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Role of Mineral Mixture Supplementation in Enhancing Productivity and Profitability of Peri-urban Dairy farming

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ABSTRACT

A study of 3 months duration was conducted in coastal belt of Odisha to assess the effect of supplemental mineral mixture on productive performance of lactating crossbred cows. Twenty crossbred cows were divided into two groups (T_1 and T_2) consisting of ten animals each. Animals in group T_1(control) were fed on homemade concentrate mixture in fodder based diet consisting of concentrate and roughage (40:60), whereas the animals in group T_2 were additionally supplemented with mineral mixture at 2% of concentrate mixture. Average daily dry matter intake (DMI), milk yield, milk composition were recorded at fortnight intervals during the trial. A digestibility trial of six days duration was conducted at the end of experimental feeding. DMI was not influenced by mineral mixture supplementation. Apparent digestibility of crude protein and ether extract were higher ($P<0.05$) in mineral mixture supplemented group than control group. Supplementation of mineral mixture improved the serum mineral level and improved milk yield by 18%. It was concluded that dietary supplementation of mineral mixture improved nutrient utilization, mineral bioavailability and milk production performance in dairy cows fed fodder based diet and enhanced income of farm families by 30%.

Key words: Cow, Feed intake, Mineral mixture, Milk yield, Milk composition, Serum metabolite

INTRODUCTION

Farm women in peri-urban dairy farming usually feed homemade concentrate and rarely practice mineral mixture supplementation of concentrates. Role of feeding balanced ration with mineral mixture in lactating cows is of paramount importance in improving productive performance. Minerals play crucial roles in metabolism, lactation, reproduction and microbial fermentation in rumen. Mineral deficiency and metabolic diseases in dairy animals were reported due to lower content and lower bioavailability of some essential macro- and micro-mineral in different feedstuff. More than 90 percent of mineral deficiencies exist at sub-clinical level in livestock (Underwood and Suttle, 1999). Supplementation of area specific mineral mixture to dairy animals are not practiced in most part of the country. National survey work conducted by NDDB indicated that Zn, Cu, S, Mn, and Co were deficient in the ration of dairy animals (Bhanderi *et al.,* 2006). Forages usually supplied to animals for meeting their mineral requirements may not be sufficient for optimum productive performance. The feeds and fodder in coastal area were deficient in Zn and Cu, but rich in Fe, Mn and Co (Gouda *et al.,* 2017). Dietary deficiencies result in failure of the mineral homeostasis mechanism affecting the productive potential of the animals. Supplementation of mineral mixture under such circumstances is likely to improve metabolism and productive performance of animals. The response of mineral supplementation varies with production status, type of feedstuff and its mineral content, requirement of minerals for animals *etc.* (Underwood, 1999) and a blanket recommendation may not be the most viable option. Therefore, the study was designed to assess the effect of supplemental mineral mixture on nutrient utilization, mineral bioavailability, milk production performance and profitability of peri urban dairy farming.

MATERIALS AND METHODS

The present study was conducted at established dairy farm in Jagannath Vihar, nearby ICAR-CIWA, Bhubaneswar. Twenty milch crossbred cows with average lactation yield of 2300 litres (milk yield, 7.5±0.25 kg; 65±0.75 days post calving), were selected from the

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local dairy farms, were randomly divided into 2 groups (T_1 control and T_2 treatment) of 10 based upon body weight, parity, days in milk and milk yield. Animals were kept under uniform managemental conditions by housing them in well ventilated pucca shed with facilities for individual feeding. Feeding trial of three months was carried out. Animals in group T_1 were fed homemade concentrate mixture (rice bran 47, de-oiled soybean cake 15, mustard oil cake 5, maize 25, pulse chuni 7, and salt 1 part). Concentrate mixture of the cows of group T_2 were additionally supplemented with a commercial grade mineral mixture at 2% to meet the nutrient requirement (ICAR, 2013). The concentrate and roughage ratio were maintained at about 40:60 level. The concentrate mixture was fed twice in the morning and evening, whereas hybrid Napier was offered to the animals, preferably after the feeding of concentrate mixture. Fresh water was offered *ad libitum* twice daily.

Each cow was milked twice daily at 6.30AM and 5.00 PM. Milk samples were collected and subjected to analysis of fat, solid not fat (SNF), protein, and total solids content. Milk constituents were analyzed using milk analyzer. FCM was calculated as per formula (4%FCM=0.4M+0.15XFXM) of Tyrell and Reid (1965).

After 90 days of feeding, a digestibility trial of six days duration was conducted preceded by a three day adaptation period of cows. During the collection period, the representative samples of feed offered, orts, and faeces were collected daily. Total daily faecal output was recorded and sub-samples (20%) were collected and dried at 80±2°C for 48 h in a hot air oven, pooled for each animal, ground and stored for chemical analysis. Representative samples of faecal collection of individual animals were pooled for six days and preserved in diluted (1:4) sulfuric acid for nitrogen and mineral estimation. Blood samples were collected by puncturing the jugular vein with the help of a clean, sterilized needle into test tubes containing sodium EDTA in the morning before feeding on days 0 and 90 of feeding trial, serum was harvested by slanting and centrifugation, and stored at -20°C for further analysis.

Representative samples of feed offered, residues and faeces collected during the digestion trial were grinded, passed through a 1 mm sieve and analyzed for proximate principles (AOAC, 2000) and fibre components (Van Soest *et al.,* 1991) following standard methods. Calcium (Ca) and inorganic phosphorus (P) in feed, faeces, and serum were also estimated (AOAC, 2000). Trace elements (Zn, Cu, Fe, and Mn) were estimated sing atomic absorption spectrophotometer (AAS; Model 4141, Electronic Corporation of India Limited, Hyderabad, and India). For this, samples were processed following wet digestion method in triple acid mixture, *i.e.*, perchloric acid, sulfuric acid, and nitric acid (1: 2: 4). Serum concentration of glucose, protein, albumin, globulin, cholesterol, alkaline phosphatase (ALP), alanine transaminase (ALT) and aspartate transaminase (AST) were analyzed using diagnostic kits (Span Diagnostic Limited, Surat, India). Data generated were statistically analyzed using SPSS 17.0 package. For comparison of groups, Generalized Linear Model ANOVA procedure and Duncan's multiple range tests were used with a test of significance at P<0.05.

RESULTS AND DISCUSSION

The chemical composition, fibre fraction, and mineral profile of concentrate mixture and green fodder offered to dairy cows were found to be within the normal range (ICAR, 2013). Organic matter content of concentrate mixture of group T_2 was lower than that of group T_1. This was expected and according to experimental protocol as mineral mixture was incorporated at 2% of concentrate mixture in group T_2 (Table 1). Feed intake was similar in both the treatments (Table 2). However, apparent digestibility of crude protein and ether extract was found to be higher (P<0.05) in mineral supplemented group of animals. Although the digestibility coefficient of DM, total carbohydrate and neutral detergent fibre were higher in mineral supplemented group of animals, the values were statistically non-significant. Minerals like Cu, Zn and Fe are having a direct role on energy and protein metabolism as activator of many digestive enzymes like carboxylase, peptidase, dehydrogenase, transferase and arginase (Prasad *et al.,* 2005).

Supplementation of mineral mixture improved

Table 1. Chemical composition (% DM basis) of feed and fodder

Nutrients	Concentrate(CM-I)	Concentrate(CM-II)	Hybrid Napier
Organic matter	91.65	90.35	91.25
Crude protein	17.75	17.05	7.74
Ether extract	3.15	3.21	3.05
Total carbohydrates	70.75	70.09	80.46
Neutral detergent fibre	48.51	48.25	72.15
Acid detergent fibre	13.15	12.37	48.72
Calcium (%)	1.55	2.27	0.65
Phosphorus (%)	0.65	1.05	0.39
Zinc (ppm)	85	150	39
Copper (ppm)	18	41	11
Iron (ppm)	140	205	225
Manganese (ppm)	77	110	46

CM-I, Concentrate mixture without added mineral mixture; CM-II, concentrate mixture supplemented with mineral mixture @2%

($P<0.05$) serum levels of Ca, P, Cu, Zn, Fe and Mn in dairy cows (Table 3). Similar to our findings, Samanta *et al.* (2005) found significantly higher serum phosphorus level in mineral supplemented group than non-supplemented cows. Satapathy *et al.* (2016) reported significantly higher serum Ca, P, Zn, Cu and Mn levels in mineral supplemented crossbred cows. In consistent with the present findings, the serum levels of Ca, Cu and Mn was found to increase ($P<0.05$) due to dietary supplementation of mineral mixture in dairy cows (Gouda *et al.,* 2017).

Increased ($P<0.05$) mineral level with the advance in experimental feeding showed that lactating cows were earlier deficient in minerals, and mineral mixture supplementation overcome the deficiency (Garg *et al.,* 2008; Minz *et al.,* 2013; Raju *et al.,* 2015). In the present study, the serum concentration of Ca and P at 0 days was found to be lower than critical level. This signifies that control diet was deficient in these elements and supplementation of mineral mixture was able to overcome the deficit. Our finding corroborates well with previous reports (Tiwari *et al.,* 2012; Panda *et al.,* 2015).

Table 2. Nutrient utilization in lactating cows fed mineral mixture supplemented diet

Attributes	T_1	T_2	SEM	P value
Dry matter intake (kg/day)				
Concentrate	4.55	4.61	0.55	1.05
Roughage	6.82	6.97	0.75	0.65
Total DM intake	11.37	11.58	0.68	0.78
Apparent digestibility (%)				
Dry matter	60.44	62.62	1.81	0.79
Organic matter	62.10	61.05	1.79	0.72
Ether extract*	62.30[a]	64.23[b]	1.26	0.05
Crude protein*	59.91[a]	62.64[b]	0.58	0.04
Total carbohydrate	56.89	59.52	1.93	0.71
Neutral detergent fibre	60.04	62.31	1.75	0.50
Acid detergent fibre	55.03	56.34	1.62	0.45

[*a,b]Mean bearing different superscripts in a row differ significantly ($P<0.05$)

Table 3. Effect of mineral mixture on serum mineral level in lactating cows

Treatment	Days post experiment		Mean ±SEM	P value	
	0	90		T	P
Calcium (mg/dl)					
T_1	8.11	8.17	8.14^a±0.15	0.05	0.04
T_2	8.03^A	8.90^B	8.47^b±0.33		
Phosphorus (mg/dl)					
T_1	4.33	4.39	4.37^a±0.27	0.05	0.04
T_2	4.25^A	4.98^B	4.62^b±0.17		
Zinc (ppm)					
T_1	0.87	0.89	0.88^a±0.40	0.03	0.03
T_2	0.85^A	1.55^B	1.20^b±0.77		
Copper (ppm)					
T_1	0.83	0.91	0.87^a±0.31	0.03	0.03
T_2	0.81^A	1.42^B	1.11^b±0.37		
Iron (ppm)					
T_1	10.75	11.01	10.88^a±3.29	0.03	0.05
T_2	10.64^A	11.75^B	11.19^b±2.58		
Manganese (ppm)					
T_1	2.05	2.11	2.08^a±0.13	0.04	0.05
T_2	2.11^A	2.63^B	2.37^b±0.31		

*A,B Mean bearing different superscripts in a row, and a, b Mean bearing different superscripts in a column differ significantly (P<0.05)

In consistent with the present findings, the serum level of Ca, Cu and Mn was reported to be increased from below critical level to normal level by dietary supplementation of mineral mixture in dairy cows (Samanta *et al.,* 2005; Hackbart *et al.,* 2010; Sharma *et al.,* 2009; Agrawalla *et al.,* 2017).

Among the different serum biochemical parameters, glucose concentration varied significantly (P<0.05) between control and treatment groups at 90 days of the experiment (Table 4). Satapathy *et al.* (2016) reported that serum glucose concentration increased (P<0.05) after the mineral mixture supplementation (44.55±2.43 *vs.* 54.85±2.06 mg/dl). The higher blood glucose concentration in treatment groups might be due

Table 4. Effect of mineral mixture on blood metabolites in lactating cows

Attributes	T_1	T_2	SEM	P value
Glucose*	42.14	46.86	0.84	0.04
Total protein	6.87	7.16	0.16	0.42
Albumin	3.26	3.28	0.06	0.88
Globulin	3.61	3.88	0.19	0.51
Cholesterol	218	225	10.32	0.65
HDL cholesterol	117	129	2.69	0.094
Alkaline phosphatase	133	142	3.12	0.18
Alanine transaminase	68	89	7.26	0.18
Aspartate transaminase	134	157	9.33	0.26

a, b Means with different superscripts in a row differ significantly (P<0.05).

Table 5. Effect of mineral mixture on milk yield (l/d) and composition

Attributes	T_1	T_2	P-value	% increase
Milk Yield (l/day)*	7.05[a]	8.25[b]	0.05	18
Fat (%)	4.08	4.77	0.09	14
SNF (%)	8.59	8.78	1.12	-
Protein (%)	3.07	3.2	1.05	-
FCM Yield (l/day)*	7.20[a]	9.10[b]	0.05	26

SNF, solid not fats; FCM, fat corrected milk

to altered molar proportion of VFA in the rumen with an increase in propionate concentration resulting in increased glucose level in the plasma due to mineral supplementation (Aliarabi and Chhabra, 2006; Mushtaq *et al.,* 2017). The post-partum plasma glucose level was increased by supplying 50 g of mineral mixture and 1500 IU of vitamin E which might be due to effect of minerals either as the cofactors and/or activators of many enzymatic systems associated with the metabolism of nutrients. Zn is known to alter molar proportion of VFA in the rumen with an increase in propionate (Arelovich *et al.,* 2000; Aliarabi and Chhabra, 2006; Khan *et al.,* 2015). Serum concentrations of protein, albumin, globulin and activity of serum enzymes (ALP, ALT and AST) were similar between the groups. Our results corroborate well with that of a previous report which indicate no influence of mineral supplementation on these parameters (Ashry *et al.,* 2012). Apparrently, HDL cholesterol level was found to be higher (P>0.05) in mineral supplemented group however, the value were found to be non-significant.

The milk yield and fat corrected milk (FCM) yield were increased (P<0.05) by 18% and 26% by supplementing mineral mixture to lactating cows (Table 5). In consistent with the present findings, average daily milk yield, peak yield and total milk yield were found to be higher by 13.4%, 16.17% and 13.07 % in crossbred cows fed supplemental mineral mixture (Gupta *et al.,* 2017). Other study also reported that supplementation of mineral mixture to lactating cows improved milk yield (0.5–1.0 kg/animal/day) and milk fat (0.3–0.5%) content (Prasad *et al.,* 2005). Mineral supplemented cows were able to hold peak yield for longer duration than the control group which revealed that mineral mixture could improve milk production potential of crossbred cows because micro- and macro-element positively modulate the working of mammary cell to enhance milk production (Verma *et al.,* 2009; Singh *et al.,* 2016).

Composition of milk was not influenced by mineral supplementation. Similarly, supplementation of phosphorus and organic trace minerals to dairy animals

Table 6. Effect of mineral mixture supplementation on feed cost

Attributes	T_1	T_2	SEM	P value
Dry matter intake (kg/day)				
Concentrate (kg)	4.5	4.6	0.19	0.98
Roughage (kg)	7.1	7.0	0.55	0.23
Total dry matter intake (kg)	11.6	11.9	0.60	0.28
Economics of feeding				
Total feed cost (₹/d)	116	123	0.19	0.24
Total income (₹./d)*	211	247	0.55	0.05
Net return over feed cost* (₹/d)	95	124	0.85	0.04
Feed cost/kg FCM yield (₹)*	16.10	13.50	0.82	0.05

[a, b] Means with different superscripts in a row differ significantly (P<0.05).

supported high milk production without any alteration in milk components (Rabiee *et al.,* 2010; Begum *et al.,* 2010). The DM intake through concentrate and roughage was similar in both the groups. However, milk and FCM yield was higher in mineral supplemented group. As a result, the feed efficiency and economics was found to be better ($P<0.05$) in mineral supplemented group (Table 6).

CONCLUSION

It was concluded that supplementation of mineral mixture improved milk production, and feed conversion efficiency without any adverse impact on milk composition. Further, it improved the profitability of peri-urban dairy farming, and thus opening up a new vista for women empowerment.

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