of mineral nutrient. The aim of present work was to analyse the level of calcium, magnesium, potassium and sodium being used at the Livestock Experimental Station in forages or feed stuffs for rearing the livestock. To continue our work so as to establish a database on the chemical composition of various biological systems as well as the regional peculiarities of element accumulation, we have estimated the chemical composition of forages and blood of goats grazing at a natural pasture to gain the knowledge of requirements of the grazing livestock.

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Materials and Methods

Thirty apparently healthy three-year old adult goats were selected for blood sampling. These include ten each of male, lactating (at stage of early lactation during summer) and dry females. These were randomly selected from a herd of 150 animals at the Livestock Experimental Station owned by the Government of the Punjab, Pakistan.

Feed and management: Goats are managed in the traditional semi-nomadic system. Flocks are accompanied at all times by herdsmen. Animals graze natural and improve pasture during winter and summer and are housed for during the night, but are taken out for grazing each day. Native pastures were the main source of diet for grazing goats throughout the year. The soil of these pastures was predominantly sandy in nature with some dunes scattered randomly within the pastures. The forage plants consumed by grazing goats were mostly cultivated species and included both minor and major fodders such as swank (*Echinochloa* sp.), Mung (*Vigna radiata*), Moth (*Vigna aconitifolia*), True millet (*Panicum miliaceum),* foxtail millet (*Setaria italica),* grass pea (*Lathyrus sativus*), persian Clover or shaftal (*Trifolium resupinatum*), mustard (*Brassica campestris* var. *sarson*), brassicas *(Brassica juncea),* Barley (*Hordeum sativum),* Senji or Indian clover (*Melilotus indica),* vetches (*Vicia* spp.), Italian Ryegrass (*Lolium multiflorum),* Sorghum (*Sorghum bicolor*), Cowpeas (*Vigna unguiculata),* Lucerne (*Medicago sativa),* Elephant grass (*Pennisetum purpureum),* oat (*Avena sativa),* and berseem or Egyptian clover (*Trifolium alexandrinum).* However, animals had free access to crop stubble grazing for a brief period immediately after crop harvested as well as occasional provision of common salt. Forage samples were collected randomly which were mostly fed to the animals during the experimental period. All samples were dried at 70ºC for 48 h.

Blood collection: Grazing healthy goats investigated during the present studies, were three years old. Blood samples were collected from the jugular vein and heparinized immediately after collection and blood plasma was prepared by centrifugation at 3000 rpm for 15 to 30 minutes. Plasma samples were put in clean polypropylene vessels and frozen. A sample of one ml plasma was taken and dried slowly over a hot plate at 150º C for six hours. After drying all samples were properly packed and stored at room temperature for mineral determination.

Wet digestion and mineral analysis: The forage samples were ground to pass a 1 mm screen mesh. About 0.1 g dried crushed material powder was digested with HNO_3. After cooling, the digested samples were diluted with double distilled water to final volume of 50 mL. In contrast, plasma samples were subjected to wet digestion with HNO_3 and $HclO_4$ (8 mL: 0.6 mL). After digestion the volume was made up to 25 ml with double distilled water. Ca, Mg, K, and Na of plants and animal samples were analyzed with an atomic absorption spectrophotometer.

Statistical analysis: The analysis of forage and blood plasma mineral concentrations was conducted with the aid of Statistical Analytical System (Anon., 1987). Statistical significance was tested at 0.05, 0.01 and 0.001.

Table 1. Forage macro-minerals (Mean ± SE) as related to seasons.

Minerals (%)	Summer	Winter	Significance
	Mean ± SE	Mean ± SE	
Calcium	0.18 ± 0.25	0.14 ± 0.12	S**
Deficient	89	96	
Magnesium	0.23 ± 0.09	0.20 ± 0.07	S*
Deficient	30	50	
Potassium	2.22 ± 0.35	1.17 ± 0.24	S***
Deficient	30	50	
Sodium	0.048 ± 0.005	0.026 ± 0.003	S**
Deficient	75	100	

S= Season, *, **, ***= Significant at 0.05, 0.01, and 0.001, ns= Non-significant

Results and Discussion

Forage analysis

Calcium status: Lower limits of goat mineral requirements (Anon., 1985) were used to calculate the percent deficient. Mean forage Ca concentrations in the summer and winter season were 0.18 and 0.14%, respectively (Table 1). Forage Ca concentration for the summer and winter were 89 and 96% of samples below the critical level of 0.2 % established by Anon., (1985). Average forage Ca concentration from this investigation was in agreement with those reported previously in Pakistan (Khan *et al*., 2005 and 2006) and in Columbia, Pastrana *et al*., (1991) and lower than those reported by Rojas *et al*., (1993) in Venezuela. These low forage Ca values imply that the grazing livestock were not subjected to good quality forages, especially during the winter.

Magnesium status: Forage Mg concentration in the summer and winter seasons were found to be 0.23 and 0.20% with 30 and 50% of the samples, respectively, below the suggested critical level of 0.12% (Anon., 1985). Mean forage Mg concentrations were close to those already reported for Pakistan (Khan *et al*., 2006, 2007) and Columbia (Pstrana *et al*., 1991) but very higher than those reported by some other researchers (Velasquez-Pierera *et al*., 1997; Rojas *et al*., 1995).

Potassium status: Mean forage K concentrations during the summer and winter seasons were 2.22 and 1.17%, with 15 and 30% of the samples respectively, below the critical level of 0.5% already established (Anon., 1985). K concentrations were within the range as reported by Khan, (2003) and Khan *et al*. (2007) but higher than those found by Rojas *et al*., (1993) in Venezuela and lower than those reported by Pastrana *et al*., (1991) in Columbia. Variation of K in forages within different seasons may partially be attributed to different stages of plant maturity at the time of forage sampling. With maturity, mineral concentration declines due to a natural dilution process and the translocation of minerals to the root system (McDowell *et al*., 1983; Pastrana *et al*., 1991).

Sodium status: Mean forage Na concentrations during the summer and winter seasons were 0.048 and 0.026% with 75 and 100 % of the samples, below the critical level of 0.09% suggested by Anon., (1985). Forage Na concentrations were similar to those reported by Rojas *et al*., (1993) for Columbia, Khan *et al.*, (2007) for Pakistan and below those found by Pastrana *et al.,* (1991) in Columbia.

Table 2. Plasma mineral elements (Mean ± SE) in lactating, dry and male goats as related to seasons.

Minerals	Season	Animal groups			Significance
		Lactating	Dry	Male	
		Mean ± SE	Mean ± SE	Mean ± SE	
Ca	Summer	7.58 ± 0.68	7.92 ± 1.18	8.54 ± 0.16	S***, A***,
(mg/dL)	Winter	5.16 ± 0.42	9.54 ± 0.88	10.25 ± 0.77	S***A
Mg	Summer	2.68 ± 0.27	2.08 ± 0.22	3.90 ± 0.29	S*, A^{ns}, SA^{ns}
(mg/dL)	Winter	2.54 ± 0.24	2.40 ± 0.54	2.78 ± 0.52	
K	Summer	6.49 ± 0.32	5.90 ± 0.28	6.48 ± 0.68	S***, A***,
(mmol/L)	Winter	5.44 ± 0.32	6.40 ± 1.12	7.28 ± 0.88	SA**
Na	Summer	148.1 ± 8.6	144.5 ± 16.3	130.0 ± 18.3	S***, A***,
(mmol/L)	Winter	130.1 ± 18.7	138.4 ± 16.4	122.5 ± 16.2	SA**

A= Animal group, S= Season, SA = Interaction of season by animal group, *,**,***= Significant at 0.05, 0.01, and 0.001 levels, respectively; ns = Non-significant

Blood Plasma

Calcium status: Seasonal or animal class differences for plasma calcium were found to be significant ($p<0.001$), with concentration in summer season being higher than those in winter in lactating goats, while the reverse was true for other two goat groups. Highest plasma calcium concentrations were found in the male group during winter followed by the dry goats in summer. The lowest plasma calcium level was observed in the lactating group during both seasons. Variations ($p<0.001$) in plasma calcium was also found due to season by animal interactions for plasma calcium (Table 2).

Magnesium status: Plasma magnesium showed seasonal variation ($p<0.05$), but no differences ($p>0.05$) were found due to animal groups. Plasma contained higher ($p<0.05$) magnesium both in the lactating and dry group during winter than those during summer, while the reverse was true for the male group during both seasons. The highest plasma magnesium was found in lactating animals during winter followed by dry group in the same season, while the lowest plasma magnesium was observed in dry animals during winter. Variations ($p>0.05$) due to interaction of season and animal group were non-significant. The concentration of magnesium in soil and the ratio of Mg to other cations in the soil affect its concentration in animals (Ram, 1998).

Potassium status: Large differences ($p<0.001$) for plasma potassium concentrations were observed for lactating, dry, and male animals in both seasons, with the male goats having high concentrations of plasma potassium during winter followed by dry goats in the same season. The lowest plasma potassium was found in lactating group during winter followed by the dry group during summer. Both male and dry goat groups had higher plasma potassium during winter than those during summer, while the reverse was true for the lactating group. Effects of season by animal interactions ($p<0.01$) were also found to be significant for plasma potassium concentrations.

Sodium status: Both seasons and animal class affected ($p<0.001$) plasma sodium, with higher concentrations in the summer than in winter in all groups of goats. Variations ($p<0.01$) were also found due to interactions of season by animal class. The highest

plasma sodium was found in dry goat group during both summer and winter, while the lowest plasma sodium concentration was observed in the male group during winter followed by the lactating goat group in the same season.

The data presented here indicate that most of the minerals in the blood plasma are higher in male animals followed by the dry and lactating groups of goats. These differences in plasma macro-minerals were observed in spite of the animals of same type of digestive systems. Therefore, these differences may be related to forage selection and grazing preferences in the pasture. It has been suggested that browsed forages have higher mineral concentrations than grasses. Furthermore, as forages mature, their mineral contents decline which would likely result in low plasma minerals in all classes of grazing goats in winter (Khan *et al*., 2005, 2006; Kapu, 1976). The predominant grasses eaten by the grazing goats during winter during this investigation were dried and withered. The plasma mineral profile particularly in the lactating group of goats during both seasons compared to the others might have been due to the secretion of minerals in milk which could have changed the mineral homeostasis under the influence of some hormonal mechanism (Rowlands, 1980; Khan *et al*., 2006). Variation in macro-minerals contents of the blood plasma of various goat classes could have been due to the selective feeding and drought conditions of the season and pasture areas. The plasma mineral levels are similar to the levels established by McDowell *et al*., (1984) in Florida and Khan *et al*., (2006, 2007) with different ruminant classes in Pakistan.

The distribution of minerals within the body of animals and chemical form of the elements in the diet may be due to the availability of minerals to the grazing livestock. The grazing livestock may also get benefit from supplementation of various macro-minerals year round and particularly during the winter or dry seasons when their blood plasma shows such deficiency. These nutrients enhance the ability of rumen micro-organisms to degrade dietary substances that impairs the absorption of some mineral elements. The supplementation of mineral elements should, however, be preceded by animal response studies. Based on information on blood plasma mineral analyses, grazing livestock may be provided supplementation of all these minerals with a fortified mixture of high bioavailability throughout the year, particularly during winter when these elements are deficient in forage as well as in plasma.

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