A STUDY ON NUTRITIONAL STATUS OF TRACE MINERALS OF CATTLE IN JAVA IN INDONESIA

H. Kumagai[1], N. Ishida, M. Katsumata, H. Yano,
R. Kawashima and J. Jachja[2]

Department of Animal Science, Faculty of Agriculture,
Kyoto University, Kyoto-shi 606, Japan

Summary

The nutritional status of trace minerals in cattle of Java in Indonesia was investigated by evaluating Cu, Fe, Mo, Zn and Mn concentrations in diets and livers, and Cu and Zn concentrations in blood plasma. Investigations were conducted on Jonggol (West Java), Malang (East Java) and Mojokerto (East Java) in both the rainy and the dry seasons in 1988. In Jonggol, low Cu concentrations in diets showing 7.1 mg/kg in the rainy season and 10.9 mg/kg in the dry season were observed and all plasma samples showed Cu concentrations below the critical level (0.65 μg/ml). Thirty percent of the liver samples in Malang and 54% of those in Mojokerto showed lower Cu concentrations than the critical level (75 mg/kg on a dry matter basis). Fe concentrations in diets from the three regions showed a wide variation of values ranging from 249 to 30,000 mg/kg. A large amount of Fe was accumulated in livers from Malang and Mojokerto, giving average concentrations of 498 mg/kg. Zn concentrations in diet and plasma samples were close to the borderline and some Zn concentration in these samples showed deficient levels. Mo and Mn concentrations in diets and livers showed normal levels.
(Key Words: Java in Indonesia, Cattle, Dietary Cu, Fe, Mo, Zn and Mn, Liver Cu, Fe, Mo, Zn and Mn, Plasma Cu and Zn)

Introduction

Most beef cattle production in tropical Asia relies on native grasses and agricultural by-products. Under such conditions cattle have often suffered from mineral imbalances. A previous study (Kumagai et al., 1990) indicated that a low P concentration and a high Ca:P ratio in diets were likely to induce low plasma inorganic phosphorus concentration in cattle from Jonggol in Java. Recently other investigations in tropical Asia have indicated imbalances of trace mineral concentrations in diets and tissues such as blood and liver. Vijchulata et al. (1983) reported low Cu and wide variety of Fe concentrations in diets and low Cu concentrations in blood plasma and livers of cattle from Central Thailand. Hayashi et al. (1985) indicated low Cu concentrations in diets and blood plasma of cattle from some pastures around Medan in Sumatra. However, available information concerning the trace mineral status of cattle in tropical Asia is limited and the relationship between mineral concentrations of diets and animal tissues is still obscure.

In the present study, the nutritional status of trace minerals of cattle in Java, Indonesia was examined by evaluating trace mineral concentrations in diet, liver and blood plasma samples. Se and Co status of cattle in the country will be discussed in another report.

Materials and Methods

Description of cattle, location and season for sample collection, methods for the blood and diet sample collection and preparation of samples are described by Kumagai et al. (1990).

Collection of liver samples

About 50g of liver samples were collected from lobus caudatus of the livers of cattle which were slaughtered in Malang and Mojokerto. Samples were washed by saline, put in clean polyvinyl bags and frozen with dry ice. They were freeze-dried and ground by a ball mill after they were brought to Japan.

[1]Address reprint requests to Dr. H. Kumagai, Department of Animal Science, Faculty of Agriculture, Kyoto University, Kyoto-shi 606, Japan.
[2]Department of Animal Nutrition and Feed Science, Bogor Agricultural University, Bogor, Indonesia.
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Analytical methods

One gram of each diet and liver sample and one milliliter of each plasma sample were digested in 10 ml of a 4:1 mixture of 60% nitric and perchloric acids. The concentrations of Cu, Fe, Mo, Zn and Mn were measured by atomic absorption spectrophotometry.

Statistical analysis

The mineral concentrations in diet, liver and plasma samples were statistically analyzed as a following mathematical model:

$$Y = \mu + Ri + Sj + (RS)ij + Eijk$$

where

Y = each mineral concentration
μ = the overall mean
Ri = the effect associated with sampling region
Sj = the effect associated with sampling season
(RS)ij = the interaction effect between sampling region and season
Eijk = residual

All statistical analyses were conducted by using General Linear Model (GLM) procedure of Statistical Analysis System (SAS) program package (Barr et al., 1985). The null hypothesis that a pair of least square means in each effect is equal was tested.

Results

Mineral concentrations in diets

Species and mineral concentrations of diet samples are presented in table 1. Mean mineral concen-

TABLE 1. SPECIES AND MINERAL CONCENTRATIONS OF DIETS FROM THREE REGIONS IN JAVA OF INDONESIA

Region	Season	Species of diets	Number of samples	Cu	Fe	Mo	Zn	Mn
				mg/kg on a dry matter basis				
Jonggol	Rainy	*Cynodon dactylon*	2	9.8	8,610	2.41	51.3	170
		Imperata cylindrica	2	3.9	462	0.41	20.6	21
		Oplismenus undalatifolius	2	8.3	3,770	1.23	37.8	173
		Paspalum dilatatum	2	5.5	372	0.27	32.1	121
		Setaria sphacelata	1	8.9	249	0.61	48.8	358
	Dry	*Cynodon dactylon*	1	9.6	2,100	2.01	51.3	303
		Imperata cylindrica	1	6.8	905	1.45	45.8	70
		Setaria sphacelata	2	13.5	545	0.98	56.5	403
Malang	Rainy	corn stover	2	13.4	6,720	0.54	34.5	124
		Cynodon dactylon	2	13.9	4,770	1.67	49.0	150
		sweet potato vine	1	36.4	11,600	0.28	32.9	236
		chopped native grass[a]	2	13.4	2,460	0.78	25.8	104
	Dry	corn stover	1	9.7	1,607	1.59	45.6	46
		rice straw	2	6.2	957	1.15	42.4	559
		sugar cane leaf	2	10.2	2,370	1.41	29.4	64
		chopped native grass[a]	3	13.0	2,570	1.08	42.3	140
Mojokerto	Rainy	chinese yam skin	1	24.6	30,000	0.28	54.5	384
		Cynodon dactylon	1	10.2	2,620	3.06	46.3	90
		sweet potato vine	1	19.0	2,670	0.94	31.4	71
		chopped native grass[a]	4	21.9	10,000	1.27	69.5	199
	Dry	corn stover	1	5.4	540	0.33	10.9	79
		Cynodon dactylon	2	12.0	2,330	0.95	54.4	68
		sugar cane leaf	1	4.3	933	2.03	18.5	34
		chopped native grass[a]	2	18.2	6,304	1.74	46.7	308

[a]Species are undefined.

trations of diet samples and results of statistical analyses are presented in table 2. The Cu concentrations in diets ranged from 3.9 to 36.4 mg/kg and a significant difference was found between Jonggol and Mojokerto ($p < 0.01$). The Fe concentrations in diets showed a wide variation of values ranging from 249 to 30,000 mg/kg and the overall mean of Fe concentration was 4,400 ± 6,990 (mean ± SD) mg/kg. The Mo and Zn concentrations in diets ranged from 0.27 to 3.06 mg/kg and from 10.9 to 69.5 mg/kg, respectively. An analysis of Mn concentrations showed a wide variation of values ranging from 21 to 559 mg/kg and the overall mean of Mn concentration was 181 ± 164 mg/kg.

TABLE 2. MINERAL CONCENTRATIONS IN DIETS FROM THREE REGIONS IN JAVA OF INDONESIA

Season	Number of samples	Cu	Fe	Mo	Zn	Mn
		mg/kg on a dry matter basis				
				Jonggol		
Rainy	9	7.1 (2.4)[a]	2,960 (4,080)	0.82(0.90)	36.9(12.7)	147(110)
Dry	4	10.9 (4.3)	1,020 (740)	1.35(0.57)	52.5 (5.1)	295(203)
				Malang		
Rainy	7	15.0 (9.7)	5,640 (4,370)	1.14(0.61)	35.9(12.8)	142 (67)
Dry	8	10.2 (3.2)	2,000 (1,030)	1.24(0.39)	39.5(14.2)	213(274)
				Mojokerto		
Rainy	7	20.2(10.3)	10,760(14,710)	2.07(0.89)	58.6(17.1)	192(158)
Dry	6	11.7 (6.0)	3,120 (2,700)	1.29(0.70)	38.6(21.7)	144(140)
Overall mean	41	12.6 (7.8)	4,400 (6,990)	1.17(0.71)	42.7(16.2)	181(164)
		Significance of differences between means				
Region		**	NS	NS	NS	NS
Season		NS	*	NS	NS	NS
Region × Season		NS	NS	NS	NS	NS

* $p < 0.05$, ** $p < 0.01$, NS not significant
[a] mean (SD)

Mineral concentrations in livers

Results are presented in table 3. The liver Cu concentrations were extremely variable from 9 to 369 mg/kg and the overall mean of Cu concentrations was 123 ± 90 (mean ± SD) mg/kg. The liver Fe concentration showed a wide variety of values ranging from 211 to 1,223 mg/kg and the overall mean of Fe concentrations was 498 ± 205 mg/kg. The overall mean of Mo, Zn and Mn concentrations in livers were 2.98 ± 0.59, 145 ± 30 and 9.08 ± 1.93 mg/kg, respectively.

Mineral concentrations in blood plasma

Results are presented in table 4. The mean plasma Cu concentration in Jonggol was 0.22 μg/ml in both rainy and dry seasons. The plasma Cu concentrations in Jonggol were significantly lower than those from Malang and Mojokerto ($p < 0.01$). The overall mean of plasma Zn concentrations was 0.87 μg/ml and no significant difference was observed among regions and between seasons.

Discussion

Because of a limited number of diet samples and a wide variation of dietary mineral concentrations, it is difficult to estimate the mineral concentrations in diets which were actually fed by cattle. However, the Fe concentrations in diet samples from three regions are higher than those from Japan which have been examined in a previous study. Takahashi (1978) reported that the Fe con-

TABLE 3. MINERAL CONCENTRATIONS IN LIVERS OF CATTLE FROM TWO REGIONS IN JAVA OF INDONESIA

Season	Number of samples	Cu	Fe	Mo	Zn	Mn
		mg/kg on a dry matter basis				
				Malang		
Rainy	25	148(106)[a]	541(230)	2.72(0.58)	161(35)	9.46(2.12)
Dry	25	156 (90)	555(205)	2.91(0.64)	135(25)	8.93(1.31)
				Mojokerto		
Rainy	25	99 (66)	440(189)	3.15(0.53)	139(27)	10.40(1.96)
Dry	25	89 (79)	441(174)	3.15(0.55)	144(28)	7.49(1.01)
Overall mean	100	123 (90)	498(205)	2.98(0.59)	145(30)	9.08(1.93)
		Significance of differences between means				
Region		**	*	**	NS	NS
Season		NS	NS	NS	NS	**
Region x Season		NS	NS	NS	**	**

* $p < 0.05$, ** $p < 0.01$, NS not significant
[a] mean (SD)

TABLE 4. PLASMA MINERAL CONCENTRATIONS OF CATTLE FROM THREE REGIONS IN JAVA OF INDONESIA

Season	Number of samples	Cu	Zn
		μg/ml	
		Jonggol	
Rainy	19	0.22(0.12)[a]	0.91(0.11)
Dry	19	0.22(0.10)	0.89(0.10)
		Malang	
Rainy	25	0.95(0.17)	0.83(0.14)
Dry	25	0.81(0.20)	0.85(0.16)
		Mojokerto	
Rainy	25	0.75(0.15)	0.89(0.18)
Dry	25	0.86(0.16)	0.87(0.20)
Overall mean	138	0.66(0.33)	0.87(0.16)
		Significance of differences between means	
Region		**	NS
Season		NS	NS
Region x Season		**	NS

** $p < 0.01$, NS not significant
[a] mean (SD)

centrations in pasture samples from 76 regions in Japan ranged from 52 to 322 mg/kg. The high Fe concentrations of diet samples in this study might be induced by two causes, i.e., Fe accumulation in plant and soil contamination. Under the reducing conditions of a high and fluctuating soil water table, especially in the presence of oxidisable organic matter, plant-available ferrous iron greatly increases (Islam et al., 1954). An Fe concentration in soil is much higher than that in forage. Leech et al. (1987) suggested that the high Fe concentrations in pasture from some regions in England might be due to soil contamination. Further investigations should be made to explain the cause of high Fe concentrations in diets.

Campbell et al. (1974) reported that the liver Fe concentrations in calves, which were fed with a diet containing 1,981 mg/kg of Fe for 202 days, increased to 460 mg/kg. The mean Fe concentrations in diet samples from Malang and Mojokerto were higher than 2,000 mg/kg (table 2) and the overall mean of Fe concentrations in liver samples from Malang and Mojokerto were 498 mg/kg (table 3). It is considered that the high liver Fe concentrations in Malang and Mojokerto may have been caused by the high Fe concentrations in diets from these regions.

Harada et al. (1976) reported that the liver Cu concentrations of steers fed a diet with 295 mg/kg of Fe were lower than those of steers fed a diet with 11 mg/kg of Fe. Campbell et al. (1974) reported that the liver Cu concentrations of calves fed a diet with 1,981 mg/kg of Fe for 202 days decreased to 7 mg/kg. These studies indicated that a high level of Fe in diets influenced Cu metabolism in cattle. In the present study, 30% of the liver samples in Malang and 54% of those in Mojokerto showed Cu concentrations below 75 mg/kg which is the critical level recommended by McDowell et al. (1983). The lowest Cu concentration was only 9 mg/kg in Malang and 10 mg/kg in Mojokerto. In both of the two regions, the Fe concentrations in diets showed a high level. The low liver Cu concentrations in Malang and Mojokerto were probably due to the high Fe concentrations in diets.

McDowell et al. (1983) recommended that the critical level of plasma Cu concentration was 0.65 μg/ml. The Cu concentrations of all plasma samples in Jonggol were below the critical level and the lowest Cu concentration was only 0.09 μg/ml. NRC (1984) recommended that the Cu requirement for beef cattle was 4-10 ppm. The Cu level in diets from Jonggol was regarded as marginal because most of the diet samples ranged from 4 to 10 mg/kg (table 1). Campbell et al. (1974) reported that the plasma Cu concentrations in calves, which were fed with the diet containing 1,981 mg/kg of Fe, decreased to 0.33 μg/ml. The mean Fe concentration in diets from Jonggol were 2,960 ppm in the rainy season and 1,020 mg/kg in the dry season (table 2). It is likely that not only the marginal Cu concentration but also the high Fe concentration in diets caused the low plasma Cu concentrations of cattle from Jonggol.

Ward (1978) indicated that a high level of Mo (> 20 mg/kg) or a narrow Cu:Mo ratio (< 2.0) induced Cu deficiency in cattle. In the present study, the maximum Mo concentration in diet was 3.06 mg/kg and no sample showed a Cu:Mo ratio below 2.0 (table 1). Underwood (1971) reported that the liver Mo concentrations of cattle was 2-4 mg/kg on normal diets. Most of the liver samples from Malang and Mojokerto ranged from 2 to 4 mg/kg. Judging from the Mo concentrations in diet and liver samples, the Mo concentrations in diets from three regions were normal and were not likely to influence the Cu metabolism in cattle.

The range of Zn requirement for beef cattle is from 20 to 40 mg/kg according to the NRC standard (1984). In the present study, 42% of the diet samples showed Zn concentrations between 20 and 40 mg/kg and 7% of the samples showed Zn concentrations below 20 mg/kg. McDowell et al. (1983) recommended that a plasma Zn concentration of 0.6-0.8 μg/ml was a indicator of Zn deficiency. Twenty six percent of the plasma samples showed Zn concentration between 0.6 and 0.8 μg/ml and 4% of the samples showed Zn concentrations below 0.6 μg/ml in the three regions. Judging from the Zn concentrations in diets and plasma, the Zn status of cattle in three regions was close to the borderline or was deficient.

McDowell et al. (1983) concluded that Mn deficiency can be detected by the combination of diet and liver analyses. The overall mean of Mn concentrations in diets was much higher than the NRC standard requirement (1984) of 20-50 mg/kg for beef cattle and all the liver samples except one exceeded the critical level of 6 mg/kg recommended by McDowell et al. (1983). The Mn concentrations in diet and liver samples indicated that the Mn intake of cattle was sufficient in the three regions.

The present study indicated that the cattle in Jonggol, Malang and Mojokerto were likely to be low in Cu status judging from the low plasma Cu concentrations in Jonggol and the low liver Cu concentrations in Malang and Mojokerto. One of the causes of low plasma Cu concentrations in Jonggol was likely due to the low Cu concentrations in diets, moreover, the high Fe concentrations in diets may have influenced the plasma Cu level in Jonggol. The high Fe concentration in diet was likely to decrease the liver Cu concentrations in Malang and Mojokerto. Standish et al. (1969) indicated that a concentration of 400 mg/kg Fe in diets resulted in not only decreasing Cu concentrations in livers but also depressing feed intake and average daily gain. It is obscure that such symptoms of Fe excess are observed in the three regions in Java. However, special attention should be paid to the low Cu and excessive Fe concentrations in diets of cattle in Java, Indonesia.

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