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Short Paper

Measurement of cadmium residues in muscle, liver and kidney of cattle slaughtered in Isfahan abattoir using grafite furnace atomic absorption spectrometry (GFAAS): a preliminary study

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Summary

The aim of the present study was to determine the levels of cadmium in the muscle, liver and kidney of cattle from Isfahan and to compare the results with those reported by other countries and with the maximum acceptable levels for human consumption. Samples of muscle, liver and kidney from 60 animals aged 1–10-year-old were collected from the carcasses slaughtered at Isfahan abattoir. Samples were digested with acid and cadmium concentrations were determined by graphite furnace atomic absorption spectrophotometry (GFAAS). The mean concentrations of cadmium in muscle, liver and kidney were 3.3, 49.7 and 137.1 µg/kg fresh weight, respectively. The mean concentration of cadmium in tissue samples was generally lower than the maximum acceptable concentration in European Commission (EC). Statistical analysis showed a significant difference in cadmium concentration of liver and kidney between various age groups ($P<0.05$).

Key words: Cadmium, Muscle, Liver, Kidney, Cattle

Introduction

Cadmium is a non-essential element with a high potential toxicity for humans. It accumulates predominantly in the kidney and liver, bound to metallothioneins, with a biological half-life of more than 10 years (Baldini *et al*., 2000). Long-term exposure to excessive amount of cadmium may produce irreversible renal damages (Cicero *et al*., 1992; Coni *et al*., 1992; Lopez Alonso *et al*., 2000).

Cadmium is mainly used in compounds such as nickel-cadmium batteries, anticorrosive coating of metals, pigments and stabilizers for plastic, and significant quantities of cadmium are released from human activities (Baldini *et al*., 2000). Ninety percent of the atmospheric cadmium emissions come from anthropogenic sources. These emissions together with the release of cadmium into the aquatic and terrestrial environment, may lead to severe local pollution (Baldini *et al*., 2000). Moreover, airborne cadmium may be spread widely in the environment due to long-range atmospheric transport (Baldini *et al*., 2000; Jill *et al*., 2001).

Exposure to cadmium for the non-smoking population occurs mainly via the food. The most significant sources of cadmium in the diet are cereals and vegetables because of their high consumption rates (Baldini *et al*., 2000). Meat and offal (especially liver and kidney) are the most important sources after vegetables (Coni *et al*., 1992). Molluscs and crustaceans may contain high levels of this element (Cicero *et al*., 1992), but they generally constitute only a small part of the diet. Surveys to determine the levels of cadmium in animal products have been conducted in many countries, e.g. Germany (Kreuzer *et al*., 1988), The Netherlands (Vos

et al., 1987), Norway (Kluge-Berge *et al*., 1992), Sweden (Jorhem *et al*., 1991), Finland (Niemi *et al*., 1991), Poland (Falandysz, 1993), Slovak Republic (Kottferova and Korenekova, 1995), Australia (Kramer *et al*., 1983), Spain (Lopez Alonso *et al*., 2000) and Canada (Salisbury *et al*., 1991). The aims of the present study were to determine the levels of cadmium in the muscle, liver and kidney of cattle from Isfahan and also to compare the obtained values with those reported by other countries and with the acceptable limits proposed by European Commission.

Materials and Methods

The samples of muscle, liver and kidney from 60 cattle (32 females and 28 males) slaughtered at an abattoir in Isfahan, were collected randomly during February 2005 to February 2006. Samples were taken only from healthy animals in three age groups: less than 2-year-old, 2–4-year-old and more than 4-year-old.

The samples of at least 100 gr, were collected from the same part of each organ, namely the lobus caudatus for liver, the carnial half of left kidney and triceps muscle. All the samples were packed in plastic bags and transported to the laboratory. Visible fat, connective tissue and major blood vessels were excised and the samples were homogenized. Sub-samples (10 gr) were frozen at -18°C until analysis. Approximately 1 gr was taken from each frozen sub-samples, defrosted, weighed accurately and dried at 85°C until constant weight. The digestion of samples was carried out using the wet digestion technique (Lopez Alonso *et al*., 2000). Glassware was washed, soaked in 10% nitric acid overnight and then rinsed several times with ultrapure water before use. Cadmium was measured by graphite furnace atomic absorption spectrophotometry (GFAAS) (Lopez Alonso *et al*., 2000) apparatus with electrothermic atomizer GF-90 (UNICAM 939, UK) at 283.3 nm. Ammonium dihydrogen phosphate was used as matrix modifier. All samples were analysed in triplicate.

Statistical analysis

The mean cadmium concentration in muscle, liver and kidney tissues and the mean concentration of this metal in different tissues at various age groups were compared by one-way analysis of variance and Duncan's multiple range test. Student t-test was used to compare differences due to sex. The level of significance for each test was at $p<0.05$.

Results

The mean concentration of cadmium in the muscle, liver and kidney of cattle from Isfahan are summarized in Tables 1 to 3.

Table 1: The cadmium concentration of muscle, liver and kidney of 60 slaughtered cattle in Isfahan (µmol/kg fresh weight)

Tissue	Mean	SD
Muscle	0.002[*a]	0.003
Liver	0.044[b]	0.043
Kidney	0.122[c]	0.137

[*]different letters show significant differences ($P<0.05$)

Table 2: The cadmium concentration of muscle, liver and kidney of slaughtered cattle in Isfahan in relation to the sex (µmol/kg fresh weight)

Tissue	Sex			
	Female (n = 32)		Male (n = 28)	
	Mean	SD	Mean	SD
Muscle	0.003	0.004	0.002	0.001
Liver	0.051	0.053	0.035	0.026
Kidney	0.131	0.152	0.111	0.119

Discussion

Cadmium concentrations in cattle have been measured in many countries (Table 4). It is clear that cadmium concentration in muscle, liver and kidney of slaughtered cattle in Isfahan were generally lower than the average values reported from other countries (Table 4) and also lower than the maximum acceptable concentration proposed by the European Commission (maximum acceptable concentrations in the European Commission are 50 µg/kg for muscle, 500 µg/kg for liver and 1000 µg/kg for kidney) (EC, 2001; EC, 2004). The mean cadmium concentrations found in muscle are similar to values reported by various researchers from different countries (Table

Table 3: The cadmium concentration of muscle, liver and kidney of slaughter cattle in Isfahan in relation to the age (µmol/kg fresh weight)

Tissue	Age (year)					
	<2 (n = 20)		2-4 (n = 20)		>4 (n =20)	
	Mean	SD	Mean	SD	Mean	SD
Muscle	0.002[*a]	0.001	0.002[a]	0.002	0.003[a]	0.003
Liver	0.023[a]	0.019	0.035[b]	0.029	0.074[c]	0.056
Kidney	0.049[a]	0.053	0.111[b]	0.118	0.205[c]	0.170

[*]different letters show significant differences in the same row (P<0.05)

Table 4: Published data on cadmium concentrations in muscle, liver and kidney of cattle. Average concentrations (µmol/kg fresh weight) are given. The numbers of samples are in parentheses

Muscle	Liver	Kidney	Country	Reference
0.000 (181)	0.053 (179)	0.329 (174)	Australia	Kramer *et al*. 1983
0.033 (30)	0.105 (30)	0.304 (30)	Italy	Amodio-Cocchieri and Fiore, 1987
0.003 (215)	0.093 (146)	0.464 (210)	The Netherlands	Vos *et al*. 1987
0.000 (87)	0.030 (87)	0.197 (87)	Germany	Kreuzer *et al*. 1988
0.026 (1812)	0.156 (1100)	0.578 (1227)	Australia	Langlands *et al*. 1988
0.000 (34)	0.062 (33)	0.346 (68)	Sweden	Jorhem *et al*. 1991
0.000 (113)	0.054 (113)	0.311 (98)	Finland	Niemi *et al*. 1991
--	0.062 (2138)	0.400 (2138)	Canada	Salisbury *et al*. 1991
--	0.035 (210)	0.231 (209)	Canada	Salisbury *et al*. 1991
0.000 (80)	--	0.186 (578)	Norway	Kluge-Berge *et al*. 1992
0.005 (92)	0.106 (290)	0.542 (291)	Poland	Falandysz, 1993
--	0.044 (61)	0.204 (256)	Brazil	Aranha *et al*. 1994
0.000 (138)	0.046 (350)	--	Finland	Tahvonen and Kumpulainen, 1994
0.020 (6)	0.281 (6)	0.227 (6)	Slovac Republic	Kottferova and Korenekova, 1995
0.003 (87)	0.080 (69)	0.329 (331)	Slovenia	Doganoc, 1996
0.000 (438)	0.028 (437)	0.062 (427)	Spain (calves)	Lopez Alonso *et al*. 2000
0.000 (56)	0.086 (56)	0.407 (56)	Spain (cows)	Lopez Alonso *et al*. 2000

4). However, the mean concentration of cadmium in muscle appears to be very low, as in all published studies the concentrations were below 50 µg/kg fresh weight. Higher concentrations in cattle muscle reported by some countries may be attributed to differences in the age of the animals examined, the rate of exposure to cadmium and the analytical detection limits.

The mean cadmium concentration in the liver and kidney obtained in the present study was 15.06 and 41.54 times, respectively, higher than that in the muscle. These results were similar to those reported by Kluge-Berge *et al*. (1992), Falandysz (1993), Doganoc (1996), Lopez Alonso *et al*. (2000) and Miranda *et al*. (2002).

In this study cadmium residual levels in the liver and kidney of cattle were low, and in cattle less than 2 years of age were in the lower range of value reported in the literature (Tahvonen and Kumpulainen, 1994; Doganoc, 1996; Lopez Alonso *et al*., 2000).

In this study, the mean cadmium concentration in the liver and kidney of cattle more than 4-year-old is higher (3.11 and 4.12 times, respectively) than in cattle less than 2-year-old (P<0.05). But the difference in cadmium concentration of muscle samples was not significant in various age groups (P>0.05). Accumulation of cadmium in the liver and kidneys associated with age has also been found in other studies on cattle (Vos *et al*., 1987; Salisbury *et al*., 1991; Lopez Alonso *et al*., 2000; Lopez Alonso *et al*., 2002).

In females, the cadmium levels in muscle, liver and kidney were only slightly higher than those recorded in males. However, the difference was not significant. It is possible that the higher cadmium concentrations in female cattle in some countries may actually be due to the higher age of female animals.

According to the results of this study, fortunately, the amount of toxic cadmium in animal products in Esfahan is lower than the

acceptable maximum threshold established in the European Commission and is not hazardous for consumers.

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