Cu - deficiency
Zn - Acutely deficiency
Mn - Adequate

Trace Minerals Status of Feeds and Fodders in Junagadh District of Gujarat

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A two dimensional survey was conducted to map the distribution of relevant micro-minerals in Junagadh district, by collecting feed and fodder samples at random, taking conceptual village as a unit. The average copper content was consistently low in straws (6.36 ppm) and green fodders (5.18 ppm), whereas concentrate ingredients were better source of copper (14.36 ppm) except grains. Likewise, zinc was acutely deficient in the region (Average levels <23.0 ppm) and needed to be supplemented at a level of 80 ppm in the total ration for optimum metabolic functions. Manganese and iron levels in the most of feeds were adequate, whereas, cobalt was marginally deficient in feeds. Molybdenum content in feeds was within the safe limit (Average levels <0.5 ppm) and gave Cu:Mo ratio wider than 4.0. Selenium content in most feeds was adequate (Average levels > 1.60 ppm). From the present study, it is apparent that the levels of certain micro-minerals such as copper, zinc and cobalt were inadequate, as per the estimates for the requirement of a buffalo yielding 8 kg milk per day. However, the levels of some other mineral elements such as manganese, iron and selenium were found to be adequate in the surveyed area.

Keywords: Trace minerals, survey/status, feeds, fodders, Gujarat (India)

INTRODUCTION

In most of the developing countries, mineral deficiencies are frequently encountered in livestock rations. However, toxicity of selenium and molybdenum has also been observed due to their excess quantities (Tiffany *et al.* 2000). Zinc deficiency in India is widespread both in soils and plants, affecting crop yields. Other reported mineral problems are those of Cu, Mo, Mn and Fe in different regions (Olsen, 1999; Ramana *et al.* 2001).

It is likely that deficiency of certain minerals may not affect crop yields but their availability from such forages may be inadequate for requirements of livestock, which obtain most of the minerals required from feed and fodders. Therefore, information on the mineral composition of such feeds and fodders is essential, as recommendations leading to excess may have detrimental effect on the animals (Garg *et al.* 2000). Recommending supplemental elements without considering the base levels in feedstuffs may not be desirable (Hinders 1999). In this study, two dimensional survey was adopted to map a number of elements by collecting feed samples in a particular district, according to random sampling design based on conceptual landscape units.

MATERIALS AND METHODS

Two dimensional survey technique was adopted taking village as a unit for the collection of feed and fodder samples in different areas (taluks) of Junagadh district, to identify the mineral deficiency or excess and to judge the magnitude of the problem. Total area of Junagadh district is 10,607 sq.km, distributed into 15 taluks, from where one village in each of 9 taluks was selected at random, showing natural sampling areas of conceptual units. The district having annual rainfall of 690 mm, its location is 300 metres above mean sea level, having latitude of 21.5° and longitude of 70.5°. Atmospheric temperatures ranges from 11 to 46°C during different seasons. Samples of feeds and fodder from within each of the identified village were collected from 4-5 farmers, selected with the help of veterinary officer and village milk producers during pre-monsoon season. Details regarding the number of livestock, irrigated land and the crops grown were recorded. Following collection, green samples were dried in oven at 80°C for 24 hrs and subsequently ground, using sample mill, with a 1 mm stainless steel sieve.

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2002-038 Date received: September 2001; Accepted: June 2002

Ground samples of feed and fodder were stored in plastic bags until analysis. Samples were prepared and digested using 5 ml concentrated HNO_3 plus 1 ml concentrated HCl by microwave digestion method and total volume of mineral extract was made to 25 ml with deionized water. All the prepared samples of feed and fodder were analyzed for Cu, Zn, Mn, Fe, Co, Mo and Se using Inductively Coupled Plasma - Optical Emission Spectrometer (Perkin Elmer Optima - 3300 RL).

In Junagadh district, amongst various breeds of milch animals, buffaloes are the main milk producer. Hence, a buffalo yielding 8 litres of milk was considered for assessing mineral requirements. Assessment of quantitative intake of total feed in milch animals was made to calculate the dry matter (DM) intake, on the basis of which mineral status was compared against the standard requirements (NRC, 2001), to identify quantitative deficiency, adequacy or even excess. In India, hardly any information on mineral requirements for milch buffaloes is available; hence, NRC (2001) was taken as a base for calculation of mineral requirements of buffaloes. The data were analysed statistically using SAS system (1990) for analysis of variance.

RESULTS AND DISCUSSION

Copper (Cu)

Copper content was recorded consistently low in almost all the collected feed samples. Out of the green fodders, bajra green contained 8.12 ppm copper, whereas in rest of the green fodders, it averaged around 4.35 ppm (Table 1). In grains, the levels again were very low. Wheat bran and cotton seed cake were relatively higher in copper content. Village to village variation in the quantity of copper was significantly different for bajra straw, groundnut straw, sorghum green and local grasses, whereas it was not so for some other feedstuffs. Subclinically, the problems of poor growth rate, coarse wool and infertility may be encountered in certain species due to decrease in activity of superoxide dismutase enzyme. Copper deficient sheep had increased mortality from bacterial infection (Chew, 2000). Similarly, dietary copper reduced the incidence of mammary gland infection (mastitis) and increased the killing ability of neutrophils (Harmon and Torre, 1994).

Copper status from traditional feeds and fodders fed to a buffalo, yielding 8 kg milk per day, is 91.86 mg per day against the requirement of 100 mg (Table 2).

Zinc (Zn)

Zinc was deficient in most of the feeds and fodder samples, a picture very similar to Kaira district of Gujarat (Garg *et al.* 2000). From this surveillance (Table 1), it was apparent that most of the feed ingredients, particularly straws, were unusually low in Zn content (20 ppm). Bajra green, sorghum green, local grasses, hybrid napier and sugarcane tops were showing somewhat better levels (26.40 ppm). It seemed that Zn transfer from plant segment to seeds was quite substantial as apparent from the figures in bajra grain, sorghum grain and wheat grain. Cotton seed cake, groundnut cake and wheat bran were better sources of zinc. Village to village variation was significantly different ($P<0.01$, $P<0.05$) for bajra green, cotton seed cake, sorghum straw, sugarcane tops and wheat bran, whereas it was not so for some others (Table 1).

For a milch buffalo, yielding 8 kg milk per day, the requirement difference was to the extent of 416 mg per day with a traditional feeding system. Night blindness, hypertension and reproductive failure are the ailments, which may result from its deficiency (Chhabra and Arora, 1985). A nutritional deficiency of zinc is consistently associated with increased morbidity and mortality in livestock. Zinc deficiency is associated with reduced phagocytosis and killing by macrophages. Zinc as Zn methionine reduced somatic cell counts (SCC) by about 22% in a trial (Kincaid *et al.* 1999). To overcome Zn deficiency, its level should be 80 ppm in the total ration (Arora, 1981) which could be made up through Zinc sulphate supplementation, so as to avoid subclinical and clinical problems.

Manganese (Mn)

Most of the straws offered to livestock contained reasonable amount of Mn (60.6 ppm), whereas, concentrate ingredients were low in Mn content (Table 1) except wheat bran. The green fodders were higher in Mn content (56 ppm). Local grasses also were unusually high in Mn content (122.85 ppm). Village to village variations of Mn content did not reveal any significant difference in feeds like bajra grain, bajra straw, groundnut straw, groundnut cake, sorghum straw and wheat straw. Differences ($P<0.05$, $P<0.01$) were, however,

Table 1: Mineral Contents of Some Feedstuffs on DM Basis in Different Villages of Junagadh District

Feeds	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Co (ppm)	Mo (ppm)	Se (ppm)
Bajra grain (3)	6.19±0.74	40.13±6.67	19.33±4.18	80.97±12.89	0.37±0.03	0.41±0.26	0.18±0.12
Bajra green (3)	8.12±1.30	31.50±5.50*	71.53±12.17**	578.00±46.18**	0.45±0.12	0.05±0.05	0.00±0.00
Bajra straw (10)	8.15±1.20*	14.42±2.04	51.84±6.54	250.20±29.29	0.40±0.05*	0.20±0.16**	2.85±0.81*
Banyan leaves (1)	5.26	17.10	22.10	719.00	0.38	0.00	4.99
Cottonseed cake (14)	11.44±0.54	43.01±0.92*	22.71±2.15**	308.64±29.62*	0.51±0.05	0.11±0.04	2.28±0.32*
Dudhdhara dan (2)	16.35±0.65	48.55±0.35	116.00±13.00	985.00±15.00	3.28±0.41	0.42±0.42	0.39±0.02
Dudhganga dan (1)	19.90	35.10	138.00	1000.00	3.69	0.00	0.80
Groundnut straw (21)	7.17±0.31*	22.07±1.01	58.20±4.32	941.41±16.75**	0.87±0.07*	0.08±0.04**	4.64±0.41*
Groundnut cake (2)	19.30±1.30	55.35±3.55	37.20±1.45	762.50±114.50	0.70±0.10	0.47±0.03	0.00±0.00
Garlic leaves (1)	29.30	28.30	14.80	384.00	1.80	0.00	0.00
Hybrid napier (1)	4.30	30.10	37.30	470.00	0.39	0.00	1.85
Sorghum grain (1)	6.72	39.90	16.40	262.00	0.87	0.21	0.68
Sorghum green (19)	5.27±0.56**	24.84±2.02	48.57±2.86*	540.24±60.12**	0.49±0.08*	0.10±0.05	0.86±0.24
Sorghum straw (21)	5.71±0.58	23.91±1.42**	49.58±2.37	417.19±40.16**	0.26±0.03	0.04±0.03	2.26±0.24*
Local grasses (14)	3.82±0.43*	20.54±1.88	122.85±62.68**	616.36±82.65**	0.41±0.09	0.06±0.05	1.13±0.33
Maize grain (2)	2.89±0.07	22.40±2.80	8.44±1.19	116.45±16.75	0.24±0.04	0.14±0.13	0.76±0.21
Maize straw (2)	6.76±0.63	23.95±2.55	67.10±2.00	343.50±47.50	0.22±0.02	0.00±0.00	2.82±0.71
Neem leaves (1)	6.38	23.60	55.30	521.00	0.30	0.00	2.86
PJ Pods (2) (Prosopis juliflora)	6.88±0.03	11.70±1.60	18.30±0.50	293.50±10.50	0.22±0.01	1.56±1.56	0.39±0.37
Sardardan (1)	14.30	29.00	105.00	1230.00	3.41	0.00	3.45
Sugarcane tops (7)	3.06±0.31	24.84±8.07**	48.24±5.34*	367.00±86.45**	0.18±0.03	0.00±0.00	0.31±0.16*
Urd gotar (1) (Phaseolus mungo)	6.28	17.30	74.20	453.00	0.34	0.00	4.71
Wheat bran (9)	12.36±0.57	76.04±3.20**	107.30±4.49*	217.78±39.09**	0.19±0.03	0.28±0.10*	0.47±0.22
Wheat grain (2)	6.31±0.25	31.95±1.85	41.75±2.35	79.40±18.80	0.09±0.01	0.00±0.00	0.50±0.14
Wheat straw (3)	4.03±0.46	15.53±2.79	76.30±15.15	691.67±86.92	0.42±0.07	0.00±0.00	1.78±0.56

Figures in parentheses indicate no. of samples analysed.
Note: * $P<0.05$ and ** $P<0.01$ is village to village variation for the same feed ingredient.

observed between samples from different villages in bajra green, sorghum green, local grasses, sugarcane tops, wheat bran and cotton seed cake (Table 1).

Adequate manganese availability from feeds and fodders was also recorded in Kaira district (Garg *et al.* 2000). The milch buffalo yielding 8 kg milk per day, required 400 mg manganese per day, whereas feeds and fodders provided 598 mg per day (Table 2).

Iron (Fe)

Distribution of iron (Fe) was found to be unique in the sense that it exceeded the requirement in all the feed ingredients, being fed to livestock (Table 1). Even straw samples were quite rich in Fe (528 ppm). Bajra green, hybrid napier, sorghum green, local grasses and sugarcane tops showed an average of 514 ppm Fe. Grains had around 134 ppm, while cotton seed cake, groundnut cake and wheat bran were exceptionally rich, containing 608 ppm Fe. Thus, Fe seems to be quite rich in this district, as also reported from Kaira district (Garg *et al.* 2000). The Fe concentration in the majority of feedstuffs was very high and could probably interfere with the copper metabolism (Youssef *et al.* 1999). Village to village variations was significantly different ($P<0.01$, $P<0.05$) for bajra green, cotton seed cake, groundnut straw, sorghum green, sorghum straw, local grasses, sugarcane tops and wheat bran, whereas it was not so, for some other feeds (Table 1).

For a buffalo yielding 8 kg milk per day, the availability of iron from feeds is 3807 mg and the requirement is only 500 mg per day (Table 2).

Cobalt (Co)

The cobalt level in this zone was found to be marginally deficient. The cobalt content in straws and green fodder was 0.43 ppm (Table 1). Bajra, sorghum, maize and wheat grains were found to be moderate sources of Co (0.39 ppm). Cottonseed and groundnut cakes showed better levels (0.6 ppm). Wheat bran was again poor source of Co. Village to village variations of cobalt

Table 2: Availability and Requirement of Fe, Cu, Zn, Mn and Co in a Buffalo Producing 8 Kg Milk Per Day (7% Fat)

Attribute Feeds	Tentative Daily DMI (kg)	Fe Level (ppm)	Fe Daily intake (mg)	Cu Level (ppm)	Cu Daily intake (mg)	Zn Level (ppm)	Zn Daily intake (mg)	Mn Level (ppm)	Mn Daily intake (mg)	Co Level (ppm)	Co Daily intake (mg)
Bajra Straw	2.5	250	625	8.15	20.37	14.42	36.05	51.84	129.60	0.40	1.00
Groundnut Straw	1.0	941	941	7.17	7.17	22.07	22.07	58.20	58.20	0.87	0.87
Sorghum Green	2.0	540	1080	5.27	10.54	24.84	49.68	48.57	97.14	0.49	0.98
Cotton Seed Cake	2.0	308	616	11.44	22.88	43.01	86.02	22.71	45.42	0.51	1.02
Wheat Bran	2.5	218	545	12.36	30.90	76.04	190.10	107.30	268.25	0.19	0.47
Total Daily Intake	10.0		3807		91.86		383.92		598.61		4.34
Daily Requirement	10.0	50	500	10	100	80	800	40	400	0.5	5.00

for the same feed did not show any significant difference, except bajra straw, groundnut straw and sorghum green. A buffalo yielding 8 kg milk daily, would need 5.0 mg Co per day as per the standard requirements, whereas feeds and fodders available in the area when fed, provide 4.43 mg per day, showing a marginal deficiency of Co (Table 2). However, in other regions of Gujarat Co availability from feeds and fodder was found to be adequate for a buffalo yielding 8 kg of milk (Garg *et al.* 2000).

Molybdenum (Mo)

The molybdenum levels as estimated in the samples of crop residues were within the safe limit (0.11 ppm). Amongst the green fodders, sorghum green (0.10 ppm) had the highest Mo content, followed by local grasses (0.06 ppm) and bajra green (0.05 ppm). Bajra, sorghum and maize grains were relatively higher in molybdenum content (0.25 ppm). Groundnut cake, cotton seed cake and wheat bran were still high in molybdenum levels (0.29 ppm). Village to village variation of Mo content in feed samples did not reveal any significant difference, except for Bajra and groundnut straws. The lowest and highest Cu:Mo ratios in the feedstuffs were 4.0 and 162.0, respectively. Miltimore and Mason (1971), stated that a Cu:Mo ratio below 2.0 would be expected to cause conditioned copper deficiency in cattle, while Alloway (1973) suggested that a ratio closer to 4.0 is necessary to avoid hypocuprosis in sheep. Molybdenum 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).

Selenium (Se)

The selenium content of the crop residues varied from 1.78 to 4.64 ppm (Table 1). However, selenium level was nil, 0.31 ppm, 0.86 ppm and 1.13 ppm, in bajra green, sugarcane tops, sorghum green and local grasses, respectively. Grains had around 0.51 ppm Se, while cottonseed cake was an exception with higher Se content (2.28 ppm) (Table 1). Village to village variation in Se content was noticed in bajra straw, groundnut straw, sugarcane tops and cottonseed cake. Certain other feeds like bajra grain, bajra green, sorghum green, local grasses and wheat bran did not show any significant variations in Se levels between samples from different villages. Selenium is necessary for growth and fertility in animals and it is component of glutathione peroxidase, an enzyme that inactivates oxygen radicals such as hydrogen peroxide and prevents them from causing cellular damage (Engle, 2001). The minimum dietary Se requirements of all classes of ruminant livestock range from 0.10 to 0.30 mg per kg DM (NRC, 1980). Accepting the minimum requirements of 0.3 mg Se per kg DM, which is the level considered adequate for preventing deficiency in sheep and dairy cattle (NRC, 2001), most of the feeds and fodders studied would satisfy their requirements. Therefore, its supplementation in mineral mixture is unnecessary.

It is apparent from the present studies, that milch buffaloes yielding 8 kg milk per day in various taluks of Junagadh district are able to meet their mineral requirements, except zinc and copper and occasionally cobalt. However, there are many factors that could affect an animal's response to mineral supplementation such as the duration and concentration of mineral supplementation, the absence or presence of dietary antagonists, bioavailability of minerals from feedstuffs, environmental factors, breed difference and also the type of accompanying feed in mineral metabolism (Engle, 2001). In additionl to this, mineral status of feeds and fodders depends upon the interaction of a number of factors, such as soil type, plant species, stage of harvesting, crop yield, intensity of agricultural systems and fertilization (McDowell *et al.* 1993). Recommending supplemental trace mineral levels without considering the trace mineral levels in the feedstuffs may cause more harms than good.

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