Animal Nutrition and Feed Technology (2005) 5 : 9-20

Assessment of Adequacy of Macro and Micro-Mineral Content of Feedstuffs for Dairy Animals in Semi-Arid Zone of Rajasthan

M.R. Garg*, B.M. Bhanderi and P.L. Sherasia

Productivity Enhancement Group
Animal Nutrition and Feed Technology Laboratory
National Dairy Development Board, Anand-388 001, India

(Received September 12, 2003)

ABSTRACT

A study was carried out to assess macro and micro-minerals status of dairy animals in semi arid zone (Udaipur district) of Rajasthan, by analyzing feed and fodder samples. The average Ca content in straws (0.45%) was higher, whereas, concentrate ingredients were particularly low in Ca (0.23%), except sesame cake. The P content in crop residues (0.10%) and green fodders (0.30%) was lower in comparison to concentrate ingredients (0.57%). The Mg content of feeds and fodder was adequate (0.29%) to meet the requirement of animals (0.20%). The Na content was lower in concentrate ingredients (0.02%) and dry fodder (0.088%) than in green fodder (0.53%). The area under survey was found to be rich in K content (1.41%). The S content was adequate in concentrate ingredients (0.28%), whereas, crop residues were deficient in S (0.12%). Cobalt was occasionally deficient in the diet of animals, however, Fe level in most of the feed ingredients was adequate (average level > 350 ppm). Manganese was deficient in concentrate ingredients (29.90 ppm) compared to crop residues and green forages (58.0 ppm). The average Cu content was low in straws (5.92 ppm) and moderate in green fodders (11.65 ppm), whereas, concentrate ingredients were better source of Cu (19.80 ppm), except grains. Molybdenum content in feeds was within safe limit (average level < 0.77 ppm) exhibiting a Cu:Mo ratio wider than 5.0. Selenium content in most of the feeds and fodder samples was adequate (0.40ppm). Zinc was acutely deficient in most of the feedstuffs (average level < 34.0 ppm). From the present study, it was apparent that the levels of certain minerals such as Ca, P, Na, S, Zn, Cu, Mn and Co were inadequate and much below the requirement of a buffalo yielding 8 kg milk (7% fat) per day.

Key words: Buffaloes, Major elements, Trace elements, Semi arid zone.

---

*Reprint request: Dr. M.R. Garg, Tel: +91-2692-226248, Fax: +91-2692-260158,
E-mail: mrgarg@nddb.coop

INTRODUCTION

Livestock in India do not receive mineral supplements, except for common salt and calcite/dolomite powder (Garg *et al.*, 2003b). Hence, dairy animals depend on forages for their mineral requirements. A number of researchers 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 through scientific means for maximizing yields, ensuring more economic returns to the farmers. However, in the process of intensive farming practices, soils from all over the country are getting depleted for one or more mineral element resulting in 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. Keeping this in view, an assessment of mineral status of feedstuffs was undertaken in different agro-climatic zones of Rajasthan for promoting optimum mineral status of buffaloes. Results of semi arid zone (Udaipur district) are presented here.

MATERIALS AND METHODS

Location, climate and sampling procedure

At random, one village from each of the ten taluka of Udaipur district was selected for taking representative samples of feeds and fodder. Total area of Udaipur district is 12510.6 sq.km., distributed into 10 talukas. The district is having annual rainfall of 75 cm, having latitude of 24°11' and longitude of 73°20'. Atmospheric temperature ranges from 5 to 45° C during different seasons. Within the village help was sought from village milk producers and Udaipur District Cooperative Milk Producers' Union, for identification of 4 to 5 farmers. The recorded parameters were number of livestock, land holding, irrigated facilities, fodder and other crops being grown etc. Land location was considered for identification of farmers, one each from Northern, Eastern, Western and Southern directions, to cover soil types on each side of selected village.

Further information regarding the amount and types of feeds and fodder being offered to the animals, approximate rate of daily feed intake and milk yield of individual animal were collected from individual farmer, using standard sampling procedure. Total intake of various minerals was compared against the requirement on dry matter basis (Campbell *et al.*, 1999; NRC, 2001), so as to identify quantitative deficiency, sufficiency or even excess. In India, any information on mineral requirements for milch buffaloes is hardly available, therefore NRC (2001) for dairy cattle was 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°C for 24h 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 Ca, P, Mg, Na, K, S, Cu, Zn, Mn, Fe, Co, Mo and Se using Inductively Coupled Plasma-Optical Emission Spectrometer (Perkin-Elmer, OPTIMA - 3300 RL).

The word "critical" is used in this article to note a concentration of various minerals in feedstuffs below or above what is considered the requirement for animal. This assumes the expected consumption of minerals as estimated by the NRC (2001) standards. Total grams/milligrams of minerals consumed per day determine the true adequacy of a mineral, not the forage concentration. Dry matter intake data was based on actual measurements made during the sample collection. Total intake of minerals was compared against the requirement on dry matter basis to accertain deficiency or adequacy.

RESULTS AND DISCUSSION

Feeding management

The survey work revealed that most of the small farmers kept their animals on grazing and supplementation of maize straw or local grasses collected from the forest as basal roughage. This practice was found to be common also for other categories of farmers. However, the medium farmers were supplementing the ration of animals with single unit concentrate ingredient in the form of crushed barley, whole cottonseed or crushed maize. Supplementation with home grown multiple unit concentrate mixture (crushed barley, cottonseed, guar chuni, crushed maize, mustard or sesame cake) was found to be practiced only by large farmers. Total quantity of multiple concentrate mixture was fed 3.5 to 4.0 kg per day to the animals. Proportion of concentrate ingredients depended on the availability and cost. Some farmers feed mustard oil (approx. 100g per day) mixed with concentrate mixture at the time of milking of animals. Some of the large farmers use compounded cattle feed (2 kg for body maintenance+@ 400 g per kg milk yield). It was noticed that some of the farmers feed their animals with cultivated fodders like lucerne (*Medicago sativa*) or oat (*Avena sativa*). The green fodder was available only for a limited period due to water scarcity and frequent drought in the area. Hence, farmers without access to irrigation facility are feeding local grasses available in the forest to their animals. In the surveyed area, average dry matter intake (DMI) of animals (n=56) was in the range of 11 to 15 kg (12 $\pm$ 0.22 kg) per day and was based on actual measurements made at the time of sample collection. Interestingly, it was observed that none of the farmers supplemented the ration of animals with additional mineral supplements, except for occasional therapeutic recommendation by veterinary doctor.

Macro-minerals profile of feeds and fodder

The survey work revealed that amongst the dry roughages maize (*Zea mays*) straw and local grasses (mixture of dry grasses) was most prevalent while use of lucerne, oat and maize among the green forages were used most commonly by the farmers of this area. Crushed barley, guar chuni, crushed maize, mustard cake, sesame cake and crushed wheat were offered as concentrate supplements to the animals. The profile of various macro and micro-minerals in the feeds and fodder is presented in Table 1 and 2, respectively.

The average calcium content in straws (0.45%) was higher, but this was low in phosphorus (0.10%). Soybean (*Glycine max*) straw showed exceptionally higher level of calcium (0.91%). The concentrate ingredients commonly fed to animals contained low calcium (0.23%) except sesame cake (2.62%), but high in phosphorus level (0.57%). Lucerne being a legume contained higher amount of calcium (Table 1). Local grasses, guar pods and urd pods were poor source of P as compared to calcium. Grains of bajra, barley, guar, maize and wheat were deficient in calcium and probably due to poor transfer of Ca from plant segment to seeds. Unlike phosphorus and magnesium, calcium is absorbed from the gut according to body needs. Addition of more calcium to the diet will not necessarily improve plasma levels of calcium except proper Ca:P ratio and/or adequate phosphorus and vitamin D_3 in the diet. 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, which may disturb the metabolism of Ca and P. As a result, plasma Ca and P may decline. Under such conditions, 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 8 kg milk per day would need 55.20 g Ca, whereas, feeds and fodders available in the area when fed as per diet formulation given in Table 3, would provide 53.83 g Ca. When green fodder was not available, deficiency of Ca may occur. 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 34.28 g against the requirement of 36.84 g per day for a milch buffalo yielding 8 kg milk, showing a deficiency of 2.50 g per day (Table 3).

The magnesium levels as estimated in the samples of crop residues were adequate (Table 1). Amongst the green fodders, lucerne green (0.41%) had the

Table 1. Macro-mineral profile of feedstuffs used for dairy animal feeding (on DM basis)

Feedstuff	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(2)	0.055±0.02	0.43±0.004	0.17±0.0	0.011±0.002	0.53 ±0.02	0.17 ±0.0
Barley grain(16)	0.087±0.007	0.32±0.007	0.14±0.003	0.072±0.014	0.57±0.015	0.14±0.005
Cotton seed, whole (12)	0.31±0.046	0.49±0.037	0.34±0.032	0.02±0.003	1.45±0.18	0.32±0.09
Guar chuni(11)	0.21±0.018	0.58±0.056	0.28±0.023	0.017±0.001	1.40±0.091	0.32±0.026
Guar grain(7)	0.22±0.019	0.46±0.017	0.24±0.005	0.013±0.001	1.27±0.041	0.27±0.01
Maize grain(12)	0.021±0.003	0.31±0.008	0.12±0.003	0.009±0.0009	0.40±0.02	0.14±0.004
Mustard cake(2)	0.88±0.024	1.18±0.028	0.46±0.004	0.015±0.0008	1.45±0.016	1.78±0.012
Sesame cake(5)	2.62±0.20	1.09±0.17	0.58±0.08	0.016±0.002	1.13±0.079	0.66±0.09
Wheat grain(2)	0.07±0.009	0.35±0.008	0.15±0.008	0.009±0.0001	0.44±0.016	0.16±0.012
Compounded cattle feed(27)	0.76±0.029	1.11±0.042	0.64±0.022	0.73±0.046	1.20±0.037	0.42±0.019
(II) Dry and green roughages						
Guar pods(12)	0.65±0.033	0.093±0.007	0.36±0.03	0.094±0.021	2.05±0.15	0.085±0.003
Local grasses(35)	0.44±0.028	0.089±0.013	0.24±0.02	0.076±0.028	1.16 ±0.094	0.13±0.012
Maize straw(29)	0.37±0.029	0.16±0.017	0.25±0.013	0.02±0.002	1.68±0.11	0.081±0.003
Rice straw(5)	0.28±0.027	0.091±0.019	0.20±0.011	0.20±0.10	2.21±0.36	0.099±0.009
Sorghum straw(5)	0.38±0.038	0.12±0.011	0.29±0.045	0.019±0.003	1.62±0.15	0.098±0.008
Soybean straw(3)	0.91±0.19	0.092±0.025	0.39±0.043	0.032±0.01	1.35±0.29	0.11±0.007
Urd pods(2)	1.04±0.12	0.096±0.003	0.49±0.04	0.85±0.18	1.28±0.02	0.27±0.057
Wheat straw(4)	0.33±0.045	0.06±0.004	0.15±0.025	0.18±0.054	1.57±0.064	0.13±0.012
Lucerne green(13)	2.11±0.093	0.31±0.021	0.41±0.042	0.39±0.062	2.70±0.23	0.34±0.021
Oat green(10)	0.42±0.024	0.29±0.022	0.26±0.016	0.67±0.11	2.91±0.19	0.30±0.024

Figures in parentheses indicate no. of samples analyzed.

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

highest Mg content, followed by green oat (0.26%), showing that considerable quantities of Mg were apparently available for the livestock. Compared to critical level of 0.20 percent, the grains of bajra, barley, guar, maize and wheat were found to contain low levels of Mg (0.16%). Cottonseed (*Gossypium herbaceum*), mustard cake and sesame cake were good sources of Mg (Table 1). Sarasdan, compounded cattle feed, produced and marketed by Jodhpur District Cooperative

Table 2. Trace mineral profile of feedstuffs used for dairy animal feeding (on DM basis)

Feedstuff	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(2)	0.10 ±0.077	7.10 ±0.16	119.75 ±19.85	15.50 ±1.14	0.0 ±0.0	0.57 ±0.37	50.35 ±12.98	...
Barley grain(16)	0.50 ±0.072	11.83 ±0.69	129.31 ±12.54	23.55 ±1.10	0.75 ±0.45	0.14 ±0.10	29.55 ±2.0	15.77
Cotton seed, whole (12)	0.36 ±0.065	13.15 ±1.13	434.33 ±74.52	27.25 ±2.8	0.057 ±0.056	1.19 ±0.42	37.85 ±1.38	230.70
Guar chuni(11)	0.63 ±0.056	16.10 ±0.85	464.09 ±25.85	24.31 ±2.79	2.12 ±0.23	0.30 ±0.21	57.36 ±3.94	7.59
Guar grain(7)	1.14 ±0.2	15.37 ±0.66	481.71 ±16.9	15.74 ±0.79	2.76 ±0.78	0.23 ±0.18	57.45 ±1.64	5.56
Maize grain(12)	0.30 ±0.051	5.36 ±0.31	93.20 ±28.05	9.21 ±0.58	0.22 ±0.052	0.31 ±0.10	26.82 ±0.86	24.36
Mustard cake(2)	0.36 ±0.008	16.95 ±1.84	659.50 ±26.61	73.50 ±0.49	0.0 ±0.0	0.10 ±0.086	84.35 ±1.26	...
Sesame cake(5)	0.61 ±0.11	37.14 ±4.55	907.60 ±175.2	44.92 ±3.92	1.97 ±0.24	0.12 ±0.022	115.80 ±5.50	18.85
Wheat grain(2)	0.31 ±0.023	8.11 ±0.53	113.05 ±22.88	38.65 ±0.20	0.0 ±0.0	0.09 ±0.008	34.20 ±1.06	...
Compounded cattle feed(27)	1.50 ±0.13	25.89 ±1.31	828.77 ±38.36	105.89 ±4.64	1.96 ±0.28	1.45 ±0.37	106.06 ±4.43	13.20
(II) Dry and green roughages								
Guar pods(12)	0.24 ±0.044	7.64 ±0.62	282.50 ±52.84	24.10 ±2.09	0.23 ±0.17	0.57 ±0.37	16.54 ±1.05	33.21
Local grasses(35)	0.16 ±0.03	5.91 ±0.36	265.48 ±42.09	48.76 ±3.48	0.43 ±0.24	1.08 ±0.24	27.50 ±1.50	13.74
Maize straw (29)	0.10 ±0.026	6.39 ±0.36	239.36 ±34.12	39.21 ±2.76	0.40 ±0.10	0.52 ±0.11	35.15 ±3.27	15.97
Rice straw (5)	0.44 ±0.11	5.98 ±0.65	356.40 ±73.42	168.18 ±39.85	0.10 ±0.046	0.55 ±0.12	28.62 ±4.62	59.80
Sorghum straw (5)	0.084 ±0.039	6.04 ±0.60	186.60 ±33.09	36.58 ±6.20	0.10 ±0.033	0.35 ±0.13	35.74 ±3.41	60.40
Soybean straw(3)	0.30 ±0.011	6.86 ±0.56	553.66 ±125.9	38.53 ±7.46	0.22 ±0.06	0.55 ±0.0	18.76 ±0.00	31.18
Urd pods (2)	0.15 ±0.049	7.83 ±1.28	286.0 ±70.42	48.15 ±12.57	0.72 ±0.018	0.055 ±0.012	17.90 ±2.70	10.87
Wheat straw (4)	0.22 ±0.069	4.35 ±0.60	309.50 ±17.93	47.85 ±3.80	0.034 ±0.022	0.082 ±0.027	11.57 ±0.50	127.94
Lucerne green(13)	0.26 ±0.06	11.88 ±0.68	503.30 ±60.02	54.49 ±3.56	1.27 ±0.33	0.41 ±0.15	24.81 ±1.05	9.35
Oat green (10)	0.15 ±0.035	11.42 ±0.91	287.50 ±62.82	79.79 ±7.40	2.09 ±0.81	0.55 ±0.29	30.92 ±2.48	5.46

Figures in parentheses indicate no. of samples analyzed. [a]Critical level = concentrations below which are considered deficient or excessive in the case of Mo (McDowell *et al.*, 1993), based on requirements for cattle (NRC, 2001).

Table 3. Calculated requirement and availability of macro and micro-minerals in lactating buffaloes*

Attribute	Tentative daily DMI(kg)	Ca (g)	P (g)	Mg (g)	Na (g)	K (g)	S (g)	Co (mg)	Cu (mg)	Fe (mg)	Mn (mg)	Zn (mg)	Se (mg)
Maintenance	12.00	18.00	13.00	—	—	—	—	—	—	—	—	—	—
Milk production	—	37.20	23.84	24.00	21.60	108.00	24.00	6.0	120.0	600.0	480.0	960.0	3.60
Daily requirement	12.00	55.20	36.84	24.00	21.60	108.00	24.00	6.0	120.0	600.0	480.0	960.0	3.60
Feeds													
Whole cottonseed	—	4.65	7.35	5.10	0.30	21.75	4.80	0.54	19.50	651.0	40.50	56.77	1.78
Crushed barley	960.0	0.87	3.20	1.40	0.72	5.70	1.40	0.50	11.80	129.0	23.55	29.00	0.14
Crushed maize	960.0	0.21	3.10	1.20	0.01	4.00	1.40	0.30	5.36	93.0	9.21	26.80	0.31
Guar chuni	1.50	3.15	8.70	4.20	0.25	21.00	4.80	0.94	24.00	696.0	36.45	85.95	0.45
Local grasses	2.00	8.80	1.78	4.80	1.52	23.20	2.60	0.32	11.82	530.0	97.40	54.00	2.16
Maize straw	3.50	12.95	5.60	8.75	0.70	58.80	2.83	0.35	22.36	836.0	136.50	122.5	1.82
Lucerne green	1.00	21.10	3.10	4.10	3.90	27.00	3.40	0.26	11.80	503.0	54.00	24.80	0.41
Oat green	0.50	2.10	1.45	1.30	3.35	14.55	1.50	0.07	5.70	143.0	39.90	15.50	0.27
Daily availability	12.00	53.83	34.28	30.85	10.75	176.00	22.73	3.29	112.34	3581.0	437.51	415.32	7.34

* 400 kg live weight, producing 8.0 kg milk (7 % fat) per day.

Milk Producers' Union Ltd., Jodhpur contained 0.64 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). Magnesium is considered to be an important factor in the occurrence of grass tetany in animals (Garcia and Williams, 2000) and is necessary for all phosphate transfer reactions (NRC, 1980). Ruminants are generally at risk from hypomagnesaemia when the forage contains less than 0.20 per cent of Mg and is high in K content (Garg *et al.*, 2003a). The Mg requirement of a milch buffalo yielding 8 kg milk per day was 24.0 g (Table 3), whereas, feeds and fodders fed in that area provided 30.85 g of Mg per day.

The sodium content was unduly low in all the feeds and fodders, ranging from 0.009 to 0.20 per cent. Only lucerne and oat green contained sodium as high as 0.53 per cent. Compounded cattle feed had an appropriate quantity of sodium to the extent of 0.73 per cent, because of added sodium chloride (Table 1). Higher K content of feedstuffs may be due to its selective uptake from the soil and was much higher than Na. Similar findings were also reported by Singh *et al.* (2002). Potassium content in straws and stovers was higher than the concentrate feed ingredients (Table 1) 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. Unlike K, the availability of Na from feed sources was only 10.75 g against the requirement of 21.60 g per day, showing a deficiency of 10.85 g per day, for milch buffalo yielding 8 kg milk per day (Table 3). However, the farmers practiced feeding of common salt in the survey area.

The sulphur content was low in most of the crop residues (0.12%). The concentrate ingredients being fed to livestock in this area contained 0.28 per cent, except mustard cake, which contained exceptionally high sulphur (1.78%). However, lucerne and green oat from various locations had around 0.32 per cent sulphur (Table 1). 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). The availability of S from feed sources was 22.73 g and the requirement was 24.0 g per day (Table 3), showing a deficiency of 1.27 g per day. However, sulphur supplementation was necessary in the ration of animals due to high level of selenium in various feedstuffs and limited bioavailabilty of S from feed resources (McDowell, 1992; Garg *et al.*, 2003a).

Micro-mineral profile of feeds and fodder

The cobalt levels in this zone ranged from 0.084 to 0.44 ppm in straws, 0.15 to 0.26 ppm in green fodders and 0.10 to 0.50 ppm in grains. Whole cottonseed and guar chuni revolved around 0.50 ppm Co (Table 2). Sarasdan compounded cattle feed, mustard and sesame cakes contained 1.50, 0.36 and 0.61 ppm cobalt, respectively. A buffalo, yielding 8 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, provide 3.29 mg, showing a deficiency of cobalt (Table 3).

Copper quantity was recorded low especially in dry roughages. Straws of rice, sorghum, maize, soybean and wheat contained very low level of copper (5.92 ppm). Lucerne and oat green contained around 11.0 ppm copper (Table 2). Cottonseed (13.15 ppm), mustard cake (16.95 ppm), guar chuni (16.10 ppm) and sesame cake (37.14 ppm) were better source of copper. Grains of bajra and maize (6.23 ppm) contained low Cu as compared to barley and guar (13.60 ppm). Tentative Cu intake from available feeds and fodders fed to a buffalo, yielding 8 kg milk per day, was 112 mg against the requirement of 120 mg per day (Table 3) and therefore, its supplementation was required.

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 2). Even straw samples were quite rich in Fe (328 ppm). Lucerne and oat green showed an average of 395 ppm Fe. Grains had around 114 ppm Fe, while whole cottonseed, sesame and mustard cakes were exceptionally rich, containing 666 ppm iron.

Thus, Fe seems to be quite rich in the feed resources of the 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). The symptoms of Cu deficiency like depigmentation of hair coat, anemia and infertility were recorded in the surveyed area. For a buffalo yielding 8 kg milk per day, the availability of Fe from feed resources was 3581 mg and the requirement was only 600mg per day (Table 3).

Most of the straws offered to animals contained around 40 ppm Mn (Table 2), except rice straw (168 ppm). However, higher Mn level was found in lucerne (54.49 ppm) and oat green (79.79 ppm). Amongst the concentrate ingredients, mustard cake (73.50 ppm) had the highest Mn content, followed by sesame cake (44.92 ppm), wheat grain (38.65 ppm), cottonseed (27.25 ppm) and guar chuni (24.31 ppm).

Adequate Mn availability from feeds and fodder was recorded in other parts of the country (Garg *et al.*, 2000; Yadav *et al.*, 2002). Mn deficiency (<40 ppm) was observed in most of the feeds and fodder. Considering minimum requirement to be 40 ppm, the animals were deficient and Mn supplementation was needed (Table 3).

The molybdenum levels as estimated in the samples of crop residues were within the safe limit (Table 2). Amongst the dry fodders, local grasses (0.43 ppm) had the highest Mo content, followed by maize straw (0.40 ppm), soyabean straw (0.22 ppm) and rice straw (0.10 ppm). Lucerne and oat green contained 1.27 and 2.09 ppm Mo, respectively. Guar chuni (2.12 ppm) and sesame cake (1.97 ppm) contained high Mo (Table 2). The most of the feedstuffs contained Mo level within the safe limit and gave Cu:Mo ratio wider than 5.0. Molybdenum has obtained more importance in animal nutrition, because of its inhibitory role on the other trace elements particularly copper. Suttle (1991), stated that a Cu:Mo ratio below 2.0 would be expected to cause conditional 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 the surveyed area, Cu deficiency exists in most of the feeds and fodder, so excess level of Mo was undesirable.

The selenium content of the crop residues varied from 0.055 to 0.55 ppm (Table 2). However, Se level was recorded 0.41 and 0.55 ppm, in green lucerne and oat, respectively. Grains had around 0.27 ppm Se, whereas whole cottonseed (1.19 ppm) was an exception with high Se content (Table 2). Guar chuni, mustard and sesame cakes contained around 0.17 ppm Se. Selenium acts as an antioxidant and is essential constituent of glutathione peroxidase, which destroys peroxides before they can attack cellular lipid membranes. The minimum dietary Se requirements of all classes of ruminant livestock ranges from 0.10 to 0.30 ppm and toxic dietary levels are about 10 to 50 times greater (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 is not advocated.

Zinc is one element, which is found to be deficient in many geographical zones of India (Ramana *et al.*, 2003; Garg *et al.*, 2003b; Udar *et al.*, 2003). From this surveillance (Table 2), it was apparent that most of the feed ingredients, particularly straws, were unduly low in Zn content (23.60 ppm). The zinc content of the green fodders varied from 24.81 to 30.92 ppm (Table 2). Grains had around 39.20 ppm Zn, while mustard and sesame cakes were an exception with higher Zn content (99.50 ppm). Zinc content was found 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.

For milch buffalo yielding 8 kg milk per day, the requirement difference was to the extent of 545 mg per day in a traditional feeding system (Table 3). Mastitis, night blindness, parakeratosis and reproductive failure are the ailments, which may result from its deficiency (McDowell, 1992; Singh and Pachauri, 2001). The role of Cu and Zn in augmenting production and reproduction is well documented and are known to have a significant correlation with reproductive hormones (progesterone and estradiol), as they are specific activators of enzyme systems that assist in maintaining the activity of hypophyseal hormones in blood (McDowell, 1992). Probably that is the reason that majority of the animals in this area had reproductive problems like anestrus and repeat breeding.

CONCLUSION

It was apparent from the present studies that milch buffaloes yielding 8 kg milk per day in various talukas of semi arid zone (Udaipur district) of Rajasthan were deficient in calcium, phosphorus, sodium, sulphur, cobalt, copper, manganese and zinc when fed on locally available feed resources. Therefore, it is necessary to supplement these minerals in the diet by providing area specific mineral mixture having better bioavailable mineral salts.

Acknowledgement

We are grateful to the Management of National Dairy Development Board, Anand for providing necessary facilities and encouragement for taking up these studies. Help rendered by the Rajasthan Cooperative Dairy Federation Ltd., Jaipur and the staff of Udaipur District Cooperative Milk Producers' Union Ltd., Udaipur is gratefully acknowledged.

REFERENCES

Arora, S.P. 1981. Zinc and vitamin A relationship in metabolism. In: *Trace Elements in Man and Animals (TEMA4),* (Eds. J.M. Gawthorne, J.M.C. Howell and C.L. White) Perth, Australia: Springer-Verlag, Berlin, New York, 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: 1019-1022.

Garcia-Gomez, F. and Williams, P.A. 2000. Magnesium metabolism in ruminant animals and its relationship to other inorganic elements. *Asian-Australasian Journal of Animal Sciences*, 13: 158-170.

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.

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

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).

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

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

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

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, Wellingford, UK.

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.