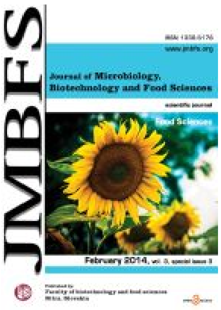

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CONTENT OF MERCURY AND LEAD IN LEAVES OF SPINACH (SPINACIA OLERACEA, L.)

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ABSTRACT

Spinach is one the most nutritious leafy vegetable. Only 22 calories per 100 grams, a high amount of protein, carbohydrate and fat make it very suitable ingredient in reduction diets. For a wealth of minerals and vitamins in addition it has an extraordinary nutritional value. 100 g contains two-thirds of its daily requirement of vitamin A, virtually the entire daily need for folic acid, half the dose of vitamin C, almost a quarter of the daily needs of more than a quarter of the needs of iron and magnesium.
According to some studies, it is a good remedy for cancer prevention. In spinach are found in high concentrations of carotenoids, which protect cells from destruction, and so help to antiaging. Lutein-carotenoided pigment, an adequate supply may delay the emergence of degenerative diseases of the retina of the eye. In the framework of monitoring, we have focused on the analysis of the levels of lead and mercury in 7 samples of spinach from the commercial network of the Slovak republic. The lead content in all samples was 0.00 $mg.kg^{-1}$, mercury content was in the range of 0.0019 – 0.0054 $mg.kg^{-1}$. From the point of view of the sanitary evaluation of the HPQ for the content of lead and Hg was not exceeded in either sample.

Keywords: mercury, lead, spinach, food contamination

INTRODUCTION

Spinach originated from Persia, particularly its origin is likely to be in the front, central and southwest Asia. It was given as a gift by Nepalese King to China. In Europe appearing in 11. century in Spain, where it was brought by Maurs. By the end of 16. century it was commonly known, recognized and grown for almost all over the world in addition to tropical areas **(Kubáček, 1999)**. For us it is the most cultivated green leafy vegetable. The first recipes, which uses the spinach, are preserved in the cookbook of the year 1390. The greater part is treated by freezing process. The edible part of the spinach is rosette, which is pale green to dark green leaves roasted **(Kopec, 1998)**.
It contains only 22 calories per 100 grams, high amount of protein, low carbohydrate and fat, which make it very suitable ingredient in weight-loss diets. For the great wealth of minerals and vitamins, has extraordinary nutritional value. In 100 g contains two-thirds of its daily need of vitamin A **(Eliášová, Jóžeffiová2002)**. It contains almost daily need for folic acid, half the dose of vitamin C, almost a quarter of the daily needs of magnesium and of course more than a quarter of the needs of the iron. Spinach also contains calcium, magnesium, zinc and selenium. Proteins in spinach make a prevention before absorption of cholesterol and bile acids. Its regular consumption helps in reducing cholesterol levels in the blood **(Eliášová, Jóžeffiová 2002)**.
In spinach are represented as well as flavonoids and phenolic acids, which act against calcification and inflammation. It contains a mixture of vitamins of group B which is important for the metabolism of carbohydrates, the executive for the brain and good nerves. A significant proportion is niacine and biotine. Spinach is a significant source of potassium, copper, iodine and iron. In leaves is located lecithine, spinacine and saponins. The source of the contaminants in spinach is contaminated soil from natural or antropic resources, environmental pollution, contaminated irrigation water, rainwater, but also increased application of agrochemicals and plant protection products. These sources of risk elements can also lead to increased content of heavy metals in the leaves of spinach. Lead is among the toxic heavy metals with a wide advantage in the industry, however, it is not known its nutritional advantage. Toxic effect of lead in foodstuffs recorded a joint experts of FAO and WHO committee on food additives (JEFCA FAO/WHO).
Our body can not recognize the difference between lead and calcium. Relatively low doses of lead can lead to chronic damage of kidneys and liver, reproductive, cardiovascular, immune, nervous and digestive system. The short-term burden on high doses of lead can cause gastrointestinal disease, anemia, diseases of the brain and even death. Lead is particularly dangerous to infants and children.

Table 1 Maximum content of lead, cadmium, mercury and arsenic in spinach in $mg.kg^{-1}$ by Velíšek, Hajšlová (2009)

	As	Cd	Pb	Hg
Spinach	0.005-0.020	0.01-0.350	0.01-0.290	0.001-0.0080

Lead is presented in all plants in natural conditions. The current content is 2-3 mg of $Pb.kg^{-1}$. Plant passive income of Pb. Income is influenced by pH and temperature. In some plants, the total intake of Pb from the atmosphere reaches up to 80%. In small concentrations of active salt of lead $Pb(NO_3)_2$ stimulates the growth of plants. At higher temperatures leads to interactions with the other elements of that disruption of the metabolism of calcium, inhibit the enzymatic systems, reduced CO_2 uptake, operate on the cell division and limit the intake of water. High doses of lead produced chlorosis at the plants.
The leaves remain green, later change their colour to yellow - brown and the leaves are stunted. The most sensitive plant on the accumulation of lead is mainly leafy vegetables. In the cultivation of spinach is necessary to avoid soils, where in the past applied pesticides containing lead arsenate. Based on several studies, the natural concentration of lead in foodstuffs is generally low, below 0.5 $mg.kg^{-1}$. Mercury in food is around tenthousands up to plus/minus hundredths $mg.kg^{-1}$. Daily dose of mercury in adult humans is tolerated around 50 mg but tolerated dose is around 33 mg for 70kg per person **(Velíšek, Hajšlová, 2009)**. Mercury reduced fertility. The metal is concentrated in the pituitary gland, which is essential for the stimulation of the production of sex hormones. Methyl Hg is mobile and can easily be taken by plants. Microorganisms can cause reduction of Hg^{2+} to Hg^0, which cause volatilization of Hg from soil. Methyl Hg is a highly toxic for people, which arises in the aquatic environment (methylmercury, dimethylmercury and metylhydrargyriumhydroxid) **(Kabata- Pendias, Pendias 1992)**.

MATERIAL AND METHODS

We used spinach samples, whose are commonly available in commercial network in Slovak republic, to determine the contents of the risk elements in the frozen spinach. 7 samples of frozen spinach were analyzed low-weight package (325 to

450 g). Each sample an average of 2 grams was withdrawn from frozen spinach. Description and characteristics of the analysed samples is given in table 2.

Table 2 Description and characteristics of the analysed samples

Sample number	Product name	Packing/weight	Producer	Country of origin
1	MOCHOV Spinach puree	450 g	Ardo Austria Frost	Austria
2	VitaStar Spinach puree	450 g	Kaufland	Slovak republic
3	Dione Spinach puree	450 g	Agrimex	Czech republic
4	Agro Jesenice Spinach leaves	400 g	Agro Jesenice	Czech republic
5	Findus Chopped spinach	325 g	Findus	Distibuted by Findus Slovakia
6	CLassic Spinach leaves	450 g	Kaufland	Belgium
7	Bonduelle Spinach leaves	450 g	Bonduelle	Spain

Purchase analysed samples was carried out in 2013. Determination of the content of heavy metals have been carried out in the Department of chemistry, Faculty of biotechnology and food agriculture. The measured values were compared with the applicable legislative provisions of risk features for the maximum permissible levels of contaminants in the spinach according to the Codex Alimentarius Commission of the EU Regulation n ° 422/SR and 2011 and 1881/2006 setting maximum levels of contaminants in foodstuffs.

Determination of the content of heavy metals in spinach

Samples of spinach were mineralized by "wet road" after thawing. We used microwave digestion unit MARS X-press from CEM (USA), according to XprAG-1 (2004). The end of determination was analysis by usig AAS (VARIAN 240 FS). Determination of mercury in samples of spinach by using methods of AMA on the AMA 254. Automatic analyzer of mercury AMA 254 is a dedicated atomic absorption spectrophotometer for determination of mercury. It is intended for the direct determination of mercury in solid and liquid samples.

RESULTS AND DISCUSSION

The lead content in all 7 samples of frozen spinach was set at the level of 0.00 mg.kg^{-1}. It means that the maximum amount provided by the food codex of the Slovak republic for this commodity (1 mg.kg^{-1}) has not been exceeded in either case.
This points to the fact, that the environment in which it is grown, probably do not increased the lead content of spinach in the abiotic components of the environment (soil, water, air). Many authors (**Bencko *et al*., 1995, Hegedušová, Valšíková, Hegedus 2010, Tóth, Bystrická, Vollmannová *et al.* 2010, Tóth, Tóth, Bončíková *et al.* 2011**) point out that lead accumulates mainly in the underground parts of plants, and only about 10 - 20% of the lead is translocated in the above - ground parts of the plant.
Contamination of the biomass comes most often just in case of increased exposure to lead in the air. Zero content of lead in spinach also supports the fact that vegetative period of spinach is a relatively short, about 80 days, which in terms of accumulation of Pb in spinach is a short interval of mesh fencing materials.

Table 3 Lead content in samples of frozen spinach (mg.kg^{-1})

Product name	Producer	Country of origin	Pb
MOCHOV	Ardo Austria Frost	Austria	0.00
VitaStar	Kaufland	Slovak republic	0.00
Dione	Agrimex	Czech republic	0.00
Agro Jesenice	Agro Jesenice	Czech republic	0.00
Findus	Findus	Distributed by Findus SR	0.00
Classic	Kaufland	Belgium	0.00
Bonduelle	Bonduelle	Spain	0.00

In terms of Hg content, it can be stated that from the frozen spinach brand Agro Jesenice with measured value 0.0054 mg.kg^{-1} contains the highest concentration of Hg. At least contains spinach puree MOCHOV with the measured value of mercury 0.0019 mg.kg^{-1}. The mercury content in the full analysis set of frozen spinach was from 0.0019 to 0.0054 mg.kg^{-1}. The mercury content in the samples is shown in table No. 4. **Velíšek, Hajšlová (2009)**, which indicates that the mercury content in spinach is from 0.001 to 0.008 mg.kg^{-1}.
According to the Food codex of the Slovak republic would not exceed the highest threshold of mercury in spinach 0.05 mg.kg^{-1}. The highest content of mercury was measured in the sample No. 4 of frozen spinach Agro Jesenice with value from 0.0054 mg.kg^{-1}.

Table 4 Mercury content in samples of frozen spinach (mg.kg^{-1})

Product name	Producer	Country of origin	Hg
MOCHOV	Ardo Austria Frost	Austria	0.0019
VitaStar	Kaufland	Slovak republic	0.0036
Dione	Agrimex	Czech republic	0.0045
Agro Jesenice	Agro Jesenice	Czech republic	0.0054
Findus	Findus	Distributed by Findus SR	0.0052
Classic	Kaufland	Belgium	0.0022
Bonduelle	Bonduelle	Spain	0.0034

Table 5 Mercury content in the samples (mg.kg^{-1})

Hg	∅	HPQ	min	max
n = 7	0,0037	0,05	0,0019	0,0054

CONCLUSION

To evaluate of the quality of frozen spinach can be concluded, that the excess hygienic sanitary limit in terms of heavy metals have not been found even in the case of lead, or in the case of mercury. Analyzed spinach is therefore suitable for consumption and does not pose any real risk of lead and mercury in the human body.

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