IRON, COPPER, COBALT AND MANGANESE REQUIREMENTS IN MILK-FED CROSSBRED CALVES

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Summary

A balance study was conducted to determine the requirements of iron, copper, cobalt and manganese in crossbred calves. Six calves were fed milk average 10 percent of their body weight and were supplemented with 15 g mineral mixture daily. A balance trial was conducted at 2½ months of age. The primary route of excretion was through digestive tract as 99.87, 80.99, 77.27 and 99.94 percent of Fe, Cu, Co and Mn were excreted through faeces. The requirements of Fe, Cu, Co and Mn were computed using the respective mineral balance data and were found to be 169.60, 7.20, 4.48 and 8.89 mg/kg respectively.

(Key Words: Trace Elements, Metabolism, Requirements, Calves, Iron, Copper, Cobalt, Manganese)

Introduction

Calves display intensive growth and mineral deposition during the first few months of their life. Milk, which is the principal diet during this period, is deficient in iron, copper, zinc and manganese (Sonawane, 1975). Young animals are also susceptible to cobalt deficiency because of their higher cobalt requirement for rapid growth and higher metabolic rate. Trace mineral supplementation thus appears essential for young calves fed on milk diets. The wide variations in mineral requirements have been reported in literature (Ellendorff and Smith, 1967; NRC, 1978; Georgievskii et al., 1982). Jenkins and Hidiriglou (1987) did not observe any toxic effects in preruminant calves supplemented with 5000 mg/kg iron, whereas, the requirements is only 100 mg/kg (NRC, 1978). Similar variations in mineral tolerance exist for other minerals as well (Cunningham et al., 1966; Ranjhan, 1980). Keeping in view these huge variations, an attempt was made to find out the requirements of some essential trace elements in milk fed calves.

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Materials and Methods

Six male crossbred calves were weaned at birth and were housed individually on iron cots painted with plastic paint to avoid any contamination. They were fed colostrum about 1/10th of their body weight for first 5 days and subsequently milk at the same rate upto 2½ months of age. The total milk requirement was fed in two instalments i.e in the morning at 9.00 hours and evening at 16.00 hours. Each calf was supplemented with 15 g mineral mixture (table 1) since day 10 of his age. A metabolic trial of 5 days duration was conducted. The total faeces voided during 24 hours was quantitatively collected and kept in a separate plastic bucket covered with lid. Each

TABLE 1. COMPOSITION OF MINERAL MIXTURE(KG)

Chemical name	Composition
Dicalcium phosphate	1.6500
Chalk powder	0.3312
Sodium chloride	0.9000
Magnesium carbonate	0.0900
Ferrous sulphate	0.0150
Zinc sulphate	0.0075
Copper sulphate	0.0021
Manganese dioxide	0.0021
Cobalt chloride	0.0015
Potassium iodide	0.0003
Sodium fluoride	0.0003

bucket was previously weighed and labelled for the respective animal. A polythene sheet was laid under the cots to protect the dung from contamination. The urine was collected in the plastic carboy by harnessing the animal. The composites of daily milk samples were homogenized and subjected to ashing prior to dilution for mineral analysis. The composites of mineral mixture, faeces (after drying) and urine were subjected to wet oxidation (Reitz et al., 1960) and diluted for further analysis on Flame Automic Absorption Spectrophotometer having stainless steel atomizer. From the balance data of each mineral, requirements were calculated using multiple regression analysis (Ahuja and Arora, 1980).

Results

The body weights at the start and end of the balance trial averaged 44.18 and 47.15 kg, respectively with a mean of 45.86 kg at which the requirements were computed. The mean dry matter intake was 0.66 kg daily in calves. The mineral composition of milk, mineral mixture and water is depicted in table 2. The copper and cobalt intakes were slightly less than their total excretion in faeces and urine (table 3) leading to just negative balances. But, the intakes of iron and manganese were sufficiently low to maintain their balances in the body (table 3). The excretion through faeces of the total excretion was 99.87, 80.99, 77.27 and 99.94 percent for Fe, Cu, Co and Mn respectively. The excretion through urine was 19.01% for Cu and 22.73% for Co and it was negligible for Fe and Mn. The apparent absorption as determined by substracting faecal excretion from the dietary intake of the mineral was found to be −74.64, 18.53, 21.45 and −169.44 percent for Fe, Cu, Co and Mn respectively (*table 3*). The mineral balance data was put to multiple regression analysis to find out the requirement as follows;

$$Y = a + b_1 X_1 + b_2 X_2$$

where,

Y = mineral intake (mg/d)
X_1 = *body weight* (kg)
X_2 = mineral balance (mg/d)
b_1 = mineral retained/kg body weight/d
b_2 = mineral required/mg *mineral retained*
a = constant representing the amount of mineral not attributable to any specific variable.

The correlation coefficients for all the minerals and different variables used were highly significant ($p < 0.01$, table 4) inspite of the mineral balances being negative. Therefore, multiple regression equations were developed (table 4) to find out the

TABLE 2. MINERAL COMPOSITION OF DIET (MG/KG)

Diet	*Iron*	*Copper*	*Cobalt*	*Manganese*
Milk	15.38	0.42	0.09	0.23
Mineral *mixture*	2280.00	245.00	170.00	315.00
Water	0.00	0.00	0.00	0.03

TABLE 3. BALANCE DATA OF Fe, Cu, Co AND Mn IN CALVES.

Parameters	Fe	Cu	Co	Mn
Intake through milk (mg/d)	76.9	2.10	0.48	1.17
Intake through mineral mixture (mg/d)	34.2	3.08	2.55	4.72
Total intake (mg/d)	111.1± 5.61	5.18 ±0.15	3.03 ±0.04	5.89± 0.08
Intake/kg body wt. (mg/d)	2.42	0.113	0.066	0.128
Faecal losses (mg/d)	194.03 ± 39.17	4.22 ± 0.62	2.38 ± 0.32	15.87 ± 2.10
Urinary losses (mg/d)	0.25 ± 0.11	0.99 ± 0.15	0.70 ± 0.06	0.06 ± 0.004
Total excretion (mg/d)	194.28 ± 39.19	5.21 ± 0.71	3.08 ± 0.32	15.88 ± 2.10
Balance (mg/d)	−83.18 ± 37.16	−0.03 ± 0.71	−0.05 ± 0.31	−0.99 ± 2.05
Faecal losses as % of total losses	99.87	80.99	77.27	99.94
Urinary losses as % of total losses	0.13	19.01	22.73	0.04
Apparent mineral absorption (%)	−74.64	18.53	21.45	−169.44

TABLE 4. REGRESSION EQUATIONS AND REQUIREMENTS OF Fe, Cu, Co, AND Mn IN CALVES

Element	Equation	Correlation[a]	Requirement		
			mg/day[b]	mg/kg BW	mg/kg in diet
	$Y = a+b_1X_1 + b_2X_2$				
Iron	$Y = 28.59 + 1.84X_1 + 0.026X_2$	0.96	112.97	2.460	169.60
Copper	$Y = 2.98 + 0.05X_1 + 0.034X_2$	0.97	5.27	0.115	7.20
Cobalt	$Y = 2.45 + 0.012X_1 + 0.023X_2$	0.96	3.00	0.065	4.48
Manganese	$Y = 4.72 + 0.026X_1 + 0.003X_2$	0.96	5.91	0.129	8.89

[a]All correlation coefficients were significant ($p < 0.01$)
[b]Calculated by using regression when mineral balance (x_2) = 0

requirements as follows.

At element balance (X_2) zero, the intake by animals can be assumed to be as the maintenance requirement.

Hence, $Y = a+b_1X_1$

Maintenance requirement per kg body weight is

$$\frac{Y}{X_1} = \frac{a+b_1X_1}{X_1}$$

or

$$\frac{Y}{X_1} = \frac{a}{X_1} + b_1$$

The requirements for Fe, Cu, Co and Mn were thus found to be 2.46, 0.115, 0.065 and 0.129 mg/kg body weight or 169.60, 7.20, 4.48 and 8.89 mg/kg (table 4) in the diet respectively in milk fed calves.

Discussion

The normal level of iron in milk has been reported to vary between 0.39-1.03 mg/kg milk (Heine et al., 1978; Mouillet, et al., 1978). The iron level in this study was 15.38 mg/kg which is very high. The reason might be that the milk was boiled in iron troughs before feeding to check any microbial contimination. The other minerals in milk were well in the normal range. Mineral supplementation in milk-fed calves is essential as milk is deficient in trace minerals (Sonawane, 1975). In this experiment, 34.2, 3.08, 2.55 and 4.72 mg of Fe, Cu, Co and Mn were supplemented daily to the milk fed calves (table 3) and the balances were still negative. The supplementation of even 60 mg Fe daily to Holsstein calves was found to be inadequate for maintaining their optimum blood haemogolobin levels (Ellendorff and Smith, 1967). Thomas (1970) recommended more than 60 mg Fe daily for calves receiving whole milk in order to maintain their normal haematological status. The increased apparent Fe absorption (−74.64%) might be due to the increased physiological needs caused by negative balance. Large amounts of minerals are secreted in the gastro-intestinal tract. Since absorption and secretion processes take place in the tract at the same time, neither of the process can be properly evaluated. So, endogenous iron might also be getting excreted through the faeces resulting in more excretion than its dietary intake. The excretion of Fe mainly occurs through the digestive tract (Malhotra, 1983; Kumar and Kaur, 1987). The daily requirement of iron using balance data was worked out to be 112.97 mg which is closer to daily intake of 111.10 mg and therefore should be sufficient to maintain the mineral balance. But, it seems that the actual availability of Fe was less from the dietary source leading to more faecal losses (194.03 mg/d). Hence, availability rather than intake is more important in maintaining the mineral balance. The iron requirement per Kg dry feed comes to 169 mg/kg (table 4). NRC (1978) has recommended an intake of 110 mg/kg Fe as adequate for calves whereas Kalnitskii et al. (1982) observed Fe requirement in the range of 56-350 mg/day in calves growing at 700 g per day.

The apparent absorption of copper was 18.53% similar to earlier reparts in calves (Suttle, 1979). Since the Cu balance was just negative, the supplementation of 3.08 mg Cu through mineral mixture appeared sufficient at this age. The Cu requirement of 7.20 mg/kg (table 4) is quite close to the NRC (1978) requirement of 10 mg/kg for calves. The excretion through urine was 19.01 % for Cu in this study. Georgievskii et al. (1982) have also reported 12-13 % Cu excretion in calves. Cobalt excretion through urine was 22.73% whereas Comar et al. (1948) observed only 0.5% excretion. Monogastrics have been reported to excrete more Co in urine than ruminants (Georgievskii et al., 1982). Since the calves in this study were in their pre-ruminant stage, the higher Co excretion through urine might be due to this reason. Cobalt requirement was found to be 4.48 mg/kg which is higher than the NRC (1978) recommendations. But, Malhotra (1983) reported 9.14 mg/kg Co requirement in six months old calves. As in the present findings, Mn had been accounted almost all to the extent of 98% in faeces while little or no excretion occurred through urine (Thomas, 1970; Grace and Gooden, 1980). NRC (1978) has reported 40 mg/kg Mn requirement for calves whereas it was found to be 8.89 mg/kg in this study. In summary, the balance data suggested 169.60, 7.20, 4.48 and 8.89 mg/kg requirement of Fe, Cu, Co and Mn in the diet of milk fed crossbred calves.

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