Study on Availability of Various Macro and Micro-Minerals in Lactating Buffaloes under Field Conditions of Sabarkantha District of Gujarat

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Abstract: A study was conducted in the Sabarkantha district of Gujarat to assess the status of some macro and micro-minerals in lactating buffaloes. Feeds and fodder samples were collected from 17 representative villages of the district for analysis of macro and micro-minerals. Calcium content in cottonseed cake (0.17%), crushed maize (0.03%) and maize cake (0.22%) was found to be below the critical level (0.30%). The phosphorus content in concentrate ingredients was high (0.32-0.67%) but low in dry roughages (0.06-0.20%). Feeds and fodder were found to be adequate in magnesium (0.40%), sodium (0.29%) and potassium (1.15%). Straws were found to be deficient in sulphur (0.16%). Green roughages were good source of copper (12.31 ppm). Wheat straw was found to be low in zinc (19.71 ppm) but comparatively high in manganese (47.88 ppm) and iron (630.24 ppm). Lucerne and chikori green were found to be rich source of cobalt (>0.35 ppm). Selenium (0.68 ppm) was present in appreciable quantities in most of the feedstuffs. Lactating buffaloes were also found to be excess in energy and crude protein (70%), whereas, calcium and phosphorus were deficient in the ration (65%). Ration of lactating buffaloes was found to be deficient in Ca, P, S, Cu, Zn and Co. Supplementing the deficient minerals through area specific mineral mixture could alleviate the deficiency and improve productivity and reproduction efficiency of lactating buffaloes.

Keywords: Calcium, Phosphorus, Copper, Zinc, Selenium, Lactating buffaloes.

INTRODUCTION

The importance of minerals in regulating biological systems, growth, production and reproduction is well documented [1], however, livestock in India do not receive mineral/vitamin supplements except for common salt and calcite powder [2]. Hence, dairy animals depend on forages for their mineral requirements [3]. A number of researchers in the world have reported high incidences of forage and blood serum samples below the critical levels for different mineral elements, especially copper (Cu), zinc (Zn) and phosphorus [4]. Soils from all over country are getting depleted for one or more mineral elements in soil, plants and animals [5]. The quantity of minerals, thus, present in forages may not be sufficient for optimum growth, milk yield and reproduction efficiency of dairy animals [3]. In order to avoid macro and micro-minerals imbalances in the ration, a study on assessment of mineral status of lactating buffaloes was undertaken in Sabarkantha district.

MATERIALS AND METHODS

Sampling Procedures

One or two villages from each taluka were selected at random for taking representative samples of feeds, fodders and hair. Total area of Sabarkantha district is 1790 sq.km., distributed into 13 talukas, having 1500 villages. The district is having annual rainfall of 50-100 cm, latitude of 23°03' and longitude of 73°39'. Atmospheric temperature ranges from 6 to 45° C during different seasons. Within the village, help was sought from village milk producers and district animal husbandry officer for identification of 4 to 5 farmers. The recorded parameters were number of livestock, land area, irrigation 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 direction 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, rate of daily feed intake, number of milch animals and milk yield were collected from individual farmer. Total intake was compared against the requirements on dry matter basis [6], so as to identify quantitative deficiency, sufficiency or even excess.

Sample Preparation and Analytical Methods

Composite samples of green fodder, dry fodder, concentrate ingredients and the compound cattle feed (concentrate mixture) were collected from all over the surveyed area. Green samples were dried in oven at 80^0C for 24 hours and subsequently ground (1mm). Ground samples of concentrate and fodder were stored in airtight bags until analysis. All the samples were analyzed for calcium (Ca), phosphorus (P), magnesium

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ISSN: 1927-5196 / E-ISSN: 1927-520X/13

(Mg), sulphur (S), sodium (Na), potassium (K), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), cobalt (Co), selenium (Se) and molybdenum (Mo), using Inductively Coupled Plasma-Optical Emission Spectrometer (Perkin-Elmer, OPTIMA-3300 RL) [7]. The data were analyzed statistically as per Snedecor and Cochran [8].

RESULTS AND DISCUSSION

Crop residues were found to be the main source of roughage in the ration of animals. It was noticed that some of the farmers fed cultivated fodders like lucerne (*Medicago sativa*), maize (*Zea mays*), jowar green (*Sorghum bicolor*), chicory leaves (*Cichorium intybus*) etc. Some farmers offered crushed maize, crushed wheat alone or mixture of two. Feeding of groundnut cake, cottonseed cake and maize cake was also observed in some parts of district. Those farmers, who don't feed concentrate feed ingredients, were fed compound cattle feed to their buffaloes, depending on the level of milk production. The use of common salt and mineral mixture supplementation was not a common practice in the surveyed area, except for therapeutic purpose.

Table 1: Levels of Macro Minerals in Feed and Fodder in Sabarkantha District of Gujarat

Particulars	Ca	P	Mg	S	K	Na
Critical level	**<0.30%**	**<0.25%**	**<0.20%**	**<0.20%**	**<0.9%**	**<0.06%**
	(%)					
Wheat straw (58)	0.45±0.01	0.06±0.00	0.21±0.01	0.16±0.01	1.41±0.04	0.25±0.04
Jowar straw (38)	0.57±0.02	0.19±0.01	0.49±0.02	0.14±0.01	1.11±0.08	0.07±0.01
Paddy straw (6)	0.45±0.01	0.09±0.01	0.34±0.01	0.15±0.01	1.56±0.04	0.40±0.04
Bajra straw (7)	0.45±0.01	0.16±0.02	0.75±0.12	0.17±0.02	2.23±1.35	0.23±0.12
Groundnut straw (10)	1.30±0.09	0.18±0.01	0.78±0.04	0.17±0.01	1.06±0.10	0.05±0.01
Saunf straw (3)	1.17±0.32	0.20±0.03	0.21±0.03	0.23±0.06	1.07±0.43	1.03±0.21
Maize straw (12)	0.50±0.07	0.18±0.02	0.44±0.10	0.13±0.02	1.19±0.12	0.04±0.01
Maize green (8)	0.60±0.11	0.24±0.04	0.59±0.16	0.19±0.02	2.11±0.64	0.06±0.01
Bajri green (20)	0.71±0.03	0.29±0.01	0.72±0.04	0.25±0.01	2.36±0.25	0.15±0.04
Sorghum Sudan grass (2)	0.70±0.04	0.32±0.01	0.40±0.06	0.27±0.02	4.30±0.02	0.04±0.01
Local grass (16)	1.11±0.18	0.25±0.02	0.59±0.06	0.31±0.02	2.06±0.30	0.78±0.26
Lucerne green (24)	1.67±0.10	0.31±0.10	0.43±0.03	0.39±0.02	1.42±0.20	0.34±0.04
Cottonseed cake (25)	0.17±0.01	0.67±0.01	0.39±0.01	0.29±0.01	1.34±0.03	0.04±0.01
Crushed maize (29)	0.03±0.01	0.32±0.01	0.13±0.01	0.12±0.01	0.40±0.01	0.03±0.01
Crushed wheat (19)	0.07±0.01	0.32±0.01	0.14±0.01	0.16±0.01	0.44±0.01	0.03±0.01
Cattle feed (50)	0.79±0.11	1.12±0.04	0.66±0.02	0.37±0.03	1.10±0.03	0.47±0.06
Isabgol husk (2)	0.21±0.01	0.44±0.01	0.14±0.02	0.24±0.01	0.53±0.05	0.01±0.01
Chikori green (7)	1.62±0.12	0.27±0.04	0.52±0.03	0.48±0.03	1.58±0.74	1.13±0.10
Crushed maize & wheat mixture (5)	0.19±0.01	0.25±0.02	0.12±0.01	0.11±0.01	0.34±0.02	0.02±0.01
Whole cottonseed (2)	0.19±0.01	0.54±0.10	0.34±0.04	0.27±0.05	1.13±0.13	0.04±0.01
Hybrid- napier (2)	0.50±0.05	0.15±0.02	0.24±0.01	0.18±0.02	2.79±0.19	0.08±0.01
Jowar green (27)	0.58±0.05	0.23±0.01	0.50±0.05	0.16±0.01	1.27±0.10	0.06±0.01
Neem leaves (2)	1.00±0.21	0.18±0.01	0.26±0.04	0.39±0.03	2.70±0.69	0.07±0.03
Maize cake (10)	0.22±0.03	0.52±0.13	0.28±0.07	0.23±0.01	0.51±0.08	1.15±0.40
Maize gluten (2)	0.11±0.01	0.26±0.03	0.15±0.04	0.14±0.01	0.30±0.03	1.24±0.05
Maize bran (2)	0.05±0.02	0.09±0.03	0.05±0.02	0.21±0.01	0.17±0.02	0.06±0.03
Moong straw (2)	3.05±0.21	0.23±0.03	1.04±0.04	0.19±0.01	1.04±0.03	0.04±0.01

Figures in the parentheses indicate no. of samples analysed.

Macro-Minerals Profile of Feeds and Fodders

The straws of wheat, jowar, paddy and groundnut were the main roughage source in the surveyed area (Table **1**). The average Ca content ranged from 0.45 to 1.30 percent in roughages, as compared to 0.03 to 0.22 percent in concentrate feed ingredients. These findings are similar to the findings of Ramana *et al.* [9] and Yadav *et al.* [10]. P content in concentrates (0.25 to 0.67 %) was higher than roughages (0.06 to 0.20 %). Crushed grains were low in Mg as compared to cakes (Table **1**). Sulphur content was found below critical level (<0.20%) in most of the straws and crushed grains (Table **1**). Higher K level in green fodders (Table **1**) may be due to its selective uptake from the soil and regular application of potash fertilizer in the soil [2]. Na content was low in some of the feed stuffs (Table **1**).

Micro-Minerals Profile of Feeds and Fodders

Copper (Cu) content was found below the critical level (<8ppm) in all types of straws and concentrate ingredients except cottonseed cake and isabgol husk (Table **2**). Zinc (Zn) content was below critical level (<30ppm) in all the straws except paddy straw. Green fodders and oilcakes were found to be a better source

Table 2: Levels of Micro Minerals in Feed and Fodder in Sabarkantha District of Gujarat

Particulars	Cu	Zn	Mn	Fe	Co	Mo	Se
Critical level	**<8ppm**	**<30ppm**	**<40ppm**	**<50ppm**	**<0.10ppm**	**>6ppm**	**<0.2ppm**
Wheat straw (58)	5.23±0.03	19.71±1.18	47.88±1.44	630.24±35.02	0.30±0.01	0.82±0.03	0.62±0.03
Jowar straw (38)	7.02±0.38	28.31±2.31	55.83±4.36	581.71±30.74	0.34±0.01	0.84±0.06	0.63±0.06
Paddy straw (6)	5.08±0.24	34.21±0.58	478.12±54.00	482.26±49.67	0.71±0.09	0.87±0.11	0.64±0.07
Bajra straw (7)	5.63±0.33	17.91±3.33	36.47±3.14	709.21±93.23	0.25±0.04	0.70±0.08	1.07±0.05
Groundnut straw (10)	5.40±0.78	23.36±3.46	44.64±3.73	1123.61±93.17	0.46±0.04	0.72±0.05	0.54±0.05
Saunf straw (3)	5.74±0.09	14.74±5.10	42.27±6.01	353.84±53.15	0.25±0.02	0.36±0.06	1.10±0.20
Maize straw (12)	7.38±0.80	24.17±2.76	58.34±13.46	513.84±66.49	0.34±0.08	0.81±0.08	0.71±0.10
Maize green (8)	8.07±0.88	51.05±4.42	62.64±11.28	975.59±54.16	0.48±0.10	1.05±0.18	0.95±0.10
Bajri green (20)	11.85±0.69	49.07±3.22	65.58±3.13	741.33±43.91	0.42±0.01	1.72±0.39	1.05±0.12
Sorghum Sudan grass (2)	11.96±0.07	49.75±0.90	48.67±2.24	694.65±55.75	0.28±0.02	0.80±0.10	0.52±0.10
Local grass (16)	13.66±1.34	41.79±2.78	62.28±7.15	1118±197.03	0.59±0.08	0.79±0.10	0.76±0.10
Lucerne green (24)	13.30±0.94	35.96±3.20	41.82±1.54	571.46±38.69	0.38±0.03	2.10±0.47	1.02±0.13
Cottonseed cake (25)	8.98±0.15	40.97±0.72	15.32±0.25	135.80±10.54	0.37±0.01	0.83±0.07	0.68±0.05
Crushed maize (29)	4.50±0.05	24.18±1.38	13.18±2.34	106.90±17.06	0.21±0.01	1.63±0.07	0.41±0.05
Crushed wheat (19)	5.50±0.09	26.66±0.72	37.34±1.38	187.34±18.46	0.20±0.01	1.63±0.11	0.48±0.05
Cattle feed (50)	10.48±0.94	79.09±3.44	100.4±4.05	613.67±27.09	0.56±0.10	1.83±0.06	0.60±0.04
Isabgol husk (2)	8.44±0.56	30.48±0.93	17.36±1.04	189.95±1.06	0.26±0.01	4.69±0.32	0.54±0.04
Chikori green (7)	20.30±1.23	58.11±7.19	67.07±8.31	1418.54±193.7	0.66±0.06	0.97±0.15	1.83±0.29
Crushed maize & wheat mixture (5)	4.02±0.14	22.51±1.36	41.74±0.86	1043.50±2.21	0.26±0.01	0.45±0.05	0.24±0.02
Whole cottonseed (2)	6.47±2.17	35.09±4.62	15.57±0.35	140.20±72.21	0.23±0.04	0.69±0.33	0.44±0.25
Hybrid napier (2)	10.08±0.20	32.39±1.05	132.99±2.81	629.79±8.91	0.35±0.03	0.68±0.03	0.67±0.03
Jowar green (27)	13.11±0.74	63.36±4.98	53.86±4.60	994.57±79.92	0.43±0.03	1.69±0.34	0.75±0.07
Neem leaves (2)	8.46±0.34	43.13±12.59	29.64±3.04	780.15±7.06	0.30±0.12	2.84±2.45	0.70±0.002
Maize cake (10)	6.47±0.46	43.43±5.44	46.02±11.27	575.27±46.34	0.48±0.01	1.07±0.23	0.61±0.11
Maize gluten (2)	5.90±0.67	21.41±3.21	75.74±10.89	876.85±56.78	0.54±0.08	0.97±0.28	0.35±0.15
Maize bran (2)	6.60±0.68	23.93±2.65	9.86±8.65	378.62±34.56	0.18±0.05	1.84±0.23	0.21±0.11
Moong straw (2)	7.71±0.01	27.89±4.15	57.68±8.67	675.62±7.80	0.35±0.01	0.89±0.02	0.39±0.02

Figures in the parentheses indicate no. of samples analysed.

Table 3: Mineral Content in Hair Samples of Buffaloes

Particular	Ca (%)	P (%)	Mg (%)	Cu (ppm)	Zn (ppm)	Mn (ppm)	Se (ppm)
Hair samples (n=15)	0.32±0.029	0.02±0.005	0.18±0.013	6.28±1.65	73.51±4.00	88.27±9.35	2.82±0.24

of Zn, as compared to crushed grains. The Mn levels in the district ranged from 36.47-478.12 ppm in straws, 62.64-132.99 ppm in green fodders, 13.18-75.74 ppm in concentrate ingredients (Table **2**). Average Fe content was 769.43 ppm in roughage and 403.22 ppm in concentrates, showing adequacy of this mineral. Yadav *et al.* [10], Youssef *et al*. [11] and Mandal *et al*. [12] reported high Fe levels in forages. Cobalt in feeds and fodders ranged from 0.18 ppm to 0.71 ppm. Selenium content was adequate in all the feeds and fodder (Table **2**). High levels of molybdenum (>2 ppm) in forages could interfere with copper metabolism. The molybdenum levels as estimated in the samples of crop residues were within the safe limit. Most of the feedstuffs contained Mo level within the safe limit and gave Cu:Mo ratio wider than 5.0. Mo has gained more importance recently in animal nutrition, because of its inhibitory role on the other trace elements, particularly copper. Suttle [13] stated that a Cu:Mo ratio below 2.0 would be expected to cause conditioned Cu deficiency in cattle. Mo level at 5 to 6 ppm inhibits Cu storage and produce signs of molybdenosis [14]. Even 2 ppm or less Mo can be toxic, if forage Cu is sufficiently low [12]. In case of ruminants, Mo reacts with sulphur in the rumen and forms mono-, di-, tri- or tetra-thiomolybdates [13], making Cu unavailable for absorption and utilization [15].

Mineral Levels in Hair Samples of Lactating Buffaloes

Hair samples collected during survey were analyzed for the same minerals as in feeds and fodders. Mineral levels in hair must reflect the concentration and (or) activity of the certain minerals in other parts of the body and reflect dietary mineral status of animals [16] (Combs, 1987). The average levels of copper and zinc in hair were 6.28 and 73.51 ppm, respectively (Table **3**). When compared with critical levels for Cu (<10 ppm) and Zn (<100 ppm), 50 and 100 per cent animals showed sub-normal levels in hair samples indicating their dietary deficiency. It has been demonstrated in several studies that concentration of Zn in hair is correlated with dietary Zn intake. Studies have shown the level of Zn in hair on normal diet to be 120-150 ppm [1]. The selenium level of the hair of cattle is a useful indicator of both selenium deficiency and selenium toxicity. Most studies have shown that cattle with hair values consistently below 0.25 ppm probably need supplementation and that over 5 ppm may lead to clinical signs of selenosis. The average selenium level in hair samples was 2.82 ppm indicating the adequacy of the element in the ration.

Daily Mineral Intake by Lactating Buffaloes

The daily intake of different minerals by a buffalo (450 kg body weight) yielding 10 kg milk (6% fat), with the prevailing feeding system in the surveyed area is presented in Table **4**. Since mineral mixture supplementation was not being followed so the intake of minerals through feeds and fodder was taken as index of total mineral supply and compared with the recommended requirements to know the dietary mineral adequacy/inadequacy. Ration of lactating buffaloes was found to be deficient in Ca, P, S, Cu, Zn and Co. Hence, it is necessary to supplement these minerals in ration. It was observed that Mg, K, Na, Mn, Fe, Mo and Se in ration of animals were found to adequate. Supplementation of Cu and Zn in the form of chelates found to be effective in curing problem of anestrous [17] and deficient trace minerals in the

Table 4: Macro and Micro-Minerals Availability vis-à-vis Requirement for a Buffalo (450 kg Body Weight) Yielding 10 kg Milk (6% Fat) Per Day

Attributes	DMI (kg/d)	Ca (g)	P (g)	S (g)	Cu (mg)	Zn (mg)	Co (mg)
Mineral requirement	11.50	64.5	42.80	23	115	920	5.75
Daily mineral availability from traditional feeding	11.50	50.65	29.15	21.35	75.07	333.63	3.56
% deficiency		21.47	31.89	7.17	34.72	63.73	38.08

surveyed area need to be supplemented in chelated form for better bio-availability and retention in the animal system.

Nutritional Status of Lactating Buffaloes

In order of priority, available good quality feed resources are first allocated to lactating buffaloes followed by dry pregnant, dry, heifers, growing calves and non-productive buffaloes. In the surveyed area our observation indicates that, unlike metabolizable energy and crude protein, which were excess in the ration of more than 70 percent of the buffaloes, calcium and phosphorus were deficient in the ration of about 65% of buffaloes because of low mineral mixture supplementation, probably due to high costs. Dairy farmers in most developing countries often do not feed adequate quantities of mineral mixture to their animals due to non-availability, lack of knowledge on the benefits of feeding mineral mixtures or high cost [18]. In view of this, supplementation of mineral mixture in the ration of dairy animals for improving production and reproduction efficiency need to be popularized.

Formulation of Area Specific Mineral Mixture

Information on the actual intake of each type of feeds and fodder for a particular level of milk production was collected from each of the individual dairy farmer, to calculate intake of various mineral elements against the requirement. Total mineral intake from feeds and fodder was compared against the requirements on dry matter basis (Table **5**), to identify quantitative deficiency and adequacy of minerals. Based on the degree of deficiency, area specific mineral mixture formulation was developed for the supplementing buffaloes in the Sabarkantha district of Gujarat (Table **6**). To enhance the usefulness of mineral mixture, chromium was also incorporated in the formulation.

Table 5: Mineral Requirements for Lactating Buffaloes

Particular	Buffaloes	
	Calcium	Phosphorus
Maintenance (g)	18	13
Milk yield (g/kg MY)	4.65	2.98

Mg and S: 0.20 % of DM Intake, Copper: 10 ppm, Manganese: 40 ppm, Na: 0.18 % of DM Intake, Iron: 50 ppm, Cobalt: 0.50 ppm, K: 0.90 % of DM Intake, Zinc: 80 ppm, Selenium: 0.30 ppm, Cl: 0.25 % of DM intake, Iodine: 0.60 ppm, Chromium: 0.50 ppm.

Table 6: Specifications for Area Specific Mineral Mixture for Sabarkantha District

S. No.	Characteristic	Requirement
1.	Moisture (%), Max.	5.0
2.	Calcium (%), Min.	22.0
3.	Phosphorus (%), Min.	14.0
4.	Sulphur (%), Min.	1.90
	Sulphur (%), Max.	2.75
5.	Copper (%), Min.	0.15
6.	Zinc (%), Min.	1.40
7.	Manganese (%), Min.	0.14
8.	Cobalt (%), Min.	0.013
9.	Iodine (%), Min.	0.026
10.	Chromium (%), Min.	0.004
11.	Fluorine (%), Max.	0.09
12.	Acid insoluble ash (%), Max.	3.00
13.	Lead (ppm), Max.	35
14.	Arsenic (ppm), Max.	10

Note: The values for requirements (2) to (14) are on moisture-free basis.

CONCLUSION

It was evident from the present study that majority of lactating buffaloes in Sabarkantha district were deficient in Ca, P, S, Cu, Zn and Co. Therefore, it is necessary to supplement these minerals in the ration of buffaloes by formulating area specific mineral mixture, having highly bio-available mineral salts. Deficient trace minerals, except Co, may be supplemented in the form of chelates, for better bio-availability and improving productivity, reproductive efficiency and productive life of buffaloes.

ACKNOWLEDGEMENT

Financial assistance and necessary facilities provided by the management of National Dairy Development Board, Anand, for undertaking this study are gratefully acknowledged.

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Received on 04-01-2013 Accepted on 10-02-2013 Published on 22-03-2013

DOI: http://dx.doi.org/10.6000/1927-520X.2013.02.01.3