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THE EVALUATION OF NICKEL, CHROMIUM, LEAD AND MERCURY CONTENT IN SWEET CORN

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ABSTRACT

In the framework of monitoring, we have focused on the analysis of the levels of nickel, chromium, lead and mercury in 9 samples of sweet corn (frozen and canned) from the commercial network of the Slovak Republic. Homogenised samples of sweet corn were mineralized using microwave digestion unit MARS X-press and next analysed by atomic absorption spectrometer VARIAN 240 FS for tested metal concentration, excluding mercury which was was determined by automatic mercury analyser AMA 254.Nickel content in all samples was in the range of 0.376 – 0.556 $mg.kg^{-1}$, chromium content was 0.088 – 0.546 $mg.kg^{-1}$, lead content was 0.054 – 0.146 $mg.kg^{-1}$ and mercury content was 0.000013 – 0.011458 $mg.kg^{-1}$. The measured values have been compared with the limit values set out legislation for the maximum quantity of hazardous elements according to the Food Code of the Slovak Republic. From the point of view of the sanitary evaluation, the content of nickel, chromium, lead and mercury were not exceeded in either sample.

Keywords: Food contamination, sweet corn, nickel, chromium, lead, mercury,

INTRODUCTION

Sweet corn (*Zea mays amylacea saccharata*) is one of the oldest foods in the world, about 5,000 years old. It comes from the American continent and was imported by discoverers of America to Europe. First of all corn was grown in Spain. At the end of the 15th century became the cultivation of corn significant development. Since the beginning of the 16th century it began to expand throughout Europe **(Gay, 1984)**. In terms of the world's economy can be corn considered as the most important feed material and human nutrition **(Jurášek, 1997).** The fruit of corn is a grain or achene from the botanical point of view. It may be a variety of shapes and colors. Endosperm consists of 80 - 84% of grain weight and contains starch **(Ryšavá *et al.*, 2004).** The corn provides an important raw material for the processing industry, especially for food, construction, chemicals and pharmaceuticals **(Pospíšil, 2002).** The corn is very beneficial for health due to its composition. The main component of grain corn is starch (60 - 70%). Corn also contains proteins in an average 10 %, vitamin A, E, B and also vitamin C, D and K in trace amounts.
Heavy metals from natural and anthropogenic sources have harmful effects on soil, reduce nutritional, technological and sensory value of the plant and affects the health of animals and people. The sources of heavy metals are transport, industry as well as agriculture. Soil is a fundamental component of environment. The importance of care and preservation of safe and hygienic land that produces food and feed is enhanced by its difference from the other components of the environment **(Ducsay *et al.*, 2000).** The phytotoxic effects depend on the concentration and amount of an acceptable form of heavy metals in the soil solution, the speed of the element from a solid phase to a liquid solution, the physical and chemical characteristics of the soil but also the type of cultivated plants. In the potentially toxic elements even slight increases in concentrations of these elements operates phytotoxic in terms of quality but also quantity harvested production **(Kulich, 1994; Gábriš *et al.*, 1998; Kočík, 1991; Ducsay, 1995).** Heavy metals are at certain concentrations in the organism toxic or lethal. Through the food chain are significantly great risk to plants, animals and people. The excess of heavy metals in the body produces free radicals that destroy organic molecules in the body **(Zeng *et al.*, 2011).**
The aim of our work was to determine the concentration of heavy metals in sweet corn available in the commercial network of Slovak Republic.

MATERIAL AND METHODS

Sweet corn samples commonly available in commercial network in Slovak republic was tested to determine the contents of the risk elements (nickel, chromium, lead, mercury) in the frozen (n=3) and canned (n=6) sweet corn. Description and characteristics of the analysed samples was given in table 1.

Table 1 Description and characteristics of the analysed samples

Sample number	Product name	Packing/weight	Country of origin
1	Novo - fruct	210 g	Slovak Republic
2	Jamar	400 g	Poland
3	Mňam - Mňam	425 g	China
4	Znojmia	340 g	Czech Republic
5	Bonduelle – Sweet corn	425 g	Hungary
6	Bonduelle – Super sweet corn	400 g	Hungary
7	Iglo	325 g	Austria
8	Klassik	450 g	Belgium
9	Cukrík	350 g	Unknown

Determination of heavy metals in grain of sweet corn (excluding mercury)
Samples (1g) of sweet corn were mineralized by wet road using microwave digestion unit MARS X-press. The metal contents were determined by Flame Atomic Absorption Spectrometry AA240FS Varian (Varian, Australia). Repetition of the experiment was three and the average value was used in the analysis of measurement.

Determination of mercury in grain of sweet corn
The total mercury concentration was determined in the homogenized corn samples (0.005-0.01 g) using a cold - vapour AAS analyser AMA 254 (Altec, Czech Republic) with a detection limit of 0.5 ng.g-, atomic absorption spectrophotometer dedicated for the direct determination of mercury in solid and liquid samples.

The results of analyses were compared with the limit values that define the Food Code of the Slovak Republic (No. 608/3/2004 – 100 setting maximum levels for contaminants in foods). For statistical evaluation of results was used the program STATGRAFICS Plus 5.1 to process gained data (Multifactor ANOVA, LSD test).

RESULTS AND DISCUSSION

The lowest Ni content was measured in the sample No. 3 with a value of 0.376 mg.kg^{-1} and the highest was measured in the sample No. 9 with a value of 0.556 mg.kg^{-1}, which was not exceeded the limit value 2.500 mg.kg^{-1}, defined in the Food Code of SR. Results are shown in the figure 1.

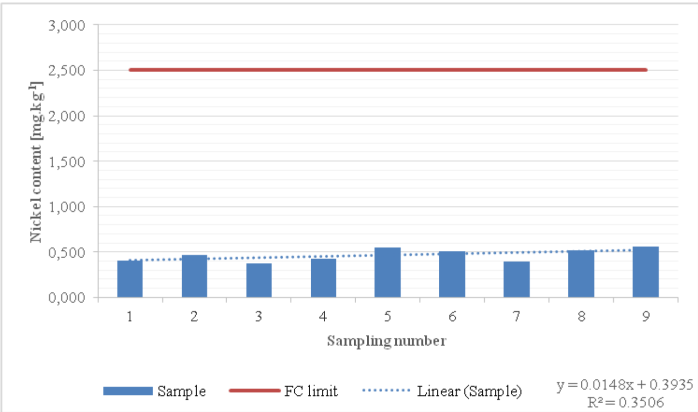

Figure 1 Nickel content in samples of sweet corn (mg.kg^{-1})

The lowest Cr content was measured in the sample No. 2 with a value of 0.088 mg.kg^{-1} and the highest was measured in the sample No. 5 with a value of 0.546 mg.kg^{-1}, which was not exceeded the limit value 4.000 mg.kg^{-1}(Food Code). Results are shown in the figure 2.

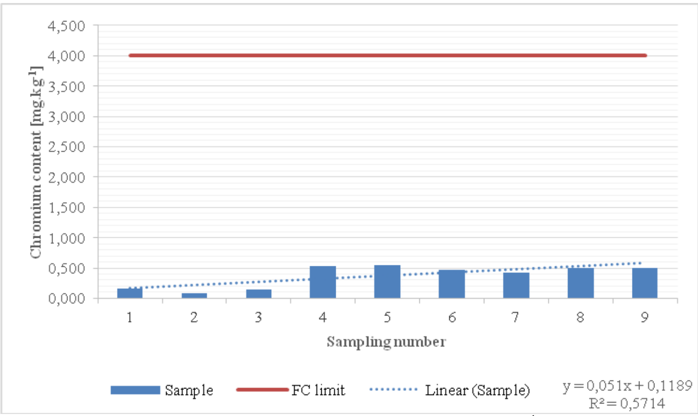

Figure 2 Chromium content in samples of sweet corn (mg.kg^{-1})

The lowest Pb content was measured in the sample No. 6 with a value of 0.054 mg.kg^{-1} and the highest in the sample No.2 with a value of 0.146 mg.kg^{-1} was measured, which was not exceeded the limit value 1.000 mg.kg^{-1} (Food Code). Results are shown in the figure 3.

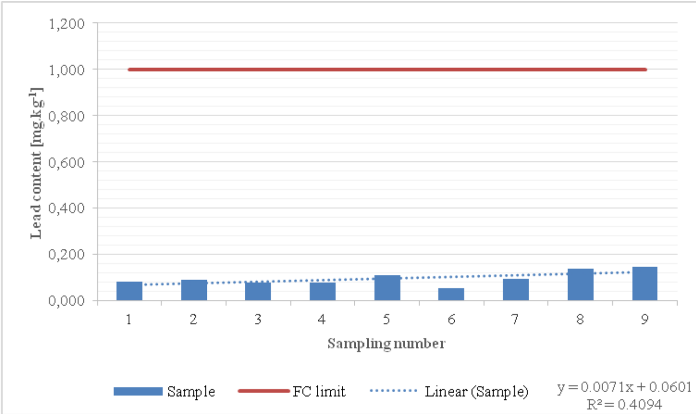

Figure 3 Lead content in samples of sweet corn (mg.kg^{-1})

The lowest Hg content was measured in the sample No. 9 with a value of 0.000013 mg.kg^{-1} and the highest in the sample number 2 with a value of 0.011458 mg.kg^{-1} was measured, which was not exceeded the limit value 0.050 mg.kg^{-1} (Food Code). Results are shown in the figure 4.

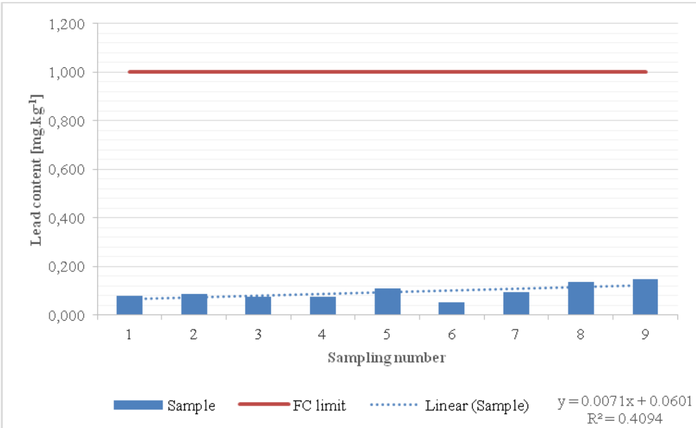

Figure 4 Mercury content in samples of sweet corn (mg.kg^{-1})

In all samples was not exceed the total content limit values of monitored heavy metals. Between samples No. 1 and 7, then 6 and 8 and finally 5 and 9 were not significant differences (P>0,05) in the concentration of nickel. Between samples No. 1 and 3, then 8 and 9 and finally 4 and 5 were not significant differences in the concentration of chromium (P>0,05), between samples No. 1, 2, 3 and 4, then 6 and 8 and finally 5 and 9 were not significant differences in the concentration of lead(P>0,05) and in the case of the concentration of mercury between samples number 4 and 5 were not significant differences (Tab 2).
We also observed strong statistical significant correlations for Ni, Cr and Pb contentin samples (Tab 3).
We also observed strong statistical significant correlation between Ni, Cr and Pb contentWith increasing Ni content, the content of Cr increase. Based on the increasing value of Pb concentration also increase Ni content. Ni content was not statistically significant influenced by Hg content. (Tab 4).
Cr content was significantly influenced by Ni and Hg content. Cr content was not statistically significant influenced by Pb content. With increasing Cr content, the content of Ni increase. Based on the increasing value of Hg concentration also increase Cr content (Tab 5).
Pb content was significantly influenced by Ni content, but not by Cr and Hg content. With increasing Pb content, the content of Ni increase (Tab 6).
Hg content was negatively influenced only by Cr content, with increasing Hg content, the content of Cr decrease (Tab 7).

Table 2 Level of the concentration significance of Ni, Cr, Pb and Hg in sweet corn

Sample	Heavy metal content			
	Ni [mg.kg^{-1}]	Cr [mg.kg^{-1}]	Pb [mg.kg^{-1}]	Hg [mg.kg^{-1}]
1	0,402 b	0,161 b	0,080 b	0,001385 c
2	0,470 d	0,088 a	0,088 bc	0,011458 h
3	0,376 a	0,150 b	0,075 b	0,002313 f
4	0,429 c	0,530 f	0,076 b	0,001523 d
5	0,546 f	0,546 f	0,109 d	0,001498 d
6	0,509 e	0,470 d	0,054 a	0,000419 b
7	0,398 b	0,426 c	0,094 c	0,007316 g
8	0,521 e	0,501 e	0,137 e	0,002033 e
9	0,556 f	0,494 e	0,146 e	0,000013 a
Mean	0,467±0,068	0,374±0,185	0,095±0,030	0,003±0,004
$HD_{0,05}$	0,0188607	0,0161931	0,0131514	0,0000994

$HD_{0,05}$ – marginal difference at 95% level of significance (LSD - test)

Table 3 Pearson correlation coefficient between samples and heavy metal content

Parameter		Correlation coefficient (r)
Dependent variable	**Independent variable**	
Sample	Ni	0,5892**
	Cr	0,7551**
	Pb	0,6311**
	Hg	-0,3004

**strong statistical significant of the correlations

Table 4 Pearson correlation coefficient between Ni and other heavy metal content

Parameter		Correlation coefficient (r)
Dependent variable	**Independent variable**	
Ni	Cr	0,5763**
	Pb	0,5816**
	Hg	-0,2854

**strong statistical significant of the correlations, *statistical significant of the correlations

Table 5 Pearson correlation coefficient between Cr and other heavy metal content

Parameter		Correlation coefficient (r)
Dependent variable	**Independent variable**	
Cr	Ni	0,5763**
	Pb	0,3605
	Hg	-0,5208**

**strong statistical significant of the correlations, *statistical significant of the correlations

Table 6 Pearson correlation coefficient between Pb and other heavy metal content

Parameter		Correlation coefficient (r)
Dependent variable	**Independent variable**	
Pb	Ni	0,5816**
	Cr	0,3605
	Hg	-0,1146

**strong statistical significant of the correlations, *statistical significant of the correlations

Table 7 Pearson correlation coefficient between Hg and other heavy metal content

Parameter		Correlation coefficient (r)
Dependent variable	**Independent variable**	
Hg	Ni	-0,2854
	Cr	-0,5208**
	Pb	-0,1146

**strong statistical significant of the correlations, *statistical significant of the correlations

Because heavy metal treatment activates different metabolic processes in different developmental parts of the root, the potential benefits of biotechnological approaches in terms of protecting the most sensitive parts of the root should be evaluated in the context of this metabolic distribution. The ability to protect the growth zones of roots from heavy metal poisoning could potentially greatly reduce the impact of heavy metal toxicity on crops (**Ovečka, Takáč, 2014**). According to published data heavy metal concentrations observed for corn were within the normal range **(Lavado *et al.*, 2001).** The heavy metal level in sweet corn was in the same order of magnitude as that obtained in Australian soils **(Oliver *et al.*, 1998).**

CONCLUSION

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

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