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Macro and Micro-Mineral Status of Feeds and Fodders fed to Buffaloes in the Semi-Arid Zone of Rajasthan

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ABSTRACT

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A survey was conducted in the semi-arid zone of Rajasthan, to find out the role of feeding practices and farm management system on certain macro and micro-minerals status of dairy animals. Feeds and fodder samples were collected at random from the area under survey. The cobalt was occasionally deficient in the diet of animals, however, iron level in most of the feed ingredients was adequate (average level>500 ppm). Manganese was deficient in concentrate ingredients (35 ppm), whereas, crop residues and green forages were richer (62 ppm). The average Cu content was unduly low in straws (6.61 ppm) and moderate in green fodders (14.0 ppm), whereas, concentrate ingredients were better source of copper (26.0 ppm), except grains. Zinc was deficient in most of the feedstuffs (avg.<42.0 ppm) and needed to be supplemented in the ration of animals. The average Ca content in straws (0.35%) was higher, whereas, concentrate ingredients were low in Ca (0.26%), except sesame cake. The P content in crop residues was lower (0.09%), but higher in green fodder (0.33%) and concentrate ingredients (0.50%). The Mg content in samples of feeds and fodder was adequate (0.42%), to meet the requirement of animals (0.20%). The sulphur content was adequate in green fodder (0.55%), whereas, crop residues and concentrate ingredients were deficient in sulphur (0.15%). The magnesium, sodium and potassium levels in feedstuffs were found to be adequate, from animal's requirement point of view. From the present study, it was apparent that the level of certain minerals such as zinc, copper, cobalt, calcium, phosphorus and sulphur was inadequate, as per the estimates for the requirement of buffalo yielding 10 kg milk (7% fat) per day.

Keywords: Calcium, Copper, Zinc, Selenium, Semi-arid zone, Buffaloes.

INTRODUCTION

Today, India is faced with an extraordinary set of challenges of increasing food production of animal origin with all other limitations like land, water, feed resources etc. and the question is how would we meet these demands. It is only possible through

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livestock intensification and better feeding practices. Although minerals are most critical to livestock production, however, livestock in India do not receive mineral/vitamin supplements, except for common salt and calcite/dolomite powder (Garg *et al.*, 2003a). Hence, dairy animals depend on forages for their mineral requirements. A number of researchers in the world have reported a high incidence of forage samples below critical levels for different mineral elements, especially copper, zinc, cobalt, sodium and phosphorus (Miles and McDowell, 1983; Underwood and Suttle, 1999; Garg *et al.*, 2002). On the other hand, constant efforts are being made to increase crop yield per hectare, year by year. For that purpose, different crop varieties are being developed through scientific means for maximizing yields, ensuring more economic returns to the farmers. In this process, soils from all over country are getting depleted for one or more mineral elements as a result of intensive farming practices, which create imbalances of mineral elements in soil, plants and animals. The quantity of minerals, thus, present in forages may not be sufficient for optimum growth, milk yield and reproduction of animals. It is, therefore, obligatory to generate information on mineral status of feeds and fodders, so as to identify mineral deficiency or toxicity. In order to avoid micro and macro-minerals imbalances in all agro-climatic zones, the study on assessment of mineral status of buffaloes was undertaken in different agro-climatic zones of Rajasthan. Results of findings in semi-arid zone (Ajmer district) are presented here.

MATERIALS AND METHODS

Sampling procedure

At random, one centrally located village from each taluk (Masuda, Nasirabad, Ajmer, Kishangarh, Beawar, Pishangarh, Bhinai, Kekari and Sarwar) of Ajmer district was selected for taking representative samples of feeds and fodder. Total area of Ajmer district is 8481 sq.km. distributed into 9 taluks, having 1001 villages. The district is having annual rainfall of 70 cm, having latitude of 27°10' and longitude of 75°15'. Atmospheric temperature ranges from 6 to 45° C during different seasons. In this study, two dimensional survey was adopted to map relevant mineral elements, by collecting feeds and fodder samples in a particular village, according to random sampling design based on conceptual landscape units (Tourtelot, 1980). Within the village, help was sought from village milk producers and Ajmer District Cooperative Milk Producers' Union, for identification of 4 to 5 farmers. The recorded parameters were number of livestock, land area, irrigated facilities, fodder and other crops being grown etc. In identification of farmers, land location was considered essentially, one each from Northern, Eastern, Western and Southern directions, to cover soil types on each side of the selected village.

Further information regarding the amount and types of feeds and fodder being offered to the animals, actual rate of daily feed intake and milk yield of individual animal were collected from individual farmer, using standard sampling procedure. Total intakes were compared against the requirements on dry matter basis (Campbell *et al.,* 1999;

NRC, 2001), so as to identify quantitative deficiency, sufficiency or even excess. In India, hardly any information on mineral requirements for milch buffaloes is available, so NRC (2001) and Kearl (1982) were taken as a base for calculation of mineral requirements of buffaloes. The data were analysed statistically as per Snedecor and Cochran (1967).

Sample preparation and analytical methods

Composite samples of green fodder, dry fodder, individual concentrate ingredients and the compounded cattle feed (concentrate mixture) were collected from all over the surveyed area. Green samples were dried in oven at 80^{o}C for 24 hrs and subsequently ground (1mm). Ground samples of concentrate and fodder were stored in airtight bags until analysis. Samples were prepared and digested using 5 ml concentrated HNO_3 plus 1 ml concentrated HCl by microwave digestion method for preventing evaporation of volatile elements and total volume of mineral extract was made to 25 ml with deionized water. All the samples were analyzed for Cu, Zn, Mn, Fe, Co, Mo, Se, Ca, P, Mg, Na, K and S, using Inductively Coupled Plasma-Optical Emission Spectrometer (Perkin-Elmer, OPTIMA–3300 RL).

The word "critical" is used in this article to note a concentration in feedstuffs below (or above with excesses) what is considered the requirement for animal. This assumes the expected consumption as estimated by the NRC (2001). Total grams/milligrams of minerals consumed per day determine the true adequacy of a mineral, not the forage concentration.

RESULTS AND DISCUSSION

Feeding and management

The survey work revealed that most of the small farmers kept their animals on grazing and supplementation of maize straw, sorghum straw or local grasses collected from the forest as basal roughages. This practice was found to be common for other categories of farmers also. However, the medium farmers were supplementing the ration of animals with single unit concentrate ingredient in the form of crushed barley or whole cottonseed or guar *chuni*. Supplementation with home grown multiple unit concentrate mixture (crushed barley, cottonseed, guar *chuni*, linseed or sesame cake) was found to be practiced only by large farmers. Few farmers were feeding crushed mustard seed (approx. 100g per day) mixed with concentrate mixture at the time of milking animals. Those farmers who don't feed multiple unit concentrate ingredients, were feeding compound cattle feed depending upon the level of milk production. Some of the farmers were feeding their animals with cultivated fodders like lucerne (*Medicago sativa*), carrot tops (*Daucus carota*) or chicori green. The green fodder availability was only for limited period due to water scarcity and frequent droughts in that area. Interestingly, it was observed that some of the progressive farmers supplemented the ration of animals with mineral supplements.

Micro and macro-minerals profile of feeds and fodder

The profile of Co, Cu, Fe, Mn, Mo, Se, Zn, Ca, P, Mg, Na, K and S in the feeds and fodder is presented in Tables 1 and 2.

Cobalt (Co)

The cobalt levels in this zone ranged from 0.10 to 0.78 ppm in crop residues, 0.17 to 0.33 ppm in green fodders and 0.21 to 0.66 ppm in grains. Whole cottonseed and guar (*Cyamopsis tetragonoloba*) *chuni* revolved around 0.59 ppm Co (Table 1). Compounded cattle feed contained 2.24 ppm Co. Linseed (*Linum usitatissimum*) and sesame (*Sesamum indicum*) cakes contained 0.93 and 0.49 ppm cobalt, respectively. A buffalo yielding 10 kg milk daily, would need 6.0 mg cobalt per day, as per the standard requirements, whereas, feeds and fodders available in the area when fed, provided 4.56 mg, showing a deficiency of cobalt (Table 3).

Copper (Cu)

Copper quantity was recorded consistently low in almost all the collected feedstuffs. Straws of sorghum, maize, bajra (*Pennisetum typhoides*) and wheat (*Triticum aestivum*) contained low level of copper (6.61 ppm). Lucerne, carrot tops and chikori green contained around 14 ppm copper (Table 1). Cottonseed (12 ppm), linseed cake (39.0 ppm), guar *chuni* (11 ppm) and sesame cake (42.0 ppm) were better source of copper. In grains, the level was again low (8.70 ppm). Copper content below the critical of 8 ppm (Cuesta *et al*., 1993) were found in most of the feeds and fodder (Table 1), hence its supplementation in the ration of animals is very essential. Copper availability from traditional feeds and fodders fed to a buffalo, yielding 10 kg milk per day, was 106 mg against the requirement of 120 mg per day (Table 3).

Iron (Fe)

Distribution of iron was found to be unique in the sense that it exceeded the requirement in all the feedstuffs, being fed to livestock (Table 1). Even straw samples were quite rich in Fe (473 ppm). Lucerne, carrot tops and chikori green showed an average of 655 ppm Fe. Grains had around 117 ppm Fe, while whole cottonseed (*Gossypium herbaceum*), sesame and linseed cakes were exceptionally rich, containing 756 ppm iron. Thus, Fe seems to be quite rich in this district, as also reported from other parts of the country (Ramana *et al*., 2001; Yadav *et al*., 2002). The Fe concentration in the majority of feed ingredients was very high and could probably interfere with the copper absorption and metabolism (Youssef *et al*., 1999). For a buffalo yielding 10 kg milk per day, the availability of Fe from feed resources was 5493 mg and the requirement was only 600 mg per day (Table 3).

Manganese (Mn)

Most of the straws offered to animal contained around 66 ppm Mn. Manganese content in lucerne and carrot tops were 79 ppm and 58 ppm, respectively. Amongst the concentrate ingredients, linseed cake (65.71 ppm) had the highest Mn content, followed

Table 1. Trace mineral content in feedstuffs collected from Ajmer district (DM basis)

Particular	Co (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Mo (ppm)	Se (ppm)	Zn (ppm)	Cu:Mo
Critical level[a]	<0.10	<8.0	<50.0	<40.0	>6.0	<0.20	<30.0	…
(I) Concentrate feed ingredients								
Bajra grain (1)	0.66	10.70	129.0	20.60	0.71	1.17	50.80	15.07
Barley grain (11)	0.46 ± 0.068	6.80 ± 1.68	114.67 ± 12.64	27.60 ± 1.86	1.87 ± 0.64	0.39 ± 0.14	26.63 ± 2.37	3.63
Wheat grain (2)	0.21 ± 0.069	8.78 ± 1.08	108.50 ± 4.50	21.25 ± 0.77	0.0 ± 0.0	0.088 ± 0.072	33.25 ± 2.49	…
Cotton seed, whole (8)	0.35 ± 0.052	12.30 ± 1.98	301.80 ± 50.87	27.20 ± 2.70	0.16 ± 0.062	0.71 ± 0.39	53.08 ± 3.53	76.87
Guar *chuni* (9)	0.83 ± 0.16	11.59 ± 3.12	568.10 ± 78.81	32.72 ± 3.39	1.55 ± 0.45	1.59 ± 0.72	71.67 ± 9.54	7.47
Linseed cake (7)	0.93 ± 0.15	39.01 ± 4.51	1271.4 ± 106.4	65.71 ± 2.88	0.68 ± 0.46	1.33 ± 0.34	125.50 ± 14.61	57.35
Sesame cake (14)	0.49 ± 0.062	42.55 ± 4.21	697.5 ± 95.82	53.05 ± 3.50	3.56 ± 0.37	3.03 ± 0.96	91.90 ± 7.13	11.95
Cattle feed (26)	2.24 ± 0.42	20.24 ± 0.89	830.30 ± 41.39	122.50 ± 2.71	4.11 ± 0.47	2.54 ± 0.43	79.40 ± 4.35	4.92
Navneet dan (3)	1.23 ± 0.20	12.30 ± 1.77	1643.6 ± 489.6	128.30 ± 19.35	2.60 ± 0.30	3.77 ± 1.69	55.26 ± 3.12	4.73
(II) Dry and green roughages								
Bajra straw (2)	0.40 ± 0.034	7.08 ± 0.55	570.0 ± 148.2	51.85 ± 6.18	0.0 ± 0.0	2.38 ± 1.24	36.85 ± 4.21	…
Maize straw (14)	0.29 ± 0.071	6.20 ± 1.23	589.80 ± 150.0	72.37 ± 9.06	1.02 ± 0.35	1.80 ± 0.35	34.72 ± 6.96	6.07
Sorghum straw (31)	0.26 ± 0.042	6.41 ± 0.72	434.70 ± 74.77	71.40 ± 8.25	0.59 ± 0.19	2.12 ± 0.43	28.17 ± 2.29	10.86
Wheat straw (2)	0.78 ± 0.14	6.75 ± 0.47	300.0 ± 40.94	70.30 ± 2.62	0.89 ± 0.47	2.90 ± 0.54	26.55 ± 8.96	7.58
Guar pods (2)	0.90 ± 0.067	9.18 ± 2.46	536.50 ± 68.38	44.05 ± 8.31	0.23 ± 0.17	0.0 ± 0.0	55.20 ± 34.31	39.91
Moong pods (2)	0.10 ± 0.001	17.12 ± 6.20	255.00 ± 67.15	62.15 ± 5.44	2.41 ± 0.85	0.27 ± 0.22	22.85 ± 3.97	7.10
Urd pods (3)	0.43 ± 0.047	9.21 ± 0.41	576.60 ± 125.4	54.9 ± 5.73	0.41 ± 0.17	0.0 ± 0.0	18.33 ± 1.06	22.46
Local grasses (14)	0.37 ± 0.054	6.36 ± 1.20	633.50 ± 109.4	72.38 ± 7.69	0.90 ± 0.21	2.02 ± 0.86	34.37 ± 3.76	7.06
Chikori green (2)	0.33 ± 0.019	17.20 ± 0.0	648.00 ± 49.95	98.80 ± 4.25	0.32 ± 0.079	0.45 ± 0.37	54.45 ± 4.62	53.75
Carrot tops (2)	0.17 ± 0.076	11.75 ± 0.12	574.50 ± 38.89	58.30 ± 3.43	0.51 ± 0.41	0.0 ± 0.0	32.40 ± 3.27	23.03
Lucerne green (14)	0.34 ± 0.083	12.14 ± 1.43	743.21 ± 74.31	79.34 ± 9.61	2.46 ± 0.92	3.57 ± 1.33	37.95 ± 3.84	4.93

Figures in parentheses indicate number of samples analyzed.

[a]Critical level = concentrations below which are low or considered deficient or excessive in the case of Mo (McDowell *et al.*, 1993), based on requirements for cattle (NRC, 2001).

by sesame cake (53.05 ppm), guar *chuni* (32.72 ppm), barley (*Hordeum vulgare*) grain (27.6 ppm), cottonseed (27.20 ppm) and wheat grain (21.25 ppm). Manganese adequacy in the ration of buffaloes was recorded in this zone, as most of the feeds contained adequate level of Mn. Yadav *et al.* (2002) and Garg ***et al.*** (2003d) reported Mn adequacy in feeds and fodder in other parts of country. The milch buffalo yielding 10 kg milk per day, required 480 mg Mn per day, whereas, feed sources provided only 662 mg (Table 3), showing adequacy of manganese.

Molybdenum (Mo)

The molybdenum levels as estimated in the samples of crop residues were within the safe limit (Table 1). Amongst the dry fodders, maize straw (1.02 ppm) had the highest Mo content, followed by local grasses (0.90 ppm), wheat straw (0.89 ppm) and sorghum (*Sorghum vulgare*) straw (0.59 ppm). Lucerne and carrot tops contained 2.46 and 0.51 ppm Mo, respectively. Guar *chuni* (1.55 ppm) and sesame cake (3.56 ppm) contained high Mo (Table 1). The most of the feedstuffs contained Mo level within the safe limit and gave Cu: Mo ratio wider than 4.0. The critical Cu: Mo ratio in animal feeds is 2:1. Suttle (1991) stated that a Cu:Mo ratio below 2.0 would be expected to cause conditioned Cu deficiency in cattle. Mo levels of 5 to 6 ppm inhibit Cu storage and produce signs of molybdenosis (NRC, 1980). Even 2 ppm or less Mo can be toxic, if forage Cu is sufficiently low (Youssef *et al.*, 1999). In case of ruminants, Mo reacts with sulphur in the rumen and forms mono-, di-, tri- and tetra-thiomolybdates (Suttle, 1991). Thiomolybdates can cause Cu deficiency by reacting with dietary copper in the digestive tract and making it unavailable for absorption and utilization (Nelson, 1988).

Selenium (Se)

The selenium content of the crop residues varied from 0.0 to 2.90 ppm (Table 1). Pods of guar, moong (*Phaseolus mungo*) and urd (*P. roxburghii*) contained negligible amount of selenium. However, Se level was recorded 3.57 and 0.45 ppm, in green lucerne and chicori (*Cichorium intybus*), respectively. Grains had around 0.55 ppm Se, whereas guar *chuni*, linseed and sesame cakes were an exception with high Se content (Table 2). The minimum dietary Se requirement of all classes of ruminant livestock ranges from 0.10 to 0.30 ppm (NRC, 1980). Accepting the minimum requirements of 0.30 ppm Se, which is the level considered adequate for preventing deficiency in dairy cattle (NRC, 2001), most of the feeds and fodders studied would satisfy requirement of Se. Therefore, its supplementation in mineral mixture may not be advocated.

Zinc (Zn)

Zinc is one element, which is found to be deficient in many geographical zones of India (Ramana *et al.*, 2001; Garg *et al.*, 2003b; Udar *et al.*, 2003). From this survey (Table 1), it was apparent that most of the feed ingredients, particularly straws, were low in Zn content (31.25 ppm). The zinc content of the green fodders varied from 32.40 to 54.45 ppm (Table 1). Grains had around 37.30 ppm Zn, while linseed and sesame cakes were an exception with higher Zn content (108 ppm). Zinc content was found

Table 2. Macro-mineral content in feedstuffs collected from Ajmer district (DM basis)

Particular	Ca (%)	P (%)	Mg (%)	Na (%)	K (%)	S (%)
Critical level[a]	<0.30	<0.25	<0.20	<0.06	<0.80	<0.20
(I) Concentrate feed ingredients						
Bajra grain (1)	0.034	0.35	0.21	0.014	0.64	0.27
Barley grain (11)	0.096±0.005	0.30±0.039	0.16±0.005	0.059±0.009	0.58±0.031	0.074±0.025
Wheat grain (2)	0.066±0.001	0.34±0.02	0.19±0.004	0.022±0.0008	0.66±0.061	0.036±0.025
Cotton seed, whole (8)	0.28±0.025	0.61±0.052	0.47±0.025	0.021±0.004	1.61±0.076	0.13±0.038
Guar *chuni* (9)	0.48±0.062	0.54±0.072	0.43±0.036	0.026±0.005	1.91±0.09	0.13±0.011
Linseed cake (7)	0.63±0.059	0.99±0.14	0.80±0.12	0.095±0.022	1.61±0.19	0.47±0.26
Sesame cake (14)	2.00±0.18	1.01±0.11	0.83±0.066	0.031±0.006	1.56±0.094	0.18±0.013
Cattle feed (26)	1.26±0.10	1.60±0.04	0.82±0.022	0.74±0.047	1.53±0.053	0.18±0.011
Navneet dan (3)	1.94±0.14	1.38±0.11	0.92±0.12	0.62±0.14	1.46±0.073	0.14±0.007
(II) Dry and green roughages						
Bajra straw (2)	0.44±0.11	0.11±0.033	0.26±0.02	0.31±0.18	1.42±0.11	0.26±0.049
Maize straw (14)	0.35±0.052	0.08±0.018	0.43±0.042	0.22±0.061	2.27±0.26	0.15±0.019
Sorghum straw (31)	0.36±0.036	0.09±0.017	0.33±0.028	0.069±0.019	2.15±0.19	0.15±0.012
Wheat straw (2)	0.47±0.02	0.056±0.014	0.22±0.04	0.11±0.041	1.64±0.27	0.20±0.092
Guar pods (2)	0.57±0.18	0.56±0.38	0.43±0.012	0.18±0.12	1.60±0.39	0.10±0.01
Moong pods (2)	1.92±0.077	0.12±0.012	0.68±0.16	0.06±0.027	2.22±0.36	0.14±0.004
Urd pods (3)	1.88±0.12	0.12±0.0	0.51±0.032	0.24±0.038	1.81±0.048	0.15±0.014
Local grasses (14)	0.24±0.048	0.12±0.04	0.38±0.051	0.36±0.068	1.86±0.19	0.16±0.013
Chikori green (2)	1.27±0.049	0.39±0.028	0.40±0.008	2.85±0.2	4.63±0.13	0.54±0.04
Carrot tops (2)	1.72±0.073	0.33±0.016	0.54±0.10	2.23±0.40	4.11±0.33	0.55±0.073
Lucerne green (14)	2.03±0.18	0.27±0.041	0.55±0.051	0.80±0.06	3.28±0.25	0.57±0.036

Figures in parentheses indicate number of samples analyzed.

[a]Critical level = concentrations below which are low or considered deficient (McDowell *et al.*, 1993), based on requirements for cattle (NRC, 2001).

below the critical level (30 ppm) in most of the crop residues and needed to be supplemented @ 80 ppm in the total ration (Arora, 1981) of animals, to overcome its deficiency. The milch buffalo yielding 10 kg milk per day, required 960 mg Zn per day, whereas, feed sources provided only 475 mg, showing deficiency of Zn (Table 3). Mastitis, night blindness, parakeratosis and reproductive failure are the ailments, which may result from its deficiency (McDowell, 1992; Singh and Pachauri, 2001).

Calcium (Ca) and phosphorus (P)

The average calcium content in straws (0.35%) was higher, but low in phosphorus (0.09%). The concentrate ingredients commonly fed to animal contained low calcium (0.26%) except sesame cake (2.0%), but high in phosphorus level (0.50%). Lucerne being leguminous family contained higher calcium amounts (Table 2). Local grasses, *guar pods* and *urd pods* were poor source of P as compared to calcium. For efficient utilization of Ca and P, Ca: P ratio should be 2:1. However, most of the feeds and fodders showed variable Ca: P ratio. Under such condition, calcium and phosphorus should be supplemented in the diet of animals to balance the Ca: P ratio for their proper utilization in the animal system (McDowell, 1992). A buffalo yielding 10 kg milk per day would need 64.50 g Ca, whereas, feeds and fodders available in the area when fed as per diet formulation given in Table 3, would provide 53.10 g Ca, showing calcium deficiency. When green fodder was not available, deficiency of Ca may be severe. Under such conditions, milk production is likely to be affected and freshly calved animal may suffer from milk fever (McDowell *et al.*, 1993). The estimated value of phosphorus from feedstuffs was 32.15 g against the requirement of 42.80 g per day for a milch buffalo yielding 10 kg milk, showing a deficiency of 10.65 g per day (Table 3). Furthermore, bio-availability of P from plant sources was low due to phytic acid-P (McDowell, 1992), leading to problems of pica, infertility and haemoglobinuria in animals.

Magnesium (Mg)

The magnesium levels as estimated in the samples of crop residues were adequate (Table 2). Amongst the green fodders, lucerne green (0.55%) had the highest Mg content, followed by carrot tops (0.54%) and chicori green (0.40%), showing that considerable quantities of Mg were available from the livestock requirement point of view. Grains of bajra, barley and wheat were found to be contained low levels of Mg (0.18%). Cottonseed (*Gossypium herbaceum*), mustard cake and sesame cake were good sources of Mg (Table 2). Compounded cattle feed contained 0.82 per cent magnesium, a level, which is higher than required as a supplement, because of its sufficiency in feed ingredients. Recommended concentrations for dietary magnesium are within the range of 0.2-0.4% of total DMI (Underwood and Suttle, 1999; Goff, 2000). Ruminants are generally at risk from hypomagnesaemia when the forage contains less than 0.20 per cent of Mg and high in K content (Michal, 1999, Garg *et al.*, 2003a,b). The Mg requirement of a milch buffalo yielding 10 kg milk per day was 24.0 g (Table 3), whereas, feeds and fodders fed in that area provided 41.69 g of Mg per day, showing adequacy.

Table 3. Availability and requirement of Co, Cu, Fe, Mn, Zn, Ca, P, Mg, Na, K and S for a milch buffalo (400 kg) producing 10 kg milk (7% fat) per day

Attribute	Daily	Daily intake (mg)					Daily intake (g)					
	DMI (kg)	Co	Cu	Fe	Mn	Zn	Ca	P	Mg	Na	K	S
Whole cottonseed	1.5	0.52	18.0	451	40.5	79.5	4.20	9.15	7.05	0.31	24.15	1.95
Crushed barley	1.5	0.69	12.2	171	40.5	39.0	1.44	4.50	2.40	0.88	8.70	1.11
Sesame cake	0.5	0.24	21.0	348	26.5	46.0	10.0	5.05	4.15	0.15	7.80	0.90
Guar *chuni*	1.0	0.83	11.0	568	32.0	71.0	4.80	5.40	4.30	0.26	19.10	1.30
Local grasses	2.0	0.74	12.0	1266	144	68.0	4.80	2.40	7.60	7.2	37.20	3.20
Maize straw	2.0	0.58	12.4	1178	144	70.0	7.00	1.60	8.60	4.4	45.40	3.00
Lucerne green	0.5	0.17	6.0	371	39.5	19.0	10.15	1.35	2.75	4.0	16.40	2.85
Sorghum straw	3.0	0.78	19.2	1302	213	84.0	10.80	2.70	9.90	2.07	64.50	4.50
Daily availability	12.0 ±0.19	4.56^{a} ±0.09	106.98^{a} ±2.94	5493^{a} ±191	662^{a} ±11.85	475.8^{a} ±8.96	53.10^{a} ±2.25	32.15^{a} ±1.15	41.69^{a} ±2.59	20.23 ±1.46	230.4^{a} ±5.0	19.20^{a} ±1.00
Daily requirement	12.0 ±0.19	6^{b}	120^{b}	600^{b}	480^{b}	960^{b}	64.5^{b}	42.8^{b}	24^{b}	21.6	108^{b}	24^{b}

^{a,b}Values bearing different superscript in a column differ significantly ($P < 0.05$).

Sodium (Na) and potassium (K)

The sodium content was unduly low in all the feeds and fodders, ranging from 0.014 to 0.31 per cent. Only lucerne, carrot tops and chikori green contained sodium as high as 1.56 per cent. Compounded cattle feed had an appropriate quantity of sodium to the extent of 0.74 per cent, because of added sodium chloride (Table 2). Higher K content of feedstuffs may be due to its selective uptake from the soil and was much higher than Na (Garg *et al*., 2003c). Similar findings were also reported by Singh *et al*. (2002). Potassium content in straws and stovers was higher than the concentrate feed ingredients (Table 2) and seemed to be another element like Mg, which did not require additional supplementation in the ration of animals. However, excessive levels of K may be the greatest dietary risk factor for milk fever (Goff, 2000). The availability of Na and K from feed sources was adequate, for milch buffalo yielding 10 kg milk per day (Table 3).

Sulphur (S)

The sulphur content was low in most of the crop residues (0.16%), the reason being its transfer to seed proteins. The concentrate ingredients being fed to livestock in this area contained 0.14 per cent, except linseed cake, which contained exceptionally high sulphur (0.47%). However, carrot tops, lucerne, chikori green from various locations had around 0.55 per cent sulphur (Table 2). The variation in S content of plants depends largely on the amount of S in plant proteins in the form of S-containing amino acids (McDowell, 1992; Garg *et al*., 2003c). The availability of S from feed sources was 19.20 g and the requirement was 24.0 g per day, showing a deficiency of 4.8 g per day. Sulphur supplementation was necessary in the ration of animals due to high level of selenium in various feedstuffs and bio-availability of S from feed resources is scanty (McDowell, 1992; Garg *et al*., 2003a).

CONCLUSION

It was apparent from the present study that the ration of milch buffaloes yielding 10 kg milk per day in various taluks of semi-arid zone (Ajmer district) was found to be deficient in cobalt, copper, zinc calcium, phosphorus and sulphur, when feed resources available in that area fed to the animals. Therefore, it is necessary to supplement these minerals in the ration by providing area specific mineral mixture, having better bio-available mineral salts. However, the levels of some other mineral elements such as manganese, iron, selenium, magnesium sodium and potassium were found to be adequate in the ration of animals.

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REFERENCES

Arora, S.P.1981. Zinc and vitamin A relationship in metabolism. In: *TEMA4* (Eds. J.M. Gawthorne *et al.*). Springer-Verlag, Perth, Australia, pp. 572.

Campbell, M.H., Miller, J.K. and Schrick, F.N. 1999. Effect of additional cobalt, copper, manganese and zinc on reproduction and milk yield of lactating dairy cows receiving bovine somatotropin. *Journal of Dairy Science,* 82: 1019.

Cuesta, P.A., McDowell, L.R., Kunkle, W.E., Bullock, F., Drew, A., Wilkinson, N.S. and Martin, F.G. 1993. Seasonal variation of soil and forage mineral concentrations in North Florida. *Communication in Soil Science and Plant Analysis,* 24: 335-347.

Garg, M.R., Arora, S.P., Bhanderi, B.M., Sherasia, P.L. and Singh, D.K. 2000. Mineral status of feeds and fodders in Kaira district of Gujarat. *Indian Journal of Dairy Science,* 53: 291-297.

Garg, M.R., Bhanderi, B.M. and Sherasia, P.L. 2002. Trace minerals status of feeds and fodders in Junagadh district of Gujarat. *Indian Journal of Dairy Science,* 55: 154-158.

Garg, M.R., Bhanderi, B.M. and Sherasia, P.L. 2003a. Macro-mineral status of feeds and fodders in Kutch district of Gujarat. *Animal Nutrition and Feed Technology,* 3: 179-188.

Garg, M.R., Bhanderi, B.M. and Sherasia, P.L. 2003b. Trace mineral status of feeds and fodder in Dahod and Panchmahal districts of Gujarat. *Animal Nutrition and Feed Technology,* 3: 27-30.

Garg, M.R., Bhanderi, B.M., Sherasia, P.L., Singh, D.K. and Arora, S.P. 2003c. Status of sodium and potassium and N:S ratio in different feeds and fodders of Kaira district of Gujarat. *Indian Journal of Dairy Science,* 56: 182-184.

Garg, M.R., Bhanderi, B.M. and Sherasia, P.L. 2003d. Macro and micro-mineral status of feeds and fodders in Kota district of Rajasthan. *Indian Journal of Animal Nutrition,* 20: 252-261.

Goff, J.P. 2000. Pathophysiology of calcium and phosphorus disorders. *Veterinary Clinics of North America: Food Animal Practice,* 16: 319-337.

Kearl, L.C. 1982. *Nutrient Requirements of Ruminants in Developing Countries*. International Feedstuffs Institute, Utah State University, UMC 46, Logan, Utah 84322 USA.

McDowell, L.R. 1992. *Minerals in Animal and Human Nutrition*. Academic Press. San Diego, CA pp. 49-51.

McDowell, L.R., Conrad, J.H. and Glen Hembry, F. 1993. *Minerals for Grazing Ruminants in Tropical Regions*. Animal Science Department, Centre for Tropical Agriculture, University of Florida. The U.S. Agency for International Development and Caribbean Basin Advisory Group (CBAG).

Michal, G. 1999. *Biochemical Pathways*. Eds. John Wiley and Sons, New York.

Miles, W.H. and McDowell, L.R. 1983. Mineral deficiencies in the Ilanos ranges. *World Animal Review* 46: 2-10.

Nelson, J. 1988. *Review of trace mineral chelates and complexes available to the feed industry*. Western Nutrition Conference, Winnipeg, Manitoba, September, p. 1.

NRC. 1980. *Mineral Tolerances of Domestic Animals*, National Academy of Sciences, National Research Council, Washington, DC.

NRC. 2001. *Nutrient Requirements of Dairy Cattle*, 7th Revised ed. National Academy of Sciences, National Research Council, Washington, DC.

Ramana, J., Prasad, C.S., Gowda, N.K.S. and Ramachandra, K.S. 2001. Levels of micro-nutrients in soil, feed, fodder and animals of North East transition and dry zones of Karnataka. *Indian Journal of Animal Nutrition,* 18: 235-242.

Singh, K.K., Nag, S.K., Pailan, G.H., Kundu, S.S., Garg, M.R. and Bhanderi, B.M. 2002. Sodium and potassium contents of some common forages. *Indian Journal of Animal Nutrition,* 19: 378-380.

Singh, S.V. and Pachauri, S.P. 2001. Zinc, immunity and mastitis, *Pashudhan*, 16: 1.

Snedecor, G.W. and Cochran, W.G. 1967. *Statistical Methods*, 6th ed. Oxford and IBH Publishing Company, New Delhi, India.

Suttle, N.F. 1991. The interactions between copper, molybdenum and sulphur in ruminant nutrition. *Annual Review of Nutrition,* 11: 121-140.

Tourtelot, H.A. 1980. Geochemical Surveys in United States in Relation to Health. *Environmental Geochemistry and Health.* Royal Society, London, pp. 113-126.

Udar, S.A., Chopde, S. and Dhore, R.N. 2003. Mineral profile of soil, feeds and fodder and buffaloes in Western Agro-climatic Zone of Vidarbha. *Animal Nutrition and Feed Technology,* 3: 165-172.

Underwood, E.J. and Suttle, N.F. 1999. *The Mineral Nutrition of Livestock*. 3rd ed. CAB International Publishing Co.

Yadav, P.S., Mandal, A.B. and Dahiya, D.V. 2002. Feeding pattern and mineral status of buffaloes in Panipat District of Haryana State. *Animal Nutrition and Feed Technology,* 2: 127-138.

Youssef, F.G., McDowell, L.R. and Brathwaite, R.A.I. 1999. The status of certain trace minerals and sulphur of some tropical grasses in Trinidad. *Tropical Agriculture,* 76: 57-62.