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ORIGINAL ARTICLE

Content of Heavy Metals in Poppy Seeds (*Papaver Somniferum* L.)

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ABSTRACT

Opium poppy (*Papaver somniferum* L.) is an industrial crop with valuable oil in Central Europe. The main production area is intended for the production of poppy seeds as it is traditional delicacy food, used for direct consumption. On the other hand poppy plants have the ability to accumulate heavy metals. The main dangerous element of these pollutants is particularly the cadmium. Various research papers have presented different levels of heavy metal contamination in the poppy seeds and contamination is dependent on several environmental factors. Poppy seed accumulation of Cd was determined in the range of 0.090 to 2.300 $mg.kg^{-1}$, Pb from 0.050 to 1.600 $mg.kg^{-1}$ and Cr from 0.206 to 5.200 $mg.kg^{-1}$. Intake of these dangerous elements by plants can be reduced using the good agricultural production practice. A complex of measures including selection of growing area, soil treatment of pH over 6.5, increasing organic matter and humus content in the soil, appropriate increase in nutrition and fertilization, especially the application of Bo.

Key words: accumulation, cadmium, contamination, heavy metals**,** poppy seeds

Introduction

Opium poppy (*Papaver somniferum* L.) is grown mainly for oilseeds in Europe. Poppy seeds are used in baking as a decorative garnish or as a paste of ground seeds. In households they are used in various breads, cakes and pastries which are often sprinkled on top with black seeds on traditional dishes. The size of growing area varies in different Central European countries depending on cultivation conditions and demand. The legally largest producer being the Czech Republic. Between the years 2000 – 2008 the average area of poppy crop is 43,067 ha per year. In the same period the average production area in Slovakia is 1,170 ha per year. Mostly varieties of poppy with a high yield potential of seeds are grown, which accumulate from 0.4 to 0.6% morphine in dry capsules. Regarding using the seeds in baked goods health concerns may arise with the accumulation of heavy metals in poppy seeds when growing plants. The most concern heavy metals are cadmium (Cd) together with other elements such as lead (Pb) and chromium (Cr). Monitoring their accumulation in plants and looking for possibilities how to eliminate the content of hazardous elements to a minimum is the key factor in obtaining high-quality and safe poppy products for consumers.

Poppy Seeds and Cadmium Accumulation:

Cd substances are commonly found in nature, in minerals together with other components. It is widely used in the industry. The main sources of Cd contributing to environmental conditions are mining, burning fossil fuels and waste

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management. Iljin [4] found that 50-80% of heavy metal air pollution is in inaccessible form but this does not apply to cadmium. According to the Lum et al. [7] 85% of Cd is available to plants through air pollution. In the past twenty years the main source of this dangerous element in soil was natural super phosphate used as a fertilizer. In the soil the most Cd accumulates in the layer with 0-50 mm depth and with the growing depth its concentration decreases. The weathering of rocks easily passes the element into the soil solution where it occurs as Cd^{2+}. Its accumulation is influenced by several factors, mostly the environment and the soil and land management. In general plants accumulate most of this element in the roots followed by leaves, stems, fruits and seeds. Plants do not have any mechanism for excretion of this element [14]. Opium poppy (*Papaver somniferum* L.) is a crop with the ability to accumulate large amounts of Cd in different organs and particularly in the seeds. Consumption of this traditional delicacy in the countries of Central Europe is around 300 g per capita per year. With regard to this fact monitoring of Cd contamination and risk reduction is a prerequisite for preventing negative effects on the health of the population.

Several research papers were presented on the Cd content in the poppy seed. Salamon [13] evaluated the accumulation of heavy metals in poppy seed in the Eastern Lowland of Slovakia. Samples for analysis were obtained from the grower field from six localities in the region. The content of heavy metals in seed has been studied (Table 1). The Cd concentration in seeds ranged from 0.121 to 0.578 $mg.kg^{-1}$. The highest content account of poppy samples was from the localities in Vysoká nad Uhom and Kuzmice which were polluted by the electric power station and steelworks.

Smrček and Pavelka [11] have presented the Cd contamination of poppy from Novy Jicin in the Czech Republic. The analyses of soil before sowing, plant material - roots, stems, capsules and seeds at the stage of harvest maturity were analysed. The results obtained are shown in tab. 2. The content of Cd in the soil amounted to 29.1 to 42.9% of the maximum permissible content in soil (0.8 $mg.kg^{-1}$). The most contaminated parts of plants were roots and seeds. Seeds were showing contents from 0.256 to 2.300 $mg.kg^{-1}$ of this element. According to the results presented, although the soil did not show a high contamination with Cd, plants were able to accumulate high levels in seeds.

Pavlíková *et al.* [9] determined the influence of Cd content in soil, crop rotation and its accumulation in plant biomass. The four-year experiments on two soil types with different physic-chemical characteristics, and content of Cd, was on four types of crop rotation grown oat, maize, spring barley and poppy. Soil type of luvisol contained 0.180 $mg.kg^{-1}$ and chemozem contained 17.560 $mg.kg^{-1}$ of this heavy metal. The results of the contamination in poppy seeds are shown in tab. 3.

The most Cd accumulation was more apparent in the seeds than in the capsules and stems with leaves. These results correspond with the information given by other authors [11,13]. Crop rotation has influenced the content of Cd in soil. Luvisol contained 0.080 to 0.140 $mg.kg^{-1}$ and chemozem from 16.010 to 16.800 $mg.kg^{-1}$ of Cd quantity.

Accumulation of Cd is influenced by the variety of cultivated poppy. This was shown in the results of Salamon [12] experiments in the Vysoká nad Uhom (Slovakia) in which he determined the Cd contents in seed within three varieties (table 4). The experiments showed that the varieties Dubník and Albin accumulated significantly more Cd than the variety Gerlach. Different genotypes of this species seem to have different abilities to accumulation of this element.

Similar content of Cd in poppy seed are also shown by other authors. Knápek et al. [5] during the years 2004 to 2009 analyzed 202 samples of poppy. The average Cd content in the seed was 0.640 $mg.kg^{-1}$. For products containing poppy content was 0.085 $mg.kg^{-1}$ Cd. Özcan and Atalay [8] evaluated the accumulation of heavy metals in seven varieties of poppy in Turkey. In six varieties they found 0.300 $mg.kg^{-1}$ Cd and one variety accumulated 0.200 mg.kg-1 Cd. Chizola *et al.* [3] monitored the content of heavy metals in several species of medicinal plants in Austria. Plant samples were collected from local farmers in the Lower and Upper Austria and the average content of Cd in poppy seed was 0.250 $mg.kg^{-1}$, with a range of 0.090 $mg.kg^{-1}$ to 0.420 $mg.kg^{-1}$. Tlustoš et al. [16] provides 0.213 $mg.kg^{-1}$ Cd. Hoffman and Blasenbrei [2] found the average heavy metal content 0.739 $mg.kg^{-1}$ in the blue poppy seed from Germany. Intermediates contained 0.317 $mg.kg^{-1}$ and poppy bread 0.107 $mg.kg^{-1}$ Cd.

Poppy Seeds and Other Heavy Metals:

It is general practice to commonly observe poppy seed Cd content whereas accumulation of other heavy metals is given little attention, and the risk elements, which may be contaminated with poppy seeds, are particularly lead (Pb) and chromium (Cr). An overview of the contents of these metals from selected sources is given in

table 5.

Samples from experimental and production areas of Slovakia contain 0.130 to 0.304 $mg.kg^{-1}$ Pb and 0.206 to 0.297 $mg.kg^{-1}$ Cr (Table 1 and 5). Monitoring in Austria [3] confirmed the average lead content of 0.100 $mg.kg^{-1}$ (range 0.050 to 0.400 $mg.kg^{-1}$). Poppy varieties evaluated in Turkey [8] accumulated from 0.300 to 1.600 $mg.kg^{-1}$ lead and 2.300 to 5.200 $mg.kg^{-1}$ of chromium. In the container experiment of Tlustoš *et al.* [16] the concentration of lead in seed was 0.027 $mg.kg^{-1}$. He also evaluated the occurrence of arsenic, which he found 1.610 $mg.kg^{-1}$. The content of these elements varies considerably and is probably influenced mainly in locations from which samples were obtained for analysis.

Ways of Reducing the Cadmium Content in Poppy Seed:

The accumulation of heavy metals including cadmium is affected by complex of factors. According to Tlustoš et al. [16] it is difficult to account bond individual risk elements in soil and their interaction with plants. Accessibility features depend mainly on three soil transformation processes such as the adsorption and desorption, formation and breakdown of complex compounds and precipitation and solution reactions. These processes continually seek to balance. They are influenced by the activity of soil microorganisms. Large influence on these processes is mainly soil reaction.

The main factor in assessing of risk and for the elimination of accumulation is the selection of suitable locations and ground. Close to industrial areas where there is more air pollution gradient the Cd content in soil is higher. Heavy contamination of soil and air gradient cause greater accumulation of this element in the seed. This is confirmed by the results of Šalamon [13], who found highest Cd content in poppy seed from locality near electric works and ironworks, though experiments of Pavlíková et al. [9] showed that high soil contamination accumulated high content of Cd in the seed. Poppy can accumulate considerable amount of Cd in seed, even though the soil is not greatly contaminated with this element [11] (tab. 2). It states that the uptake from soil is affected by several factors.

The agricultural practice recommends the adjustment of soil reaction to pH 6.5 with liming [1,6]. Increasing the pH decreases the uptake of Cd. Tiller *et al.* [15] declare that the change inpH from 5.0 to 7.0 strongly influenced the content accessible to Cd. He found a decrease from 75% to 15% of the available quantity. A high intake and accumulation of Cd within the poppy plants affects low humus content in soil and lack of organic fertilizer. Fertilizing with organic fertilizers increased Cd fixation and reduced its uptake [6,16]. Tlustoš *et al*. [16] confirmed with pot trial that the application of manure had a long-term positive effect on lower uptake of Cd. He also evaluated the impact of application of bentonite.

Table 1: The contents of heavy metals contaminating the produce of poppy seed in the Eastern Lowland in Slovakia (1994)

Localities on the Slovakian East-Low Land	Heavy metals		
	Cd	Pb	Cr
	x	x	x
Vysoká nad Uhom (fields of research institute)	0.578	0.304	0.206
Vranov nad Topľou (fields of Central Control and Testing Institute for Agriculture)	0.304	0.246	0.287
Kuzmice (fields of poppy large-scale cultivation)	0.515	0.248	0.297
Trebišov (fields of poppy cultivation)	0.298	0.130	0.231
Vysoká nad Uhom (fields of cooperative farm)	0.233	0.222	0.239
Bracovce (fields of poppy large-scale cultivation)	0.121	0.255	0.283

Source: Salamon, 1995 (analyzes by the atomic absorption spectrometer)

Table 2: The Cd contents of poppy crop production in the Nový Jičín, in Czech republic (1991)

Localities	Content of Cd ($mg.kg^{-1}$) in various poppy plant parts				
	Soil	Roots	Stems	Capsules	Seeds
Bartošovice	0.283	0.347	0.044	0.162	0.340
Albrechtičky	0.343	0.880	0.110	0.550	0.750
Suchdol	0.293	0.178	0.064	0.605	0.568
Suchdol	0.276	0.208	0.048	0.262	0.256
Pustějov	0.247	1.390	0.110	1.270	2.300
Butovice	0.233	0.760	0.270	0.620	1.150

Source: Smrček, Pavelka, 1992 (analyzes by atomic absorption spectrometer)

Table 3: Cd contents in poppy (an average of four experimental years)

Plant Part	Cd content of plant (mg.kg^{-1})	
	Luvisol	Chemozem
Seed	0.439	4.463
Capsules	0.149	2.406
Stem + leaves	0.100	1.351

Source: Pavlíková et al., 2007 (analyzes by atomic absorption spectrometer)

Table 4: The contents of Cd (mg.kg^{-1}) in the poppy seeds in the Slovak varieties

Poppy Varieties			Analysis of variance	
Dubník	Gerlach	Albín	F	P
0.58	0.46	0.66	7.0	0.00 **

Source: Šalamon, 1995/2 (analyzes by atomic absorption spectrophotometer)

Table 5: Content of other heavy metals in poppy seeds mg.kg^{-1} (selection sources)

Source	Heavy metals	
	Pb	Cr
[13] Šalamon, 1995	0.130 – 0.304	0.206 – 0.297
[16] Tlustoš *et al.*, 1997	0.027	0
[3] Chizola *et al.*, 2003	0.050 – 0.400	0
[8] Özcan and Atalay, 2006	0.300 – 1.600	2.300 – 5.200

Table 6: Content of cadmium in poppy seeds after soil fertilizer width Mg

Variant	2006		2007	
	mg.kg^{-1}	%	mg.kg^{-1}	%
Control	0.287	100	0.607	100
$Mg(NO_3)_2$	0.252	87,8	0.479	78,9
$MgSO_4$	0.247	86,0	0.561	92,4

Its use had not a significant impact on the uptake limit of the reference element (in the variant treated with bentonite he found significantly higher concentration of Pb in seed). Nutrition and fertilizer is also an important factor in agricultural practice to eliminate uptake of Cd. With regard to soil reaction physiologically acid fertilizers are not recommended. Bechyně, *et al.* [1] recommends the phosphorus fertilization in preceding crop, so that the natural Cd content can attract calcium and humus in the soil. Similarly, he recommended potassium fertilizers to be applied to wash off chlorides because they increase the uptake of heavy metals. With the foliar nutrition it is not recommended to use fertilizers with a high content of Mg, because his accumulation in the seed is assumed and is in a positive correlation with Cd. In contrast Lošák [6] experiments found that the application of phosphorus (fertilizer Amofos), potassium (fertilizer potassium salt of 50% and potassium sulphate) and magnesium (fertilizer Kieserite) did not increase Cd content in the seed. On the other hand a lower accumulation was recorded as compared with the control variant. Richter and Lošák [6] verified the impact of magnesium fertilization on Cd accumulation in seed. Results of two years of accurate container experiment are listed in table 6. After application of fertilizers accumulation of Cd had decreased from 7.6 to 21.1%.

Microelements have an important place in poppy plant nutrition. Boron is an important micronutrients. Bechyně, *et al.* [1] recommended it to be applied to limit the intake Cd 100 g of pure nutrients per hectare of boron in a chelated form in the rosette stage with five to seven leaves. The Lošák [6] recommended 150 g of boron per hectare. Liquid fertilizers with only one component are suitable. Mixing several elements in one application is not recommended.

Conclusion:

Heavy metals are toxic at relatively low concentrations. Poppy seed is able to accumulate more toxic elements of which cadmium is considered the most dangerous. The flow of cadmium in consumer food can cause a malfunction of calcium metabolism. The body retains 50-60% of received Cd in the liver and kidneys, which can cause damage. Therefore it is necessary to pay attention to eliminating the introduction of this element into the food chain. The average annual consumption of poppy seeds in Central Europe is around 300 g (sometimes less depending on the tradition of eating). This is a small amount to effect serious health problems. Nevertheless, attention should be paid to the contamination of contaminants in delicacies. Therefore steps should be taken to reduce uptake and accumulation of these substances in poppy seed.

References

1. Bechyně, M., T. Kadlec, J. Vašák and group of authors, 2001. Nutrition and fertilization, limitations of cadmium (In Czech). In Mák. Agrospoj Praha, pp: 51-55.
2. Hoffman, J. And P. Blasenbrei, 1986. Cadmium in Blaumohn und Mohnerzeugnissen. Z Lebensm Unter Forsch, 182: 121-122.
3. Chizola, R., H. Michitsch and Ch. Franz, 2003. Monitoring of Metalic Micronutrients and Heavy Metals in Herbs, Spices and Medicinal Plants from Austria. Eur Food Technol, 216: 407-411.
4. Iljin, V.B., 1990. Ozagjaznenii tjazelzmi metallami pocv is selskochozjajstvennych kultur predprijatijem cvetnoj metalurgii (In Russian). Agrochimija, 3: 92-99.
5. Knápek, J., R. Buchtová and D. Vošmerová, 2009. Determination of Cadmium in Poppy Seeds and in Poppy Seeds containing Products. Book of Abstract. *4th* international Symposium on Recent Advances in Food Analysis, Prag 2009: pp. 226-226.
6. Lošák, T., 2010. Nutrition and fertilization of poppy (In Czech). In Mák. Powerprint, Praha, pp: 129-158.
7. Lum, K.R., E.A. Kokotich and W. H. Schroeder, 1987. Bioavailable Cd, Pb and Zn in wet and dry deposition. The Science of the Total Environment, 63: 161-173.
8. Özcan, M.M. and C. Atalay, 2006. Determination of Seed and Oil Properties of Some poppy (*Papaver somniferum* L.) varieties. Grasas Y Aceites, 57(2): 169-174.
9. Pavlíková, D., J. Balík and P. Tlustoš, 2007. Effect of Cadmium Content in Soil and Crop Rotation on Cadmium Accumulation in Plant Biomass. Ecological Chemistry and Engineering, 14(3-4): 363-369.
10. Richter, R. and T. Lošák, 2006. Can magnesium nutrition influence the yielding and chemical composition of straw and seeds of poppy (*Papaver somniferum* L.). Ecological Chemistry and Engineering, 13(9): 965-972.
11. Smrček, L. and J. Pavelka, 1992. Cadmium Contamination of poppy seed (In Czech). Úroda, (10), 473-474.
12. Šalamon, I., 1995. The Effect of Environmental Pollution by Heavy Metals on Poppy Growing in the East Slovak Lowland (In Slovak). Zahradnictví [Horticulture], 22(3): 85-88.
13. Šalamon, I., 1995. Heavy metals and their accumulation in poppy varieties (In Slovak). Current Issues recovery Agrokomplex. In Proceedings of the yier 1995 from scientific conference with international participation], pp. 326-329.
14. Šalgovičová, D., 2009. Assessment of exposure to cadmium in the Slovak Republic (In Slovak). Enviromagazín, 14(4): 26 – 27.
15. Tiller, K.G, J. Gerth and G. Brummer, 1984. The Reklative Afinities of Cd, Ni and Zn for Different Soil Clay Fractions and Goethite. Geoderma, 34: 17-34.
16. Tlustoš, P., J. Balík, D. Pavlíková, And J. Száková, 1997. The Uptake of Cadmium, Zinc, Arsenic and Lead by Chosen Crops (In Czech). Rostlinná Výroba [Plant Production], 43(10): 487-494.