Utilization of Dietary Nutrients, Retention and Plasma Level of Certain Minerals in Crossbred Dairy Cows as Influenced by Source of Mineral Supplementation

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ABSTRACT : Nutrient utilization and plasma level of minerals were studied in lactating crossbred cows fed diet supplemented from different source of minerals. Twelve crossbred cows of first to third lactation during their mid stage of lactation were distributed equally under two groups and were fed concentrate mixture, green fodder (para grass) and finger millet straw as per requirement. Cows in group I were fed concentrate mixture supplemented with 1% mineral mixture whereas cows in group II were not supplemented with mineral mixture in the concentrate mixture but were offered additional quantity of green fodder (1 kg DM/cow/day) to compensate for the requirement of minerals. Balance study conducted towards the end of 120 days of feeding experiment indicated that the total dry matter intake in both the groups did not differ significantly. The cows in group II offered additional quantity of green fodder consumed significantly ($p<0.05$) more of green fodder (5.11 vs. 4.51 kg /animal/day) and the cows in group I consumed significantly ($p<0.01$) more of finger millet straw (1.71 vs. 0.92 kg/animal/day). The digestibility of major nutrients did not differ between the groups except for ether extract which was significantly ($p<0.05$) lower in cows fed additional green fodder. The total daily intake of P, Cu, Fe and Co did not differ significantly in both the groups whereas significantly higher intakes of Ca, Mg, Zn and Mn were observed in cows supplemented with inorganic source of minerals. However, supplementation through both the sources could meet the mineral requirement in group I and group II. The gut absorption (%) of all the minerals was comparable between the groups except for Mg which was significantly ($p<0.05$) higher in cows supplemented mineral mixture. The net retention of all the minerals was significantly more in the group supplemented with inorganic source of minerals. Except for P, Mg and Co the retention as percentage of total intake was comparable for all minerals in both the groups. Irrespective of source of mineral supplementation the average monthly blood plasma mineral levels (Ca, P, Mg, Cu, Zn, Fe) were within the normal range and comparable between the groups. Lower level of Cu observed at the start of the experimental feeding in both the groups increased with the advancement of supplemental feeding. The plasma Zn and Fe content in cows of both the groups did not vary. The blood plasma level of some minerals (Ca, P, Mg and Cu) was significantly higher towards the end of experimental feeding as compared to the initial values due to the reduction in milk yield with advancement of lactation or due to supplemental effect of minerals. It could be concluded that supplementation of minerals through inorganic source is better utilized in terms of retention as compared to green fodder (para grass), which is a moderate source of most nutrients. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 2 : 221-227)***

Key Words : Nutrient Utilization, Minerals, Dairy Cows, Green Fodder, Retention, Plasma Level

INTRODUCTION

Minerals play an important role in nutrient utilization and several biochemical functions concerning production and reproduction. Animals derive minerals through the consumption of natural feeds and fodders and also through supplementation of inorganic salts in the form of mineral mixture or block licks. The presence of a mineral element in required amount in the diet may not always ensure its total availability due to several factors which influence their uptake and utilization. Bioavailability can be influenced by animal species, physiological function, magnitude of previous intake of a nutrient and interactions among the dietary nutrients (Ammerman et al., 1995). With mineral elements in particular, chemical form and degree of solubility can have a profound effect on utilization of supplemental sources (Forbes and Erdman, 1983). Bioavailability of nutrients can be assessed by several ways and most commonly used techniques are apparent/true absorption, growth/production and specific tissue responses and tissue levels. In the present experiment an effort has been made to study the utilization of dietary nutrients and bioavailability of certain macro and micro minerals in medium yielding crossbred dairy cows fed diets containing minerals supplemented through either inorganic salts or through additional quantity of green fodder as a strategic supplement.

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MATERIALS AND METHODS

Experimental animals and feeding

Twelve healthy Holstein Frisian crossbred medium yielding cows (8-10 litres) during their mid stage of lactation were selected for the study and were managed in individual tie stalls with a paddock. They were dewormed (Albendazole 10 mg/kg BW) and distributed equally under two dietary groups based on their body weight, milk yield and stage of lactation. Cows in both the groups were fed as per requirement (ICAR, 1985) with concentrate mixture, green fodder (para: *Brachiaria mutica*) and finger millet (*Eleusine coracana*) as a source of dry roughage. Concentrate mixture was prepared using ground yellow maize (23/24 parts) wheat bran (40 parts) and deoiled groundnut cake (35 parts) and common salt (1 part). Cows in group I (G_1) were fed concentrate mixture supplemented with 1% commercial mineral mixture, whereas the cows in group II (G_2) were fed concentrate mixture without any mineral mixture supplementation and were provided additional quantity of green fodder (1.0 kg DM/cow/day) to meet the mineral needs. The ratio of dry matter (DM) offered through concentrate and fodder was 40 and 60, respectively for both the groups. Clean drinking water was offered to each cow thrice a day. The experimental feeding was continued for 120 days period.

Feeding schedule

The total quantity of concentrate mixture in two equal parts was offered individually once in the morning and once in the evening before milking everyday. Finger millet straw was offered after milking both in the morning and evening. Chaffed green fodder was offered to each cow during the mid day. During the last week of experimental feeding a balance trial of seven days duration was conducted involving all the cows under both the groups. Total collection of feces and urine was carried out individually in tie stalls. The representative samples of feed and fodder offered and their residues, if any, were collected daily for DM estimation after recording their weights individually. Measured quantity of clean drinking water was offered thrice a day. Each cow was hand milked in the morning (05:00 h) and evening (17:00 h) and the daily milk yield was recorded.

Sampling of feces and urine

The feces and urine of each animal collected quantitatively during 24 h period were respectively weighed and measured daily at 09:00 h. The feces was thoroughly mixed in a plastic trough and representative sample from each animal was transferred to a plastic container for further sub-sampling in the laboratory. Representative sample of urine voided by each animal was collected in plastic bottles and taken to laboratory. An aliquot of 1/200th of feces voided was dried daily in hot air oven in pre-weighed Petri dishes at 100±5°C overnight for dry matter (DM) estimation. The dried feces was pooled individually for further analysis of ether extract, fibre fractions and minerals. For nitrogen estimation 1/500th of the feces voided daily was weighed individually and transferred quantitatively to previously weighed glass bottles after mixing with two drops of 1:4 H_2SO_4 to fix nitrogen. After seven days of collection, aliquots of individually pooled wet feces (1/10th) were taken for nitrogen estimation by Kjeldahl method. For the estimation of minerals in urine and milk an aliquot of 1/250th of daily urine voided and milk yield were pooled individually in plastic bottles and preserved in refrigerated conditions (3-4°C) for further analysis.

Preparation of acid mineral extract and mineral analysis

The dried feed/fodder samples (offered and residues) and dried feces samples of each animal collected during seven days were respectively pooled and ground to 1 mm fineness. The ground samples were subjected to dry ashing in a muffle furnace at 600°C for two hours, cooled and dissolved in 5 N HCl for the preparation of mineral extract in duplicate. The undissolved residue on Whatman filter paper (No. 42) was again ignited and ashed in muffle furnace at 600°C for two hours, cooled and its weight recorded as the acid insoluble ash (AIA, silica).The content of ash, AIA and the minerals in feeds, fodders and feces samples were expressed on DM basis. The pooled milk and urine samples from each animal were suitably aliquoted and wet digested with 3:1 HNO_3 and perchloric acid mixture for preparing the acid mineral extract. Calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), cobalt (Co) and manganese (Mn) were estimated using atomic absorption spectrophotometer (Perkin Elmer AA 300). For estimation of Ca and Mg, acid extracts were suitably diluted (1:50 or 1:100) with 0.1% lanthanum chloride to avoid interference from phosphates. For estimating manganese, acid extracts were suitably diluted (1:10) with 0.2 % $CaCl_2$ to avoid interference from sulphates and phosphates. Phosphorus was estimated colorimetrically by the molybdovanadate method (AOAC, 1975). Mineral standards were run for each analysis.

Estimation of crude protein (CP), ether extract (EE) and fibre fractions

The dried samples of feed, fodder and feces were ground to a fineness of 1 mm and were analysed for crude protein (CP), ether extract (EE) (AOAC, 1990) and for fibre fractions (Goering and Van Soest, 1970).

Mineral analysis in blood plasma

At monthly interval from the start of the experiment till 120 days of feeding period, the blood was drawn from the jugular vein of each cow to the heparinised plastic tubes and preserved immediately in ice cold condition. The plasma was obtained after centrifugation (10,000 rpm, 10 min.) and preserved in deep freeze till further analysis. Minerals (Ca, Mg, Cu, Zn and Fe) in the plasma were analysed in atomic absorption spectrophotometer as per standard procedure, whereas the inorganic P was estimated colorimetrically (Fisk and Subba Row, 1925).

Table 1. Macro and micronutrient composition of feeds and fodder employed during experimental trial (DM basis)

Feeds/fodder	CP	EE	NDF	ADF	Ash	AIA	Ca	P	Mg	Cu	Zn	Fe	Mn	Co
	g/kg									mg/kg				
Concentrate (G_1)	206.6	36.3	368.5	181.0	60.7	15.4	6.8	19.8	5.3	26	84	350	78	2.2
Concentrate (G_2)	207.2	38.7	359.4	181.9	58.3	12.8	3.8	1.59	4.3	20	60	328	66	1.9
Green fodder	120.8	13.8	768.1	477.8	80.6	38.4	6.0	3.3	2.1	8.8	22	281	35	2.3
Ragi straw	50.1	5.6	820.4	510.9	72.2	45.6	10.6	1.3	4.4	6.3	21	175	365	1.5

G_1: Animals supplemented with 1 % mineral mixture in the diet. G_2: Animals provided additional green fodder instead of mineral mixture.

Table 2. Utilization of macronutrients by experimental animals (per day/cow)

Nutrient	Intake				Outgo in feces	Digestibility (%)
	Concentrate	Green fodder	Straw	Total		
DM (kg)						
G_1	3.74	4.51^{b}	1.71^{a}	10.02	4.04	59.84
G_2	3.66	5.11^{a}	0.92^{b}	9.71	3.89	59.72
SEM (D.F. 10)	0.26	0.19 *	0.21 **	0.46	0.19	0.60
CP (g)						
G_1	780	540	85.7^{a}	1,405	484.8	65.51
G_2	750	610	46.0^{b}	1,407	427.9	69.56
SEM (D.F. 10)	50	30	7 *	77	32	5
EE (g)						
G_1	135	62.8^{b}	8.6^{a}	206.4	51.3	75.0^{a}
G_2	139	72.5^{a}	4.6^{b}	216.4	83.9	61.6^{b}
SEM (D.F. 10)	0.01	2.35**	1.06 *	11.6	9.0	2.98*
NDF (kg)						
G_1	1.39	3.44	1.35^{a}	6.19	3.19	48.83
G_2	1.31	3.90	0.68^{b}	5.89	2.92	50.56
SEM (D.F. 10)	0.09	0.15	0.18*	0.29	0.20	1.46
ADF (kg)						
G_1	0.68	2.13	0.89	3.72	2.05	44.41
G_2	0.66	2.41	0.44	3.51	1.94	44.69
SEM (D.F. 10)	0.05	0.09	0.11	0.18	0.10	1.39

Means bearing different superscripts in a column (a, b) differ significantly, * $p<0.05$; ** $p<0.01$.

Statistical analysis

The data on average intake of DM, macronutrients and minerals and their outgo in feces, urine and milk with their balances were analysed for variance by following completely randomised design (Snedecor and Cochran, 1980) and the treatment means were compared with Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Nutrient composition of feeds/fodders

The macronutrient and mineral content of different feeds and fodders employed in the experiment have been presented in Table 1. The macronutrient composition (CP, EE, NDF, ADF) in both the concentrate diets (G_1 and G_2) was almost similar. However, the ash, AIA and macro as well as micromineral contents were lower in concentrate G_2 as compared to G_1. The P content in both the concentrate diets was higher than the Ca. The green fodder (para grass) contained about 120.8 g/kg CP, 768.1 g/kg NDF and 477.8 g/kg ADF. The green fodder contained moderate content of Ca, P, Mg and was low in Cu, Zn and Mn. The ragi straw (finger millet) was low in CP and contained more NDF and ADF, but it contained higher levels of Ca (10.6 g/kg), Mg (4.4 g/kg) and Mn (365 mg/kg) and less of P, Cu and Zn.

Utilization of macronutrients

The cows in group 2 fed diet with no inorganic mineral supplement and additional quantity of green fodder consumed significantly ($p<0.05$) more green fodder whereas the cows in group 1 consumed significantly ($p<0.01$) more straw (Table 2). This resulted in significantly ($p<0.05$) higher intake of CP, EE and NDF through straw by cows in group 1. However the total intake of DM, CP, EE, NDF and ADF did not differ significantly between the groups. Except for significantly ($p<0.05$) lowered EE digestibility in animals of group 2, the digestibility of DM, CP, NDF and ADF did not differ significantly between the dietary groups.

Utilization of macro minerals

The intake of Ca, P and Mg through the concentrate and straw was significantly ($p<0.05$; $p<0.01$) higher in group 1 whereas the intake of these minerals was higher through green fodder in group 2. The intake of these minerals through water was negligible. The total intake of Ca and

Table 3. Average intake and utilization pattern of macro minerals in experimental animals (per day/cow)

Micronutrient	Intake					Outgo				Retention (mg)	Retention (% of intake)	Gut Absorption (%)
	Concentrate (g)	Green fodder (g)	Straw (g)	Water (mg)	Total (g)	Feces (g)	Urine (g)	Milk (g)	Total (g)			
Ca												
G_1	25.79^{a}	27.26^{b}	23.20^{a}	500	76.76	40.74^{a}	2.75	8.28	51.78^{a}	24.98^{a}	33.11	47.17
G_2	13.90^{b}	31.67^{a}	9.07^{b}	700	55.12	27.35^{b}	4.08	6.64	38.10^{b}	17.02^{b}	30.73	49.66
SEM (D.F.10)	2.10**	1.06**	2.77**	40	4.42**	2.83**	0.69	0.87	3.40*	1.83*	1.89	4.04
P												
G_1	75.10^{a}	15.00^{b}	3.82^{a}	12.70	93.95	61.79	8.56	7.00	79.02	14.92^{a}	16.45^{a}	30.45
G_2	58.18^{b}	16.91^{a}	2.87^{b}	11.90	77.98	57.62	7.96	6.93	72.53	5.45^{b}	6.70^{b}	25.20
SEM (D.F. 10)	5.06*	0.60**	0.25*	0.98	5.33	3.68	0.77	0.98	4.57	2.33*	2.34*	2.53
Mg												
G_1	20.10	9.61	8.48^{a}	560	38.76^{a}	25.30	4.23	2.11	31.63	7.12^{a}	18.45^{a}	34.75^{a}
G_2	15.73	10.97	2.51^{b}	530	29.76^{b}	22.06	3.63	2.86	28.58	2.02^{b}	6.73^{b}	26.16^{b}
SEM (D.F. 10)	1.35	0.36	1.18**	30	2.25*	1.49	0.37	0.42	1.86	1.09**	2.67**	2.13*

Means bearing different superscripts in a column (a, b) differ significantly, * $p<0.05$, ** $p<0.01$.

Table 4. Average intake and utilization pattern of micro minerals in experimental animals (per day/cow)

	Intake					Outgo				Retention (mg)	Retention (% of intake)	Gut Absorption (%)
	Concentrate (mg)	Green fodder (mg)	Straw (mg)	Water (mg)	Total (mg)	Feces (mg)	Urine (mg)	Milk (mg)	Total (mg)			
Cu												
G_1	98.65^{a}	39.38^{b}	20.44^{a}	0.47	158.92	29.41	1.52	2.64	33.58	125.34^{a}	78.75	81.41
G_2	73.20^{b}	47.35^{a}	15.56^{b}	0.44	136.60	37.63	1.81	2.29	41.73	94.82^{b}	69.30	72.27
SEM (D.F. 10)	6.72*	1.82***	1.23*	0.03	7.77	3.82	0.16	0.19	3.85	8.13*	2.88	2.89
Zn												
G_1	318.64^{a}	100.40	26.54	-	445.60^{a}	173.41	8.43^{b}	106.71	288.61	156.97^{a}	35.39	61.59
G_2	219.60^{b}	108.78	15.16	-	343.54^{b}	136.32	19.84^{a}	94.55	250.71	92.81^{b}	29.46	61.05
SEM (D.F. 10)	22.49*	4.30	4.53	-	25.70*	15.33	2.58*	14.87	25.12	14.86*	3.41	2.46
Fe												
G_1	1,327.66	1,293.28	341.83^{a}	-	2,962.81	1,950.08	36.35	108.70	2,095.14	867.64	29.13	34.11
G_2	1,200.48	1,468.07	198.18^{b}	-	2,865.90	1,512.05	38.92	80.72	1,631.70	1,234.20	42.95	46.92
SEM (D.F. 10)	90.16	47.30	37.72*	-	129.15	143.18	6.57	14.62	151.91	129.17	4.19	4.09
Mn												
G_1	296.01	155.50	617.18^{a}	-	1,151.56^{a}	1,014.75^{a}	2.12	4.47^{a}	1,021.35^{a}	130.30^{a}	11.38	12.07
G_2	241.56	160.19	286.38^{b}	-	687.96^{b}	593.46^{b}	3.19	3.19^{b}	601.60^{b}	86.50^{b}	12.72	13.86
SEM (D.F. 10)	19.77	9.26	83.81*	-	114.61**	102.89*	0.25	0.54*	102.93*	12.00*	0.43	0.47
Co												
G_1	8.74	10.50^{b}	3.10	0.05	22.00	4.66	-	7.12^{a}	11.78	10.21^{b}	47.13^{b}	78.93
G_2	6.94	12.67^{a}	2.03	0.05	21.69	4.30	-	3.13^{b}	7.43	14.26^{a}	66.86^{a}	80.38
SEM (D.F. 10)	0.55	0.41**	0.30	0.003	0.85	0.46	-	0.95*	1.23	0.89*	4.66*	1.71

Means bearing different superscripts in a column (a, b) and differ significantly, * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Mg was significantly ($p<0.05$; $p<0.01$) higher in animals of group 1 fed diet containing mineral mixture whereas the intake of P was non-significantly higher in group 1 (Table 3). The outgo of Ca through feces was significantly ($p<0.01$) higher in group 1 whereas the outgo of P and Mg was comparable in both the groups. The outgo of Ca, P and Mg through urine and milk varied non-significantly. The total outgo of Ca was significantly ($p<0.05$) higher in animals of group 1 whereas the total outgo of P and Mg was comparable in both the groups. The net retention of Ca, P and Mg was significantly ($p<0.05$; $p<0.01$) higher in animals of group 1 supplemented with mineral mixture. However the percentage gut absorption of Ca and P was comparable between the groups and the retention as percentage of intake was significantly ($p<0.05$; $p<0.01$) higher for P and Mg in animals of group 1 (Table 3).

Utilization of micro minerals

Except for Fe, Mn and Co the intake of Cu and Zn was significantly ($p<0.05$) higher through concentrate in group 1 whereas the intake of Cu and Co was significantly ($p<0.01$) higher through the consumption of green fodder in group 2. Except for Zn and Co, the intake of remaining trace minerals was significantly ($p<0.05$) higher through straw in group 1. The total intake of Zn and Mn was significantly ($p<0.05$; $p<0.01$) higher in group 1 whereas the intake of other trace minerals in both the groups varied non-significantly. The outgo of all the trace minerals through feces remained comparable in both the groups except for Mn where the excretion through feces was significantly

Table 5. Mineral profile in blood plasma of experimental animals

Month	Ca			P			Mg			Cu			Zn			Fe		
	G_1	G_2	SEM (D.F. 10)	G_1	G_2	SEM (D.F. 10)	G_1	G_2	SEM (D.F. 10)	G_1	G_2	SEM (D.F. 10)	G_1	G_2	SEM (D.F. 10)	G_1	G_2	SEM (D.F.10
	mg %									mg/L								
Start **	8.21 ^{Aa}	7.20 ^{Bb}	0.23**	5.12 ^{B}	5.67	0.32	1.61 ^{B}	1.10 ^{B}	0.15	0.81 ^{B}	0.60 ^{C}	0.06	1.27	1.08	0.10	2.00	1.95	0.10
I	7.00 ^{B}	7.66 ^{B}	0.41	5.01 ^{B}	5.03	0.16	1.80^{B}	1.50 ^{B}	0.12	0.84 ^{B}	0.88 ^{ABC}	0.08	0.64	0.76	0.06	2.03	2.04	0.10
II	7.23 ^{B}	8.53 ^{A}	0.78	6.48 ^{A}	6.13	0.34	1.28 ^{B}	1.80 ^{B}	0.21	0.94 ^{B}	1.00 ^{ABC}	0.06	0.98	0.89	0.13	1.90	1.93	0.11
III	7.08 ^{B}	6.86 ^{B}	0.42	4.08 ^{B}	4.94	0.42	1.88 ^{AB}	1.86 ^{B}	0.12	1.32 ^{AB}	1.48 ^{AB}	0.08	0.60	0.62	0.04	2.01	1.98	0.10
IV	8.68 ^{A}	9.20 ^{A}	0.33	5.57^{A}	5.70	0.54	2.70 ^{A}	3.30^{A}	0.20	1.94 ^{A}	1.52^{A}	0.18	0.66	0.96	0.08	2.11	2.00	0.13
SEM (D.F.25)	0.21**	0.27**		0.31**	0.33		0.15*	0.18*		0.07*	0.06*		0.07	0.08		0.09	0.08	

Means bearing different superscripts in a row (a, b) and column (A, B) differ significantly, * $p<0.05$, ** $p<0.01$.

($p<0.05$) higher in group 1. The urinary excretion of Zn was significantly ($p<0.05$) higher in group 2 whereas the excretion of other minerals did not vary significantly and Co was not detected in the urine. The total excretion of Mn was significantly ($p<0.05$) higher in animals of group 1 and the total outgo of other trace minerals did not vary significantly. The net retention of Cu, Zn and Mn was significantly ($p<0.05$) higher in cows of group 1 fed mineral mixture whereas the retention of Co was significantly ($p<0.05$) higher in animals of group 2 fed additional quantity of green fodder (Table 4). Except for Co the retention as percentage of intake and percentage gut absorption of micro minerals were similar in both the groups.

Mineral profile in blood plasma

Analysis of minerals in the blood plasma of animals at monthly interval showed no significant variation in Ca, P and Mg levels in cows of both the groups. With the passage of feeding experiment and stage of lactation the Ca, P and Mg levels in both the groups tended to increase as compared to the initial values. The level of Cu, Zn and Fe also did not differ between the groups and the level of Cu increased significantly ($p<0.05$) with the progress of feeding. However, the level of Zn and Fe did not show such variation (Table 5).

DISCUSSION

Nutrient composition

The minor differences in the macronutrient composition between concentrate G_1 and G_2 were due to the non-inclusion of mineral mixture in G_2 which also resulted in lower ash and all other mineral contents in the diet. The green fodder (para grass) was a moderate source of Ca and other trace minerals whereas the ragi straw (finger millet) though contained more fibre, was a good source of Ca and Mn. These results are in agreement with the earlier reports (Gowda et al., 2001; Ramana et al., 2001).

Utilization of macronutrients

The feeding of additional green fodder to the cows in group 2 for compensating the mineral intake resulted in higher intakes of green fodder and lower intake of straw probably due to substitutional effect (Prasad et al., 1995). On the other hand cows in group 1 consumed more straw for making up the total DM intake (DMI). Irrespective of the differences in intake of CP, EE, NDF and ADF as a result of varied green fodder and straw intake, the total DMI in both the groups remained comparable. Minerals, particularly P and Zn play an important role in nutrient digestibility (Mertinez and Church 1970; Karn, 2001). But the difference in mineral intake in two groups did not affect the digestibility of DM, CP, NDF and ADF indicating that the minerals provided through the concentrate, green fodder and straw were able to meet the requirement. The lowered ($p<0.05$) digestibility of EE in group 2 may probably be due to higher intake of carotenoids from the green fodder which might have resulted in higher excretion of this in feces, resulting in apparently lowered digestibility.

Utilization of macro minerals

The dietary levels of Ca, P and Mg in group 1 and group 2 were 0.76 and 0.56%, 0.93 and 0.80% and 0.35 and 0.30%, respectively as against the requirement of 0.43 to 0.77%, 0.25 to 0.49% and 0.20 to 0.25% for Ca, P and Mg for lactating cattle (NRC, 1989). The addition of mineral mixture in diet 1 could meet the requirement of Ca, P and Mg, whereas in group 2 the levels of Ca and Mg were just above the lower limit of requirement. The level of dietary P in both the groups was much above the required level due to the inclusion of wheat bran and groundnut cake in the concentrate mixture at higher proportion which are good sources of P (0.8-1.5%) and is a normal feature in most practical diets used for feeding dairy cattle in Indian conditions. The superior net retention of Ca, P and Mg in cows of group 1 indicated that the minerals through mineral mixture supplementation were better utilized as compared to the supplementation through green fodder. The utilization in terms of percent gut absorption and retention as percentage of total intake also was better for P and Mg in group 1 suggesting that supplementation through natural feeds and fodders is influenced by several intrinsic factors (Ammerman et al., 1995). Ruminants can tolerate high Ca:P ratio if Mg is not high in the diet (Chester-Jones et al., 1990). In the present study the Ca:P ratio was 0.81:1 and

0.70:1 in diet 1 and 2 as against the suggested level of either 2:1 or 1:1 for efficient utilization. Ruminants can tolerate a wide ratio of Ca:P than the non-ruminants but feeding excess P for long time might reduce Ca absorption and result in excessive bone resorption (NRC, 2001). Dairy cattle are quite adept in excreting excess absorbed P via salivary and faecal secretion (Challa et al., 1989). High P in the diet of pregnant cows inhibits the production of active form of vitamin D, consequently increasing the risk of milk fever (Reinhardt and Conrad, 1980), If the Ca level in the diet is adequate maximum tolerable concentration of P in dairy cattle diet is 1% (NRC, 2001). The adverse effect of potassium (K) on Mg absorption is well known. Most green fodders are good source of K and higher intake of green fodder in group 2 might have resulted in lower Mg absorption and net retention in animals of group 2.

Utilization of trace minerals

The total dietary (DM) levels of Cu, Zn, Fe, Mn and Co were 15.8 and 14.0, 44.5 and 35.4, 295.7 and 295.1, 114.9 and 70.8 and 2.19 and 2.23 mg/kg in group 1 and group 2, respectively. Though the cows in group 2 were not supplemented with mineral mixture they could derive the required amount of trace minerals through the consumption of additional quantity of green fodder offered. Except for slightly low Zn level (35.4 mg/kg) in group 2 the dietary levels of all the trace minerals studied were much above the requirement. The levels of Fe, Mn and Co were many times higher than the recommended levels of 50 to 100 mg/kg, 40 mg/kg and 0.1 mg/kg, respectively due to the presence of higher level of these elements in feeds and fodders used in the study. Like the macro minerals the utilization of most trace minerals in terms of net retention was also better in animals fed diet supplemented with inorganic source of minerals. However, the retention of Fe and Co was superior in animals fed no mineral mixture, indicating that the utilization of these elements was better through additional green fodder consumption. The absorption and retention values for trace minerals vary greatly depending on several factors like dietary components, amount of other minerals, age and physiological condition of animals. Excess dietary Zn is antagonistic to Cu (Saylor and Leach, 1980). Similarly molybdenum and sulphur also exert antagonistic effect on Cu in ruminants. However the better absorption of Cu in both the groups of present experiment indicated that Cu utilization was not adversely affected by the source of supplement. Excess P and Fe intake negatively influence the Zn bioavailability (Baker and Ammerman, 1995). Higher intake of P in both the groups of the present experiment probably reduced the Zn absorption. Estimated relative bioavailability values for Fe ranged from 30 to 70% for forages and values in soybeans and cereal grains being somewhat higher. Interactions of Ca, P and Zn are important in influencing dietary Fe utilization (Henry and Miller, 1995). Iron of plant origin is more readily absorbed and hence Fe deficiency in grazing animals is generally uncommon (Morris, 1987). Excess P and Fe intake exerts an antagonistic effect on Mn absorption (Wedekind et al., 1990). Low absorption values of Mn (12 to 13%) in the present study could be attributed to higher intake of P, Fe and Co in excess of their requirement. Dietary inorganic sulphate reduces Co retention, whereas Fe and Co share a common intestinal transport pathway and generally Co utilization is less adversely influenced by other elements (Smith, 1987).

Mineral profile in blood plasma

The levels of Ca and Mg in the blood plasma of animals in both the groups were initially lower than the normal values probably due to the effect of early lactation. Towards the end of the experiment the levels of Ca and Mg reached the normal level of 8 to 12 mg % and 1.9 to 3.2 mg %, respectively which can be attributed to the supplemental effect and also due to reduction in the milk yield with the progress of lactation. Inspite of varied and lowered intake of these macro minerals the plasma levels were comparable between the two groups due to the homeostatic mechanisms (Mc Donald, 1992). The trace mineral levels (Cu, Zn, Fe) also remained comparable between the groups inspite of the differences in net retention values. The plasma Cu level tended to improve with the progress of the feeding in both the groups whereas the Zn and Fe levels did not show much change. The Cu and Fe levels in both the groups were within the normal physiological range, but the Zn level was below the normal level of 1-2 mg/kg in animals of both the groups inspite of adequate dietary intake and could be attributed to the interactions with other minerals.

CONCLUSIONS

It is concluded that supplementation of minerals to medium yielding crossbred cows (upto 10 litre milk) through inorganic source is better utilized in terms of intake and retention as compared to supplementation through para grass as it is a moderate source of most of the minerals. Providing additional green fodder (para grass) to the cows could meet the requirement of most of the trace minerals. However Ca and Mg need to be supplemented during peak production.

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