CONCENTRATION OF SEVEN HEAVY METALS IN THE KIDNEY OF CATTLE AND BUFFALOES, AND A PRELIMINARY STUDY OF INTERACTION BETWEEN METALS IN THE TISSUE

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ABSTRACT

Twenty-six and nineteen kidney samples of cattle and buffaloes respectively were collected from slaughter houses in Bandung and Sukabumi. Both species were transported from East Java for meat consumption. Tissue of the kidney was analysed for Cu, Cd, Zn, Pb, Co, Mn and Fe levels by atomic absorption spectrophotometry. The results indicated that Cu, Zn and Mn levels were higher in cattle ($P < 0.01$), but Cd and Fe levels were higher in buffaloes ($P < 0.05$). Significant positive correlation ($P < 0.01$) between the metal pairs Zn:Fe and Co:Pb in both animal species suggests that there is no competition in binding site between these elements in the tissue. However the overall metal concentrations observed in the kidneys of both species were still in the normal range.

ABSTRAK

Masing-masing 26 dan 19 sampel ginjal dari sapi dan kerbau diambil dari Rumah Potong Hewan Bandung dan Sukabumi. Ternak-ternak tersebut didatangkan dari daerah Jawa Timur untuk konsumsi daging di daerah pemotongan. Jaringan tersebut dianalisa kandungan Cu, Cd, Zn, Pb, Co, Mn dan Fe dengan menggunakan alat spektrofotometer serapan atom (SSA). Hasilnya menunjukkan bahwa kandungan Cu, Zn dan Mn lebih tinggi dalam ginjal sapi daripada kerbau ($P < 0,01$), tetapi kandungan Cd dan Fe lebih tinggi dalam ginjal kerbau ($P < 0,05$). Korelasi positif ($P < 0,01$) ditemukan antara Zn:Fe dan Co:Pb dalam ginjal kedua ternak tersebut, yang menunjukkan bahwa kedua pasang logam tersebut tidak saling bersaing dalam ikatannya (penimbunan logam satu tidak menghambat penimbunan logam yang lain). Kandungan logam-logam tersebut dalam ginjal masih dalam batas-batas normal.

INTRODUCTION

All heavy metals occur normally in the tissue of animals, some of them are essential for biological life (*e.g.* Cu, Zn, Mn, Fe), while others have no known biological functions (*e.g.* Cd, Pb) and are often accumulating highly toxic elements to the living organism (Kobayashi, 1978; Parada *et al.*, 1987). An essential elements, like Cu, is also toxic to animals when found in excess in the food and drinking water, and then accumulates at high levels in the tissue (Botswick, 1982; Chooi *et al.*, 1988).

The study described here measures the background levels of seven heavy metals (Cu, Cd, Zn, Pb, Co, Mn and Fe) in the kidneys of cattle and buffaloes, and a preliminary assessment of inter element relationship in the tissue is also made.

MATERIALS AND METHODS

Twenty-six and nineteen kidney samples of cattle and buffaloes were collected respectively from the Bandung and Sukabumi slaughter houses in West Java. The animals were transported by truck from East Java for meat consumption in these areas. About 5 grams of sample were collected by cutting the cortex of the kidney by means of a stainless steel scissors and put into plastic bags and kept at 4°C in the cooler-box during transportation and then kept at −70°C and they were dried two or three days before required for analysis.

Dried tissue samples were weighed into a 100 ml Erlenmeyer flask (Pyrex), loosely capped with a watch glass and digested with nitric acid and sulfuric acid (2:1) for about 18 hours on a hotplate at 150°C until they dried out, then redissolved in 10% nitric acid and analysed for Cu, Cd, Zn, Pb, Co, Mn and Fe by atomic absorption spectrophotometry (AAS Varian Techtron AA 217). Blanks were treated similarly and standards were made up in 10% nitric acid.

All data were calculated on a μg/g dry weight basis. Interspecies differences in the kidney levels of heavy metals were calculated by Student's t-test. Correlation coefficients were used to determine significant metal interrelationship within tissues. All computations were performed on the IBM PC computer using the Panacea statistical package.

RESULTS

The result indicated that iron (Fe) was always the most abundant element detected, followed by zinc (Zn) in both cattle and buffalo. Cobalt (Co) preceded cadmium (Cd) in order of abundance in cattle, but the reverse was found in buffaloes (Table 1).

A comparison was made between the metal concentration in the kidneys collected from both animal species in which they were almost similar. However the kidney of cattle contained significantly higher levels of Cu, Zn and Mn ($P < 0.01$), and the kidney of buffaloes contained significantly higher levels of Cd and Fe ($P < 0.05$) (Table 1).

An analysis of correlation coefficient between metal pairs in the tissue showed differences dependent upon the animal species. Intraspecific consistency correlations were only shown between Zn and Fe, and between Co and Pb. In both cases positive correlation was indicated (Table 2 and 3).

Table 1. Metal concentrations in the kidney of cattle and buffaloes (Mean ± SE)

Species	n	Metal concentrations (µg/g dry weight)						
		Cu	Cd	Zn	Pb	Co	Mn	Fe
Cattle	26	27.49** ± 2.29	0.83 ± 0.13	92.41** ± 7.47	13.63 ± 3.3	1.09 ± 0.24	4.24** ± 0.32	202.70 ± 26.09
Buffaloes	19	15.28 ± 3.37	2.46* ± 0.69	63.36 ± 5.85	11.02 ± 2.70	1.73 ± 0.43	2.56 ± 0.41	292.92* ± 34.23

* = $P < 0.05$; ** = $P < 0.01$

Table 2. Correlation matrix showing the degree of association between the concentration of metals in the kidney of cattle

Cd	Zn	Pb	Co	Mn	Fe	
0.05	0.51	0.26	0.01	0.18	0.28	Cu
	0.07	0.39	0.67**	0.54*	0.08	Cd
		0.42	0.03	0.66**	0.69**	Zn
			0.78**	0.31	0.72**	Pb
				0.25	0.24	Co
					0.39	Mn

* = Significant correlation ($P<0.05$); ** = $P<0.01$

Table 3. Correlation matrix showing the degree of association between the concentration of metals in the kidney of buffaloes

Cd	Zn	Pb	Co	Mn	Fe	
−0.20	0.18	−0.35	−0.35	0.40	−0.33	Cu
	0.51*	0.05	0.14	0.10	0.46	Cd
		−0.24	−0.29	0.14	0.70**	Zn
			0.91**	−0.23	0.09	Pb
				−0.14	−0.00	Co
					−0.31	Mn

* = Significant correlation ($P<0.05$); ** = $P<0.01$.

DISCUSSION

The data are briefly discussed with reference to those available from other areas of the world. All values were given as μg/g dry weight, unless otherwise indicated.

Copper is a covactor for a number of oxidative enzymes. The highest concentration of tissue Cu is in the liver which is from 100 – 400 μg/g (Burns, 1981). In the kidney of the control cattle in Chile compared with cattle from polluted areas the concentrations were in the range from 18.6 to 26.4 μg/g (Parada *et al.*, 1987). This was similar to the finding in the kidney of cattle in this study, but in buffaloes the concentration was lower. Concentrations of Cu in the kidney of buffaloes in this study were 60% below 10 μg/g. It suggests that these animals are deficient in Cu and copper deficiency have been reported in ruminants livestock in Indonesia (Stoltz *et al.*, 1985; Darmono *et al.*, 1988).

Zinc is found relatively high in the liver and kidney of animals. Parada *et al.* (1987) suggested that a level of 79 – 87.8 μg/g Zn in the kidney of control cattle was normal. In this study, the concentration of Zn in the kidney of cattle was higher than that reported by Parada *et al.* (1987), but in buffaloes the level was lower.

Co requirement in cattle, buffaloes and other ruminants actually is a prerequisite for rumen micro-organisms. The microbes incorporate Co into vitamin B_{12}, which is utilized by both the micro-organism and animal tissue ((McDowell, 1985). In the tissue Co usually accumulate in the liver, but report on Co level in the liver and kidney is not yet found in the literature available in Indonesia. In this study Co level was the lowest compared with the other selected metals analysed so far in the buffaloes.

Manganese is needed in the body for normal bone structure, reproduction, and normal functioning of the central nervous system (McDowell, 1985). Report on the concentration of Mn in the tissue of ruminants is not yet found in Indonesian literature.

Iron plays a vital role in animal metabolism, mainly confined to the process of cellular respiration, as a component of haemoglobin, myoglobin, and cytochrom, and in certain enzymes (McDowell, 1985). Concentration of Fe in the body of animals mostly was reported in the blood, and no report has been found in the available literature on Fe concentration in the other tissues.

Lead is one of the heavy metals which has no known function in physiological processes, and it is categorized as a non-essential element. Lead concentrations in the kidneys of cattle and buffaloes in this study were found much higher than those previous reported in the same animal species from different locations (1.5 and 1.4 μg/g wet weight equal to 6.5 and 5.3 μg/g dry weight in cattle and buffaloes respectively, assuming a wet:dry weight ratio of 4.5) (Darmono and Stoltz, 1987). But this concentration was still much lower than in suspected lead toxicity of cattle as reported by Blakely (1984) and Parada *et al.* (1987) which were 420 and 260.6 μg/g respectively.

Like lead, cadmium is categorized as a non-essential element. Concentration of cadmium in the kidney of cattle was much lower than that reported by Parada *et al.* (1987), but in buffaloes it was similar. According to Andersen and Hansen (1982), concentration of cadmium in the kidney of Danish cattle was increased coinside with the increase of age.

With respect to correlation between metal pairs in the tissue of aquatic organisms, Mason and Simkiss (1983) suggested that a consistent association between particular groups of metals could be regarded as indicative of particular biochemical pathways or, at its simplest, as demonstrating the binding of certain metals in animal which is indicated by the occurrence of particular ligands and particular combination or groups of metals can be expected and correlate at each site. In the present study consistent correlations between metal pairs were only evident for Zn:Fe and Co:Pb. This relation is positive, suggesting that there may be no competition between these elements for the supply of ligands.

From these results, it can be concluded that concentrations of selected heavy metals observed in the kidney of cattle and buffaloes are indicative of a relatively normal level, when compared with the reported value for animals with suspected poisoning. Although relatively high concentration of Pb in the kidney of both cattle and buffalo has been observed in this study, but this level is still much lower than in animals which were suffering from lead poisoning.

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