Journal of Environmental Protection and Ecology 12, No 4, 1700–1706 (2011)

LEAD AND CADMIUM CONCENTRATIONS IN VEGETABLES, THE BASE FOR THE CALCULATION OF THEIR INDEX AND RISK ASSESSMENT

H. KERAN[a], A. ODOBASIC[a]*, S. CATIC[a], N. AHMETOVIC[b,c], M. SALKIC[a], I. SESTAN[a]

[a]*Faculty of Technology, University of Tuzla, 8 Univerzitetska Street, 75 000 Tuzla, Bosnia and Herzegovina*
[b]*Agency for Food Safety, Dr. Ante Starcevica Blvd., 88 000 Mostar, Bosnia and Herzegovina*
E-mail: *amer.o@bih.net.ba*

Abstract. Heavy metals are natural ingredients in many food products, either they are eaten as fresh or processed. The consumption of food products containining higher concentrations of heavy metals, and during longer period of consumption of food providing them to be deposited in organism in non-controlled way, causes a serious consequence to consumers health. Therefore, this work is aimed to present the methodology of estimation of risk index and its total assessment referring to heavy metal intake into organism, as well as their influence on people health. The content of lead and cadmium is determined in preserved vegetables, beetroot, cucumbers and peppers. Results obtained in experiment are then used for the calculation of risk index and its total assessment. Although, risk index for cadmium was very low, other results showed very high risk to consumer health.

Keywords: index, risk, assessment, preserved vegetables, lead, cadmium.

AIMS AND BACKGROUND

Cadmium is one of the most poisons metals, because it causes acute and chronic changes in organism and act cumulatively. In organism, cadmium comes through food, drinks and breathing[1]. Cadmium has negative impact on kidneys, liver, bones, and cardiovascular and respiratory systems. In organism, a cadmium behaviour is similar to that of zinc and it can be changed by zinc in some biological functions. Cadmium is connected to mitochondria membranes where many enzymes are placed, which participate in metabolic processes. Cadmium is also accumulated in liver and kidneys, because its biological half-time in human organism is from 20 to 30 years. The long-term intake of small concentrations of cadmium can have a great negative effect on human health such as neuro toxic, respiratory changes. The influence of cadmium on zinc metabolism can lead to arterioscleroses, hypertension and other heart diseases. It is also important to emphasise the connection

* For correspondence.

between cadmium intake and cancer of lungs and prostate, because it is classified, according to IARC, as the first group of cancers[2]. According to WHO, tolerant daily intake is about 65 μg, under conditions that the long-term intake does not cause higher concentrations than 50 μg in renal skin[3,4].

Lead in organism comes through food and drinks, as well as via inhalation of small particles. Adults intake between 100 and 500 μg of lead average of daily food consumption. About 10% of intake of lead is desorbed, it has cumulative properties and is mostly deposited in bones, CNS and kidneys. Poisoning by lead is typical chronic, because metabolism and exposition of lead takes some time depending on exposition intensity[5]. At low expositions, symptoms of poisoning can be seen even months and years before. If humans are poisoned by lead, 4 classic symptoms are present in blood, such as anemy, hypo-chromic, etc. The most sensitive human beings to lead intake are babies (fetus), and children to six years of age. Researches on experimental animals have showed that intake of lead in small concentrations can cause cancer, but for humans there are not valid evidences[6]. Therefore, according to IARC classification, lead is classified in the second group of cancer metals. According to WHO, tolerant concentration for adults is 230 μg, for children to 6 month – 100 μg and for children from 6 months to 2 years – about 150 μg (Refs 3 and 4).

The aim of this work is to determine the influence of lead and cadmium from preserved vegetables using two different methodologies: risk index and risk analyses.

EXPERIMENTAL

METHODS

Analyses of lead and cadmium were performed by polar graphic method, differential pulse anodic stripping voltammetry, DPASV. The instrumental parameters are as follows:

– working electrode (WRK): HMDE;
– referent electrode (REF): Ag/AgCl (1 M KCl), E = 0.22 V;
– potentials:

Metal	Initial	Final
Cadmium	–0.9 V	–0.6 V
Lead	–0.65	–0.4;

– deposition time 300 s;
– speed of scanning 2 mV/s;
– deaeration time 120 s;
– amplitude 0.05 V.

EQUIPMENT

Electrochemical cell, Princeton Applied Research (EG & G) model 303A with working (HMDE), referent (Ag/AgCl) and supporting (Pt-wire) electrode; potenciostat/galvanostat, PAR, model 263 A; computer P II with software Model 270/250 Research Electrochemistry Software, version 4.3. Accuracy of determination to 10^{-10}.

RESULTS

In this work, two different methodologies are used to predict possible impact of lead and cadmium in preserved vegetables on consumer health.

(a) Risk index

International organisations (FAO/IAEA/WHO, JECFA, US EPA) have defined maximum allowed concentrations for lead 25 μg/kg b.w./week and cadmium 7 μg/kg b.w./week (Refs 7–9).

Risk indices are calculated on the basis of metal concentrations, obtained by experimental work and data defined by the above-mentioned organisations for the content of heavy metals in preserved vegetables, e.g. beetroot, cucumbers and peppers.

Risk indices are calculated in the following way:

$$\text{risk index} = \frac{\text{weekly intake of metals through vegetable consumption}}{\text{PTWI metals}} \times 100$$

where PTWI is provisional tolerant weekly intake for metals, in this case for cadmium and lead.

In Table 1 concentrations and risk indices are given for cadmium and lead in preserved vegetables. The graphs given in Figs 1 and 2 show voltammograms, which are obtained in experimental work, analysing preserved vegetables, only as samples. Results, presented in Table 1, are obtained by using the standard addition methodology.

Table 1. Concentration and risk indices of lead and cadmium intake through preserved vegetable consumption

Metal	Parameter	Beetroot	Pepper	Cucumbers
Lead	concentrations (mg/kg dry matter)	3.19	1.86	3.03
	risk index (%)	41.92	24.44	39.82
Cadmium	concentrations (mg/kg dry matter)	0.035	0.034	0.002
	risk index (%)	1.64	1.60	0.10

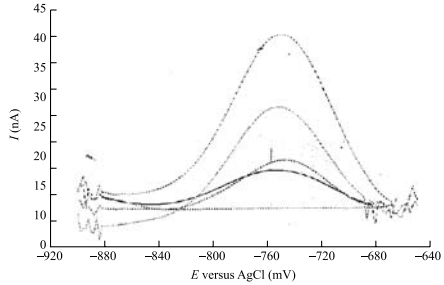

Fig. 1. Voltammogram of cadmium in preserved beetroot

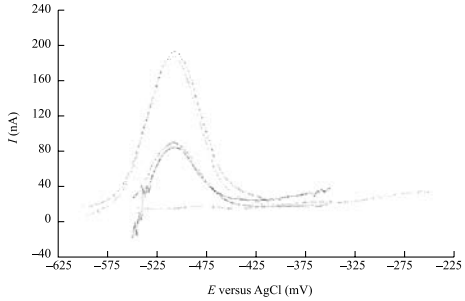

Fig. 2. Voltammogram of lead in preserved cucumbers

In Figs 1 and 2 the curves present maxima, which have been obtained using electrochemical method, differential pulse anodic stripping voltammetry, DPASV as dependence of current and potential when metal is found in sample. Horizontal curve means that cadmium or lead are not present in the sample, e.g. zero sample; the first maximum was obtained for unknown cadmium or lead concentration in the sample; the second, third and fourth maxima were obtained for known concentrations of cadmium or lead, which have been added in the samples as standard addition for calculation of unknown cadmium or lead concentrations in the examined vegetable samples. Using the method of standard addition, based on known current for unknown cadmium or lead concentrations in samples, by current and known cadmium or lead concentrations in vegetable samples, the content of metals has been found.

(b) Risk assessment

The form, which is used for risk assessment is the following:

$$R = E \times P \times C$$

where R is risk, E – exposition, P – probability of happening, C – consequences.

Exposition is the period during which consumers are exposed to consumption of specific food products, which seem to be contaminated.

In Tables 2 and 3, scoring of exposition and possibility of happening are given, respectively, while in Tables 4 and 5, scoring of consequences and total risk assessment are present.

Table 2. Scoring of exposition

Exposition	Scores
Permanently	5
Often	4
Random	3
Rare	2
Very rare	1

Table 3. Possibility of happening

Possiblity	Scores
Frequent	5
Probably	4
Random	3
Not significant	2
Without any significance	1

Table 4. Consequences to consumers health

Consequences	Scores
Catastrophic	5
Very serious	4
Serious	3
Important	2
Not significant	1

Table 5. Total risk assessment

Scores	Situation
More than 100	very high risk
70–100	high risk
40–70	important risk
20–40	possible risk
Below 20	acceptable risk

Risk assessment for lead for consumption of all preserved vegetables analysed in this work

– Exposition, often, 4

– Possibility of happening, probably, 4

– Consequences to health of consumers, very serious, 4.

Total risk assessment for lead: $R = E \times P \times C = 4 \times 4 \times 4 = 64$.

Based on total risk assessment (Table 5), there is an important risk for consumer health.

Risk assessment for cadmium for consumption of all preserved vegetables analysed in this work

– Exposition, often, 4

– Possibility of hapenning, 2

– Consequences to consumers health, very serious, 4.

Total risk assessment for cadmium: $R = E \times P \times C = 4 \times 2 \times 4 = 32$.

Based on total risk assessment (Table 5), there is a possible risk for health of consumers.

DISCUSSION

Related to maximum concentrations of heavy metals in vegetables, they are also defined for vegetables products as follows. Risk index for lead was the highest for beetroot, 41.49% and the lowest value was calculated for peppers, 24.44%. Lead concentrations in pasteurised vegetables were from 0.47 mg/kg for peppers to 0.80 mg/kg for beetroot. These concentrations are calculated by kg of dried matter. Valid B&H regulation[8] has defined maximum allowed lead concentrations in fresh and a pasteurised vegetable product as 3 mg/kg. According the EU regulation[10] and valid B&H regulation[11], maximum allowed cadmium concentration in vegetable products is 0.05 mg/kg.

The content of cadmium in pasteurised vegetables was from 0.0005 mg/kg for fresh cucumbers, to 0.0085 mg/kg for fresh beetroot. Risk index for cadmium in pasteurised vegetables was from 0.1% for cucumbers to 1.64% for beetroot. In this work, the more complicated methodology for total risk assessment of heavy metals, i. e. lead and cadmium, is chosen, because heavy metals are the most dangerous hazards of chemical origin. For lead, exposition is often, because vegetables are often grown near roads and it is either consumed as fresh or processed. As the lead is incorporated in the plant structure and it can not be eliminated from plants, particularly from their edible parts, the consequences of risk impact are very high and chance of happening is probable. Based on this, the total assessment of risk for lead is 64 points.

Plants have less affinity to cadmium, which is also confirmed by its lower content in vegetables. In order to calculate total risk assessment for cadmium, the following is taken – exposition is rare, curiosity random and consequences to health of human beings are very high. Calculation gave the total risk assessment with 440 points.

CONCLUSIONS

Risk index for lead from preserved vegetables is too much higher than for cadmium, when calculation is performed on the basis of kg of fresh vegetables. Although lead concentration, estimated in preserved vegetables does not present big problem

to consumers health, total risk assessment showed that it is necessary to establish permanent monitoring of lead accessibility to vegetable. Risk assessment has showed that lead is more often hazard to consumers health than cadmium, because, in this work, laboratory analyses of preserved vegetables showed that cadmium is less present than lead. Comparing results for lead and cadmium concentrations in preserved vegetables obtained in this work and their maximum allowed content defined by valid B&H regulation, there is no deviations. Risk index for cadmium is very low, but considering the fact that cadmium is very hazardous to human beings, it is also necessary to establish permanent monitoring of fresh and processed vegetables, as well as of other food products.

REFERENCES

1. World Health Organisation: Evaluation of Certain Food Additives and the Contaminants Mercury, Lead, and Cadmium. Sixteenth Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series No 505, FAO Nutrition Meetings Report Series No 51, Geneva, Switzerland, 1972.
2. U. S. EPA: Mutagenicity and Carcinogenicity Assessment of Cadmium. Addendum to the Health Assessment Document for Cadmium (EPA 600/B- B1-023). EPA 600/B-83-025F, 1985.
3. World Health Organisation: Evaluation of Certain Food Additives and Contaminants. 33rd Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series No 776. WHO, Geneva, 1989.
4. World Health Organisation: Evaluation of Certain Food Additives and Contaminants. 41st Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series No 837. WHO, Geneva, 1993.
5. U. S. EPA: Health Effects Assessment for Lead. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-86/055. NTIS PB85-163996/AS, 1984.
6. U. S. EPA: Evaluation of the Potential Carcinogenicity of Lead and Lead Compounds: In Support of Reportable Quantity Adjustments Pursuant to CERCLA Section 102. Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-89/045A, 1989.
7. JECFA, FAO/WHO: Joint Expert Committee for Food, 1993.
8. Joint FAO/WHO Food Standards Programme: Codex Committee on Processed Fruits and Vegetables, Methods of Analysis for Processed Fruits and Vegetables, 21st Session, San Antonio, Texas, U.S.A., 23–27 September, 2002.
9. Joint FAO/WHO Standards Programme: Codex Committee on Food, Additives and Contaminants, December, 1998.
10. European Commission: Commission Regulation (EC) No 466/2001 of 8 March 2001 Setting Maximum Levels for Certain Contaminants in Foodstuffs. Official J. of the European Communities, L77, 1–13, 2001.
11. Valid Regulation on Pesticide Concentrations and Other Poisoned Materials, Antibiotics and Mycotoxins that Can Be Found in Food. 'Sl. list SFRJ' No 59/83, 79/87.

Received 24 July 2009
Revised 8 September 2009