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RESEARCH ARTICLE

EFFECT OF DIFFERENT LEVELS OF DIETARY CALCIUM ON THE MINERAL AVAILABILITY IN CROSS BRED DAIRY CATTLE

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Abstract

A study for a period of 4 month was conducted to assess the effect of different levels of dietary calcium on mineral availability in cross bred dairy cattle. Twelve healthy cross bred dairy cattle in the last month of pregnancy were selected and divided in to two groups as uniformly as possible and allotted to two dietary treatments viz T1 (control ration where in the compounded cattle feed contained 0.5 per cent calcium as per IS (1992) standards and T2 (experimental ration) where in the compounded cattle feed contained 1.0 per cent calcium. Paddy straw was the sole roughage source in both the rations. All experimental animals were fed as per ICAR (1999) standards except for dietary calcium. A metabolism trial was conducted in the first month of lactation to study the balance of minerals. The results for calcium and magnesium balance differed significantly($p<0.05$)between the two groups. Higher retention values were recorded in gp II for Ca and gp I for Mg. The results with respect to P and Zn did not differ significantly. The results suggest that the levels of Ca in compounded cattle feed at one per cent is better than 0.5 per cent to avoid negative balance of calcium during early lactation, when paddy straw is the sole roughage source. The study also indicates that with the high levels of Ca there is need for Mg supplementation to avoid negative balance arising due to interaction of the two elements.

Introduction

With the declining grass lands and reduced availability of good quality forage, paddy straw forms the sole source of roughage. Antinutritional factors like oxalates, phytates and silica negatively affect calcium availability. As the biological availability of mineral decreases the amount of that mineral needed to meet the cows requirement obviously will increase.

Gowda and Prasad(2005) suggested additional Ca supplementation to meet the Ca requirement when rice straw is fed. Syam Mohan(2003) in his assessment of dietary level of minerals indicated that Ca is the only element that needs to be supplemented under grass based and paddy straw based systems of feeding. Anon (2001) stated that marginally lower negative balance was seen with regard to Ca in dry non- pregnant cows. Also states that poor availability of Ca due to higher oxalate content in paddy straw may be the reason for the slightly negative balance for Ca. This suggest additional Ca supplementation to meet requirement when rice straw is fed.

Numerous research involving the study of this macro mineral point out the need to increase the calcium level particularly after calving. Westerhuis (1975) recommended that after calving calcium in the rations should be greater than 1.0 per cent. Varghese (1989) in his assessment of mineral status of cattle in Kerala observed that most farmers were not following any definite pattern or schedule of feeding with regard to the quantities of concentrate or roughage provided to heifers as well as lactating cows. Indiscriminate addition of mineral supplements, most of them being of substandard quality without ascertaining the mineral content of the feeds and fodders and the mineral status of the animal has complicated the mineral nutrition of the animal especially calcium. IS (1992) recommends the minimum calcium content in compounded cattle feed as 0.50 per cent, while the NRC (1989) specification for calcium in dairy cattle ration is 0.43-0.77 per cent.

Considering all the above factors ,there is much confusion regarding dietary levels of Ca, Hence the study was carried to assess the effect of different levels of dietary Ca on the mineral availability in early lactating cows.

MATERIALS AND METHODS

Twelve healthy cross bred cows at the last month of pregnancy, which had an average peak yield of minimum eight liters in their previous lactation were selected from the herd maintained at the University Livestock Farm and Fodder Research and Development Scheme (ULF & FRDS), College of Veterinary and Animal Sciences, Mannuthy . The cows were divided into two groups (Group I & Group II) of six each as uniformly as possible and allotted to two dietary treatment viz T1(control ration) wherein the compounded cattle feed contained 0.5 per cent calcium as per IS (1992) standards and T2 (experimental ration)where in the compounded cattle feed contained 1.0 per cent Ca. Paddy straw was the sole source of roughage in both the rations. Rations were computed for individual animals as per the ICAR (1999) standards except for dietary calcium. The rations were revised fortnightly based on the individual body weight and milk yield. The daily allowance of concentrate was fed in two equal lots and paddy straw in 3 divided lots to ensure minimum wastage, regularity and uniformity of feeding. The balance of the concentrate and paddy straw left behind by each animal was weighed separately every day to calculate the actual dry matter intake. The animals were milked as per farm routine. A metabolism trial was conducted in the first month of lactation to study the balance of minerals. The mineral composition of the concentrate mixture and paddy straw fed to cows during the metabolism trial are presented in table 1.

The animals were maintained individually on their respective regime from one month before calving to 3 months of lactation. A metabolism trial involving seven days collection period was conducted to study the balance of minerals. Before the commencement of the actual collection period in each balance trial, animals were subjected to a preliminary period of seven days when they were fed from the same consignment of concentrate and paddy straw as that of the collection period and the animals were trained for facilitating easy collection of urine quantitatively. Representative samples of both concentrate and paddy straw were taken every day during the trial for proximate analysis. Dry matter content of the feed was determined everyday and the other components on dry matter basis as per standard methods described in A.O.A.C(1990) using composite samples taken after pooling the samples collected on all seven days of the trial. The Ca, Mg and Zn content in feed and paddy straw were determined by atomic absorption spectrophotometer(Perkin Elmer 3110).The P content in feed was determined by Vanado - Molybdate method (AOAC,1990).

Dung voided by each animal was collected manually in individual containers on a continuous twenty four hour basis during the balance trial. All possible precautions were taken to collect the dung quantitatively uncontaminated by urine, feed residue or dirt. The entire quantity of dung voided by each animal during the previous 24 hours was weighed separately at 8 A.M. on every day and representative samples were taken after through mixing and were kept frozen till they were analyzed. The process of collection, weighing, sampling and preservation of dung was continued till the end of the trial. Aliquots collected on all the seven days of the trial were pooled and composite samples were taken after through mixing for the determination of minerals as per the standard methods described in AOAC. (1990). Another one per cent aliquots of the total dung voided by each animal on all the seven days of the trial were stored in air tight polythene(polyvinyl) bags in frozen state.

Urine from each animal was collected manually in individual containers on a continuous twenty four hour basis during the balance trial, taking all possible precautions to ensure quantitative collection without being contaminated with dung or dirt. the entire quantity of urine collected from each animal during the previous 24 hours was measured separately at 8.A.M. on everyday and one percent duplicate aliquots of the total urine measured into separate labeled containers for each animal. The samples of urine collected were preserved with 100ml of 25 % H_2SO_4 . Composite samples taken from the pooled aliquots were used for the estimation of minerals at the end of the balance trial as per the standard methods described in A.O.A.C (1990).

Milk samples were taken from every animal at each milking on all the seven days of the balance trial. Composite samples were prepared by mixing proportionate quantities (10%) of milk from each of the two milking of every cow. The samples were stored in chilled conditions for analysis of minerals at the end of the balance trial as per the standard methods described in A.O.A .C (1990).

RESULTS AND DISCUSSION

Table 1.Mineral composition of the experimental diets fed to cows during the metabolism trial

Minerals	Concentrate mixture		Paddy straw
	Control	Treatment	
Ca(g/Kg)	5.3	9.5	2.6
P(g/Kg)	7.1	7.1	0.97
Mg(g/Kg)	2.51	2.59	1.02
Zn(g/Kg)	33.33	29.55	41.09

Results of the study are presented in tables and figures as detailed below. Data on the metabolism trials conducted during the first month of lactation with respect to dry matter intake, dry matter out go through dung, output of urine and milk are presented in table 2. The mineral content of dung, milk and urine collected from the experimental animals during the metabolism trial are given in table 3,4 and 5 respectively.

Data on retention of Ca, P, Mg and Zn in experimental animals during first months of lactation are depicted in tables 6 to 9,Consolidated in table 10 and graphically represented in figure 1. The average retention per cent for the animals of group I and II are -14.34 and 17.80 for Ca, 6.39 and 6.80 for P,16.23 and -10.09 for Mg and 56.61 and 58.48 for Zn respectively. Significant difference ($P<0.05$) was obtained for the Ca balance, Mg Balance and per cent retention of Ca and Mg between two groups.

The present study agrees with the observation of Hansard *et al* (1954,1957) who reported an apparent absorption of -19 to 26 for Ca in adult cattle. The values obtained for P balances are in agreement with Kinal *et. al* (1999) who reported an average daily P balance of 3.4 to 11g per day in lactating cows. The results of the present study are suggestive of significant effect of dietary calcium on Mg retention, this may be explained on the basis of mineral interactions existing between Ca and Mg. Jacobson et al (1972) reported that requirement of Mg increased as dietary levels of Ca increased. Chicco et al (1973) recorded that increased concentration of dietary Ca (0.78 per cent) decreases Mg utilization in ruminants and enhanced the urinary loss of Mg. Hence it may be inferred that even though high levels of Ca improve Ca balance there is a need for Mg supplementation to avoid negative balance of the element arising due to interaction of the two elements. Anon(2001) has reported values for percent retention of Zn ranging from 29.45 to 36.54 per cent which are almost similar to those observed in the present study.

No incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were observed in the experimental animals during the course of the experiment. Even though the animals of group I and group II were in negative balance with regard to Ca and Mg respectively, the serum levels of Ca and Mg were within the normal limits . This could be due to homeostatic mechanisms regulating the serum levels. An overall critical evaluation of the results obtained in the present study helps us to infer that Ca at one per cent level in compounded cattle feed is better than 0.5 per cent to avoid negative balance of calcium during early lactation when paddy straw is the sole source of roughage. The current study also indicate that with high levels of dietary calcium there is a need for Mg supplementation to avoid negative balance arising due to interaction of the two elements.

Table.2.Average daily drymatter intake and outgo of dung, urine and milk during the metabolism trial, kg

Animal No.	Body weight	Dry matter intake			Dry matter Outgo	Urine	Milk
		Conc	Straw	Total			
Group I							
1291	338	5.95	6.03	11.98	7.54	66.30	10.47
1262	366	6.47	6.09	12.56	4.85	11.82	13.15
1279	358	6.47	6.19	12.67	4.08	17.10	11.97
Co98	340	6.48	5.75	12.23	3.91	16.7	8.5
T736	330	6.47	5.75	12.22	4.34	9.76	11.57
1276	393	6.47	6.2	12.67	4.89	31.92	11.45
Mean ± SE	354.16 ± 10.4	6.38 ± 0.90	6.00 ± 0.90	12.38 ± 0.12	4.93 ± 1.2	25.60 ± 1.20	11.18 ± 0.70
Group II							
1281	320	6.55	5.94	12.49	5.07	15.19	10.47
1252	388	6.04	6.01	12.06	5.11	23.45	14.38

Co39	346	6.52	6.09	12.61	4.89	24.78	11.21
1223	338	6.51	6.15	12.66	4.06	11.39	9.2
C009	366	6.55	6.10	12.66	4.26	14.83	10.47
1233	381	6.55	5.75	12.31	4.24	15.79	10.1
Mean ± SE	356.5 ± 24.03	6.45 ± 0.90	6.00 ± 0.06	12.46 ± 0.10	4.60 ± 0.19	17.57 ± 8.31	10.97 ± 0.80

Table 3.Mineral composition of dung voided by experimental animals during the metabolism trial

Animal No.	Parameter			
	Group I			
	Ca(g/kg)	P(g/kg)	Mg(g/kg)	Zn(ppm)
1291	9.67	10.94	5.72	30.2
1262	8.90	7.80	4.16	31.5
1279	10.22	7.71	4.22	29.2
Co98	10.10	8.30	2.67	30
T736	7.60	7.50	2.74	28.2
1276	9.96	7.95	2.09	31.6
Mean ± SE	9.40 ± 0.44	8.36 ± 0.57	3.60 ± 0.29	29.25 ± 1.2
Group II				
1281	10.12	8.80	4.87	28.3
1252	9.90	7.70	3.42	26.5
Co39	9.49	7.00	4.53	27
1223	10.85	7.00	4.79	28.2
Coo9	10.40	6.81	3.42	33.2
1233	10.19	7.95	4.68	25.06
Mean ± SE	10.16 ± 0.21	7.54 ± 0.34	4.28 ± 0.30	28.77 ± 0.17

Table 4. Mineral composition of milk voided by experimental animals during the metabolism trial.

Animal No.	Parameter			
	Group I			
	Ca(g/kg)	P(g/kg)	Mg(g/kg)	Zn(ppm)
1291	1.40	1.04	0.08	4.60
1262	0.80	0.70	0.08	3.55
1279	0.95	0.90	0.06	4.00
Co98	0.945	1.07	0.08	4.60
T736	1.02	0.9	0.10	4.90
1276	0.95	0.93	0.10	5.00
Mean ± SE	1.01 ± SE	0.92 ± 0.05	0.08 ± 0.01	4.54 ± 0.31
Group II				
1281	0.99	1.10	0.07	4.85
1252	0.80	0.95	0.06	3.00
Co39	0.98	0.99	0.10	5.60
1223	1.14	1.13	0.09	5.00
Coo9	0.84	1.02	0.08	5.90
1233	1.00	1.10	0.08	4.90
Mean ± SE	0.95 ± SE	1.04 ±0.03	0.08 ± 0.01	4.87 ± 0.45

Table 5. Mineral composition of urine voided by experimental animals during the metabolism trial.

Animal No.	Parameter			
	Group I			
	Ca(g/kg)	P(g/kg)	Mg(g/kg)	Zn(ppm)
1291	0.12	0.02	0.16	0.04
1262	0.17	0.03	0.18	0.06

1279	0.11	0.02	0.17	0.06
Co98	0.17	0.02	0.185	0.03
T736	0.08	0.10	0.22	0.04
1276	0.34	0.06	0.17	0.04
Mean ± SE	0.16 ± - 0.03	0.04 ± 0.01	0.18 ± 0.01	0.04 ± 0.04
Group II				
1281	0.18	0.06	0.17	0.03
1252	0.14	0.02	0.18	0.02
Co39	0.19	0.08	0.10	0.03
1223	0.15	0.003	0.27	0.03
Coo9	0.14	0.08	0.18	0.02
1233	0.21	0.06	0.14	0.04
Mean ± SE	0.17 ± 0.01	0.05 ± 0.01	0.17 ± 0.01	0.02 ± 0.03

6. Calcium balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
Ca intake(g/day)		
Concentrate	33.85 ± 0.74	61.35 ± 0.87
Straw	15.59 ± 0.23	15.61 ± 0.017
Total	49.44 ± 0.87	76.98 ± 0.87
Ca outgo(g/day)		
Dung	40.64 ± 2.68	40.26 ± 8.02
Urine	4.68 ± 1.53	4.62 ± 1.66
Milk	11.21 ± 0.89	11.70 ± 1.12
Total	56.54 ± 4.38	63.27 ± 2.70
Ca balance(g/day)	-7.09 [a] ± 4.05	13.71 [b] ± 2.96
Per cent retention of Ca	-14.34 [a] ± 8.20	17.80 [b] ± 3.76

a, b - Values with different superscripts in the same row differ significantly between groups($P<0.05$)

Table 7. Phosphorus balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
P intake(g/day)		
Concentrate	45.35 ± 0.65	46.07 ± 0.70
Straw	5.81 ± 0.08	5.82 ± 0.06
Total	51.17 ± 0.68	51.90 ± 0.70
P outgo(g/day)		
Dung	37.12 ± 4.63	34.92 ± 2.27
Urine	0.86 ± 0.29	2.01 ± 1.03
Milk	9.89 ± 0.35	11.40 ± 0.52
Total	47.89 ± 4.74	48.36 ± 3.85
P balance (g/day)	3.27 ± 5.32	3.53 ± 4.16
Per cent retention of P	6.39 ± 3.50	6.80 ± 5.88

Table 8. Magnesium balance of experimental cows maintained on two dietary treatments during the metabolism trial.

Treatments	Group I	Group II
Number of cows	6	6
Mg intake(g/day)		
Concentrate	16.61 ± 0.25	16.14 ± 0.22

Straw	6.11 ± 0.09	6.28 ± 0.19
Total	22.72 ± 0.25	22.43 ± 0.32
Mg outgo(g/day)		
Dung	13.78 ± 1.82	20.60 ± 1.12
Urine	4.26 ± 1.50	3.20 ± 0.43
Milk	0.99 ± 0.15	0.86 ± 0.06
Total	19.04 ± 2.27	24.66 ± 1.29
Mg balance(g/day)	3.69 [a] ± 2.42	-2.25 [b] ± 2.91
Per cent retention of Mg	16.23 [a] ± 10.78	-10.09 [b] ± 5.77

a, b - Values with different superscripts in the same row differ significantly between groups(P<0.05)

Table 9. Zinc balance of experimental cows maintained on two dietary treatments during the metabolism trial.

Treatments	Group I	Group II
Number of cows	6	6
Zn intake(mg/day)		
Concentrate	212.62 ± 3.17	190.63 ± 2.68
Straw	246.60 ± 3.76	246.81 ± 2.68
Total	459.22 ± 4.73	437.44 ± 3.66
Zn outgo(mg/day)		
Dung	148.54 ± 18.13	106.25 ± 6.75
Urine	1.10 ± 0.37	0.47 ± 0.07
Milk	49.09 ± 2.17	52.32 ± 3.65
Total	198.74 ± 18.51	181.65 ± 8.76
Zn balance(mg/day)	260.48 ± 21.24	255.78 ± 8.17
Per cent retention of Zn	56.61 ± 4.35	58.48 ± 1.89

Table. 10. Consolidated data on mineral balance during the metabolism trial

Parameter	Average retention (% of intake)	
	Group I	Group II
Ca	-14.34 ± 8.20	17.80 ± 3.76
P	6.39 ± 3.50	6.80 ± 2.63
Mg	16.23 ± 10.78	-10.09 ± 5.77
Zn	56.61 ± 4.35	58.48 ± 1.89

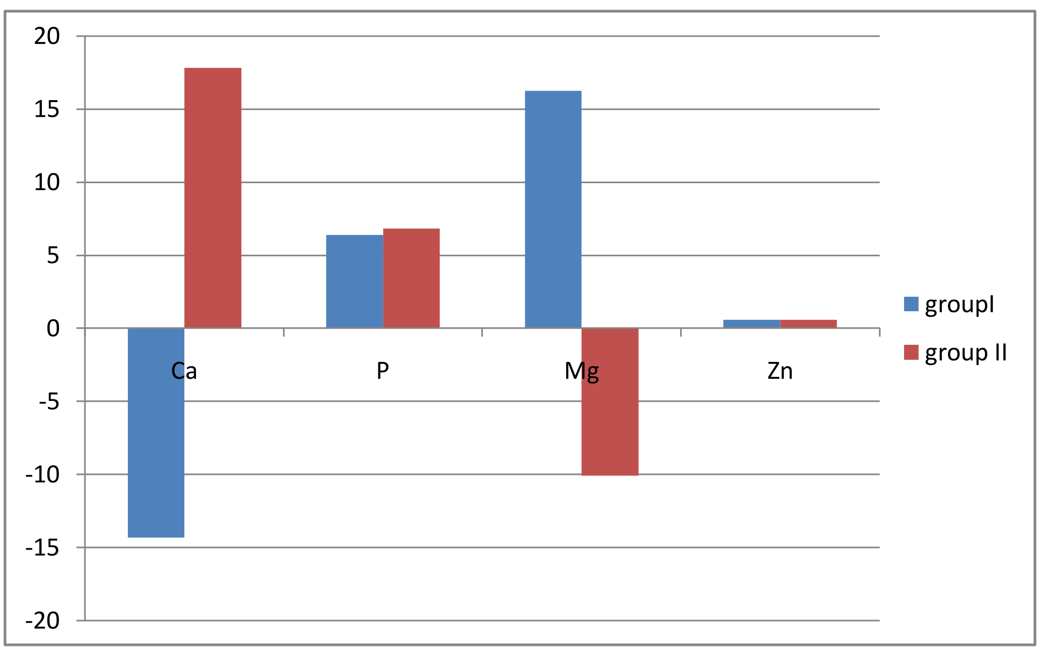

Fig 1. Mineral balance of experimental cows maintained on two dietary treatments

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