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Assessment of Macro and Micro Minerals Status of Milch Animals for Developing Area Specific Mineral Mixture for Bharatpur District of Rajasthan

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ABSTRACT

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A study was conducted in Bharatpur district (tropical zone) of Rajasthan, to assess the prevalence of macro and micro-minerals deficiency in animals, by analyzing feed and fodder samples (n=240) at random from various locations. The calcium content (0.14%) was low in concentrate ingredients, except mustard cake (0.74%). Phosphorus content (0.45%) in concentrates was higher in comparison to roughages. The average calcium content in straws (0.34%) was higher in comparison to phosphorus (0.10%). The calcium and phosphorus content in green berseem were 1.33 and 0.31 per cent, respectively. The magnesium content in feedstuffs was adequate (0.38%) to meet the requirement of large ruminants (0.20%). The feed ingredients of the surveyed area were rich in potassium content (1.55%), whereas, sodium content was consistently low in dry roughages (0.14%) and concentrate ingredients (0.064%). The sulphur content was low in crop residues (0.13%), whereas, concentrate feed ingredients (0.18%) were better source of sulphur. Cobalt was occasionally deficient in the diet of animals. However, iron and manganese contents were adequate in the diet of animals, with traditional feeding system. The average copper content was low in straws (5.40 ppm), moderate in green fodders (9.68 ppm) and concentrate ingredients (9.87 ppm). Molybdenum content in feeds was within safe limit (average level <1.25 ppm). Selenium content in most of the feeds and fodder samples was adequate (0.61 ppm) and its supplementation in the diet was not necessary. Zinc was acutely deficient in most of the feedstuffs (average level <26.30 ppm) and needed to be supplemented in the ration of animals for proper productive and reproductive functions. It was apparent from the present study that the feeds and fodders available in tropical zone of Rajasthan may not meet the requirements for calcium, phosphorus, sodium, sulphur, zinc, copper and cobalt in order to sustain a milk production of ~8 kg/day. Hence, it is necessary to supplement these minerals in the ration by formulating area specific mineral mixture.

Keywords: Calcium, Phosphorus, Copper, Zinc, Selenium, Buffalo, Tropical zone, Rajasthan.

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INTRODUCTION

It is well known that the normal productive and reproductive functions in livestock are closely associated with nutritional status of animals. Minerals, particularly some macro and trace elements play very crucial role in these functions. Large animal populations in the world, particularly in the tropics suffer from mineral imbalances or deficiencies (McDowell *et al.*, 1993) and deficiency of essential minerals may result in failure of the homeostasis mechanism, affecting the productive and reproductive performances of animals (Garg *et al.*, 2005). Mineral supplementation dramatically improves the condition of dairy animals suffering from mineral deficiency (McDowell, 1992). In India, livestock are mainly maintained on grazing with little or no supplementation of mineral mixture, except common salt (Garg *et al.*, 2004). As locally available feeds and fodder are varying in mineral content and mineral deficiency is an area specific problem, it is useful to know the mineral status of locally available feedstuffs. Therefore, the present study was undertaken to know the mineral status of feeds and fodders and their availability to animals, so as to suggest area specific mineral mixture for tropical zone of Rajasthan.

MATERIALS AND METHODS

Sampling procedure

At random, one village from each taluka of Bharatpur district was selected for taking representative samples of feeds and fodder. Total area of Bharatpur district is 5,066 sq.km., distributed into 10 talukas, having 1454 villages. The district is having annual rainfall of 75 cm, having latitude of 27°51' and longitude of 77°44'. Atmospheric temperature ranges from 6 to 45°C during different seasons. Within the village, help was sought from village milk producers and Bharatpur 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 villages.

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 animals was collected from individual farmer, using standard sampling procedure. Total intake was 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) was taken as a base for calculation of mineral requirements of buffaloes. The data were analyzed statistically as per Snedecor and Cochran (1967).

Sample preparation and analytical methods

Composite samples of green fodder, dry fodder, individual concentrate ingredients and the compound cattle feed (concentrate mixture) were collected from all over the surveyed area. Green samples were dried in oven at 80ºC 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 Ca, P, Mg, Na, K, S, Cu, Zn, Mn, Fe, Co, Mo and Se using Inductively Coupled Plasma-Optical Emission Spectroscopy (Perkin-Elmer, OPTIMA - 3300 RL).

RESULTS AND DISCUSSION

Feeding and management

The feeding practices for animals followed in Bharatpur district revealed that common dry roughages fed to the animals were straws of sorghum followed by wheat (*Triticum aestivum*) and *bajra*. Small quantity of leguminous pods of *gram*, *guar (Cyamopsis tetragonoloba)*, *moong* and *urd (Phasleolus mungo)* was also fed to animals with basal dry roughages, but availability was seasonal. This practice was found to be common for all categories of farmers. However, the medium farmers were supplementing the ration of animals with single unit concentrate ingredient in the form of crushed wheat or *bajra* (*Pennisetum spp.*) or sorghum or mustard cake. Supplementation with home grown multiple unit concentrate mixture [crushed wheat, *bajra*, sorghum, barley (*Hordeum vulgare*), *dhaincha*, mustard cake, *guar chuni* or *gram chuni*] was found to be practiced only by large farmers. Those farmers who do not feed multiple unit concentrate ingredients, were feeding compound cattle feed manufactured by Bharatpur Cattle Feed Plant, a unit of Rajasthan Cooperative Dairy Federation Ltd., Jaipur, depending upon the level of milk production. Only few farmers were fed berseem or sorghum green to their milch animals. Some farmers were feeding creepers of *guard* (*Lagenaria siceraria)* and pumpkin *(Cucurbita pepo)* and leaves of radish *(Raphanus sativus)*, spinach (*Spinacia oleracea)* etc. Those farmers, who do not have irrigation facility, were feeding local grasses (mixtures of different leguminous and non-leguminous variety) either in green or dry form available from the field or wasteland, to their animals. Interestingly, it was observed that some of the farmers feeding crushed mustard seeds (ca 100g) in the ration of milch animals, but little or no mineral supplements.

Macro and micro minerals profile of feeds and fodder

The profile of various macro and micro minerals in the feeds and fodder is presented in Tables 1 and 2, respectively. The average calcium content in straws (0.34%) was higher, but the straws were low in phosphorus (0.10%). The concentrate ingredients commonly fed to animal contained low calcium (0.14%), except mustard cake (0.74%) but were high in phosphorus level (0.45%). Berseem being of leguminous family, contained higher calcium, to the extent of 1.33 per cent (Table 1). Leaves of radish and spinach and creepers of guard and pumpkin were rich sources of calcium, but Ca availability to animals from such sources needs to be investigated.

Table 1. Macro mineral content in feedstuffs collected from Bharatpur district (DM basis)

Feedstuff	Ca(%)	P(%)	Mg(%)	Na(%)	K(%)	S(%)
Critical level†	<0.30	<0.25	<0.20	<0.06	<0.80	<0.20
Dry and green roughages						
Bajra straw (23)	0.40±0.025	0.12±0.01	0.54±0.03	0.05±0.007	2.21±0.15	0.14±0.004
Sorghum straw (31)	0.30±0.016	0.14±0.008	0.35±0.022	0.046±0.003	1.21±0.078	0.10±0.005
Wheat straw (29)	0.33±0.019	0.057±0.005	0.18±0.017	0.25±0.044	1.72±0.099	0.18±0.012
Gram pods (1)	1.11	0.10	0.33	0.11	1.40	0.13
Guar pods (1)	1.13	0.13	0.59	0.31	1.97	0.10
Moong pods (1)	1.20	0.14	0.67	0.031	1.37	0.14
Urd pods (1)	1.08	0.085	0.58	0.18	2.17	0.37
Local grasses (1)	0.63	0.068	0.24	0.15	0.80	0.38
Guard creepers (1)	1.35	0.43	0.61	0.09	3.54	0.31
Pumpkin creepers (1)	2.17	0.57	0.97	0.27	3.04	0.37
Radish leaves (1)	2.52	0.28	0.50	0.48	2.38	1.17
Spinach leaves (1)	1.20	0.30	0.79	0.20	2.05	0.51
Berseem green (1)	1.33	0.31	0.43	0.54	3.51	0.32
Sorghum green (1)	0.75	0.16	0.41	0.14	1.22	0.16
Concentrate feed ingredients						
Bajra grain (28)	0.028±0.002	0.32±0.008	0.12±0.002	0.018±0.002	0.44±0.008	0.14±0.003
Barley grain (7)	0.052±0.004	0.29±0.015	0.12±0.005	0.077±0.019	0.56±0.014	0.14±0.009
Sorghum grain (18)	0.05±0.009	0.42±0.008	0.18±0.006	0.018±0.004	0.43±0.009	0.14±0.005
Wheat grain (37)	0.046±0.001	0.31±0.007	0.13±0.002	0.022±0.001	0.44±0.015	0.16±0.003
Dhaincha grain (3)	0.20±0.036	0.59±0.065	0.14±0.019	0.027±0.005	1.01±0.057	0.19±0.007
Guar grain (3)	0.24±0.029	0.41±0.011	0.21±0.006	0.018±0.002	1.10±0.02	0.24±0.003
Methi grain (4)	0.17±0.014	0.46±0.046	0.16±0.006	0.14±0.03	1.09±0.055	0.27±0.016
Gram *chuni* (5)	0.36±0.10	0.22±0.062	0.29±0.085	0.21±0.16	0.80±0.11	0.15±0.026
Mustard cake (36)	0.74±0.006	1.01±0.013	0.39±0.004	0.05±0.009	1.21±0.011	0.33±0.028
Cattle feed (5)	0.94±0.073	1.18±0.046	0.58±0.025	0.64±0.049	1.24±0.018	0.27±0.03

Figures in parentheses indicate no. of samples analyzed. †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).

The magnesium level as estimated in the samples of crop residues was adequate (Table 1). Amongst the green fodders, berseem green (0.43%) had the highest Mg content, followed by sorghum green (0.41%), showing that considerable quantities of Mg were available from the livestock requirement point of view. Mustard cake (0.39%) and gram *chuni* (0.29%) were good sources of Mg (Table 1). 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 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 (Michal, 1999; Garg *et al.*, 2003a).

The sodium content was low in straws of *bajra* and sorghum, whereas, wheat straw and pods of leguminous crops contained high Na (Table 1). Compound cattle feed had an appropriate quantity of sodium to the extent of 0.64 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 regular application of potash fertilizer in the soil. High K was found in all green and dry forages. Similar findings were also reported by Singh *et al.* (2002). Potassium content in straws and stovers was higher than that of the concentrate feed ingredients (Table 1) and K 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. The levels of sodium, potassium, sulphur and chlorine in the diet play an important role in the dietary cation-anion difference (DCAD), which is responsible for incidence of clinical milk fever at the time of calving (McNeill *et al.*, 2002).

The sulphur content was low in most of the crop residues (0.13%), the reason being its transfer to seed proteins. The concentrate ingredients fed to livestock in this area contained 0.18 per cent S, however, berseem and green sorghum had around 0.24 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 cobalt levels in this zone ranged from 0.18 to 0.27 ppm in straws, 0.87 to 1.41 ppm in green fodders and 0.16 to 1.03 ppm in grains. Mustard cake and *gram chuni* contained 0.16 and 0.45 ppm Co, respectively (Table 2). *Sarasdan,* compound cattle feed contained 1.76 ppm Co. The Co content of *guar* and *methi* seeds revolved around 0.37 ppm.

Copper quantity was recorded consistently low in almost all the collected feeds and fodder. Straws of *bajra*, sorghum and wheat contained very low level of copper (5.40 ppm). Only berseem fodder contained 11.90 ppm Cu. Sorghum green (7.15 ppm) was moderate in copper content. Creepers of *guard* and pumpkin were good source of copper (12.60 ppm). Pods of leguminous crops contained around 6.70 ppm Cu (Table 2). Among the grains, *dhaincha* (15.90 ppm) had highest Cu content, followed by barley (9.31 ppm), wheat (6.81 ppm), sorghum (6.80 ppm) and *bajra* (5.98 ppm). *Sarasdan,*

Table 2. Trace-mineral content in feedstuffs collected from Bharatpur district (DM basis)

Feedstuff Critical level†	Co(ppm) <0.10	Cu(ppm) <8.0	Fe(ppm) <50.0	Mn(ppm) <40.0	Mo(ppm) >6.0	Se(ppm) <0.20	Zn(ppm) <30.0	Cu:Mo ...
Dry and green roughages								
Bajra straw (23)	0.27±0.037	5.78±0.35	547.59±56.81	49.56±3.90	0.33±0.10	0.36±0.12	14.15±1.03	17.51
Sorghum straw (31)	0.27±0.035	6.20±0.29	721.24±86.25	49.36±3.14	0.15±0.055	0.15±0.048	20.09±1.35	41.33
Wheat straw (29)	0.18±0.02	4.24±0.28	422.88±35.35	41.81±2.55	0.29±0.12	0.12±0.02	9.28±0.45	14.62
Gram pods (1)	0.26	3.75	483.0	61.60	0.75	0.32	9.60	11.71
Guar pods (1)	0.26	8.13	276.0	42.30	0.51	0.36	13.10	15.94
Moong pods (1)	0.21	6.77	499.0	52.20	1.14	0.36	11.90	5.93
Urd pods (1)	0.12	8.16	328.0	31.40	4.27	3.12	13.60	19.11
Local grasses (1)	0.32	4.46	996.0	90.10	0.0	2.15	17.70	...
Guard creepers (1)	0.55	12.70	1440.0	50.60	0.54	0.39	38.50	27.51
Pumpkin creepers (1)	0.46	12.50	1280.0	44.9	1.42	0.47	46.30	8.80
Radish leaves (1)	0.36	5.12	862.5	52.0	0.31	0.0	20.45	16.51
Spinach leaves (1)	0.47	8.72	1230.0	79.75	0.13	0.0	28.75	67.07
Berseem green (1)	1.41	11.90	850.0	91.40	3.17	0.33	27.60	3.75
Sorghum green (1)	0.87	7.15	780.0	65.60	0.099	0.21	23.30	72.22
Concentrate feed ingredients								
Bajra grain (28)	0.16±0.022	5.98±0.18	99.88±5.31	13.91±0.66	0.054±0.027	0.81±0.13	30.02±1.17	110.74
Barley grain (7)	0.20±0.044	9.31±0.65	141.82±21.54	20.15±1.47	0.089±0.066	1.97±0.48	27.34±2.51	104.60
Sorghum grain (18)	0.20±0.035	6.80±0.45	122.11±14.45	16.84±0.89	0.12±0.055	0.62±0.24	37.35±1.36	56.66
Wheat grain (37)	0.11±0.034	6.81±0.24	81.24±4.64	36.34±0.98	0.057±0.039	1.005±0.15	25.09±0.82	119.47
Dhaincha grain (3)	1.03±0.22	15.60±0.90	259.0±71.65	26.76±0.34	7.18±0.65	0.08±0.013	41.30±3.89	2.17
Guar grain (3)	0.41±0.056	12.50±0.89	422.0±33.61	17.73±0.48	4.53±1.03	0.44±0.30	42.66±2.03	2.75
Methi grain (4)	0.33±0.074	11.77±1.18	101.06±10.40	18.56±1.27	1.32±0.69	0.056±0.04	30.21±2.19	8.91
Gram chuni (5)	0.45±0.14	7.95±1.02	546.72±134.2	88.38±21.89	0.76±0.24	0.42±0.15	22.62±3.79	10.46
Mustard cake (36)	0.16±0.036	12.11±0.31	377.28±38.4	67.38±1.35	0.43±0.05	0.47±0.12	54.41±1.03	25.76
Cattle feed (5)	1.76±0.31	25.72±2.09	880.40±52.33	117.18±7.54	1.62±0.23	0.81±0.56	123.68±12.70	15.87

Figures in parentheses indicate no. of samples analyzed. †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).

compound cattle feed contained 25.72 ppm Cu. Copper contents below the critical of 8 ppm (Cuesta *et al.*, 1993) were found in most of the feeds and fodder (Table 2), hence its supplementation in the ration of animals is very essential.

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 (484 ppm). Berseem and green sorghum showed an average of 815 ppm Fe. Iron deficiency seldom occurs in adult animals, due to generally adequate iron concentrations in forages together with contamination of plants by Fe-rich soil (McDowell and Arthington, 2005). Grains had around 140 ppm Fe, while mustard cake (377.28 ppm and gram *chuni* (546.72 ppm) rich in Fe. *Sarasdan,* compound cattle feed contained 880 ppm Fe (Table 2). Thus, Fe seems to be quite rich in this district, as also reported from other parts of the country (Yadav *et al.*, 2002; Garg *et al.*, 2005). The Fe concentration in the majority of feed ingredients was very high and could probably interfere with the copper absorption (Bremmer *et al.*, 1987; Youssef *et al.*, 1999), which needs to be investigated.

Most of the straws offered to animals contained around 47 ppm Mn. However, higher Mn level was found in berseem (91.40 ppm) and green sorghum (65.60 ppm). Amongst the concentrate ingredients, proteinous feeds contained higher Mn than grains.

The molybdenum level as estimated in the samples of crop residues was within the safe limit (Table 2). When high Mo containing feeds were included in the ration of animals, the Cu supplementation must be regular and more frequent (Underwood and Suttle, 1999). The most of the feedstuffs contained Mo level within the safe limit and gave Cu:Mo ratio wider than 7.0. 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).

The selenium content of the crop residues varied from 0.12 to 3.12 ppm (Table 2). However, Se level was recorded 0.33 and 0.21 ppm, in green berseem and sorghum, respectively. Grains had around 0.59 ppm Se, whereas, cottonseed cake (1.21 ppm) was an exception with high Se content (Table 2). Guar and methi seeds contained around 1.10 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 ranged 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 would satisfy requirement of Se. Therefore, its supplementation in the ration is not advocated.

Zinc is one element, which is found to be acutely deficient in many geographical zones of India (Ramana *et al.*, 2003; Garg *et al.*, 2005; 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 (17.80 ppm). The zinc content of the green fodders varied from 20.45 to 38.50 ppm (Table 2). Grains of *bajra,* barley, wheat, sorghum and *dhaincha* had around 30.70 ppm Zn, while mustard cake was an exception with higher Zn content (54.41 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.

Requirement status of macro and micro minerals for large ruminants

A buffalo yielding 8 kg milk per day, if taken as a standard for the area of the study, it 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 40.77 g Ca, showing deficiency. Under such conditions, milk production is likely to be affected and freshly calved animals may suffer from milk fever (McDowell *et al.*, 1993). When compound cattle feed incorporated with proper quality and quantity of mineral mixture was available, deficiency of Ca may not be severe. The estimated value of phosphorus from feedstuffs was 28.89 g against the requirement of 36.84 g per day for a milch buffalo yielding 8 kg milk, showing a deficiency of 7.95 g per day (Table 3). Furthermore, bioavailabilty of P from plant sources has been reported to be low due to phytic acid-P (McDowell, 1992; Garg *et al.* 2005; McDowell and Arthington, 2005), leading to problems of pica, infertility and haemoglobinuria in animals.

The Mg requirement of a milch buffalo yielding 8 kg milk per day was 23.0 g (Table 3), whereas, feeds and fodders fed in that area provided 36.55 g of Mg per day. Unlike K, the availability of Na from feed sources was only 12.19 g against the requirement of 20.70 g per day, showing a deficiency of 8.51 g per day (Table 3). However, Na was found to be adequate in the diet of animals, when compounded cattle feed was fed.

The availability of S from feed sources was 19.45 g and the requirement was 23.0 g per day, showing a marginal deficiency, for a milch buffalo yielding 8 kg milk per day. Sulphur supplementation was necessary in the ration of animals due to high level of selenium in various feedstuffs and bioavailabilty of S from feed resources is scanty (McDowell, 1992; Garg *et al.*, 2003a). Similarly, the buffalo yielding 8 kg milk daily, would need 5.75 mg cobalt per day, as per the standard requirements, whereas, feeds and fodders available in the area when fed, provide only 2.45 mg Co, showing a deficiency of cobalt (Table 3).

Copper status from traditional feeds and fodders fed to a buffalo with this level of milk production, was 72.75 mg against the requirement of 115 mg per day (Table 3). Clinical and sub clinical syndromes are likely to occur in livestock due to its deficiency. Sub clinically, the problems of poor growth rate, coarse hair coat, anemia and infertility may be encountered in cows and buffaloes and neonatal ataxia (sway back) in lamb.

Table 3. Comparative tabulation of mineral availability from a typical ration vis-à-vis requirement[†] for 8.0 kg milk production[‡]

Attribute	Expected daily DM intake (kg)	Ca	P	Mg	Na	K	S	Co	Cu	Fe	Mn	Zn	Se
		g						mg					
Daily requirement													
Maintenance	11.50	18.00	13.00	—	—	—	—	—	—	—	—	—	—
Milk production	—	37.20	23.84	23.00	20.7	103.5	23.00	5.75	115	575	460	920	3.45
Total	11.50	55.20	36.84	23.00	20.7	103.5	23.00	5.75	115	575	460	920	3.45
Availability from standard ration													
Bajra straw	2.5	10.0	3.0	13.5	1.25	55.25	3.5	0.67	14.45	1367.5	123.9	35.37	0.90
Sorghum straw	2.5	7.5	3.5	8.75	1.15	30.25	2.5	0.67	15.50	1802.5	123.4	50.22	0.37
Wheat straw	3.5	11.55	1.99	6.30	8.75	60.20	6.3	0.63	14.84	1477	146.3	32.48	0.42
Bajra grain	0.5	0.14	1.60	0.60	0.09	2.20	0.7	0.08	2.99	49.94	6.95	15.01	0.40
Sorghum grain	0.5	0.25	2.10	0.90	0.09	2.15	0.7	0.10	3.40	61.00	8.42	18.67	0.31
Wheat grain	0.5	0.23	1.55	0.65	0.11	2.20	0.8	0.055	3.40	40.50	18.17	12.54	0.50
Mustard cake	1.5	11.10	15.15	5.85	0.75	20.25	4.95	0.24	18.16	565.5	101.0	81.61	0.70
Total availability	11.5	40.77	28.89	36.55	12.19	172.8	19.45	2.45	72.75	5363.9	528.2	245.9	3.61
[§]Deficit (%)	—	26.14	21.58	(+)	41.11	(+)	15.43	57.39	36.73	(+)	(+)	73.27	(+)

[†]NRC, 2001.
[‡]For a milch buffalo weighing 400 kg producing 8 kg milk (6.5% fat) per day.
[§](+) denotes adequacy.

Availability of Fe from feed resources was 5363 mg and the requirement was only 575 mg per day (Table 3). The milch buffalo yielding 8 kg milk per day, would require 460 mg Mn per day, whereas feed sources provided 528.2 mg (Table 3), showing adequacy of manganese. Adequate Mn availability from feeds and fodder was also recorded in other parts of country (Garg *et al.*, 2000; Yadav *et al.*, 2002).

For the milch buffalo with 8 kg milk per day, requirement difference for Zn was to the extent of 674.1 mg per day with the 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 anoestrus and repeat breeding.

CONCLUSION

It was apparent from the present study that the feeds and fodders available in various talukas of tropical zone (Bharatpur district) may not meet the requirements for calcium, phosphorus, sodium, sulphur, cobalt, copper and zinc in order to sustain a milk production of ~8 kg/day. Hence, it is necessary to supplement these minerals in the ration by formulating area specific mineral mixture, having highly bioavailable mineral salts.

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