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RISK ELEMENTS IN SELECTED TYPES OF VEGETABLES

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ABSTRACT
Vegetable has an important role in human nutrition. Various parts of the plants have been part of the human diet since the beginning. Vegetables have a number of properties that make its consumption very healthful. It not only is a good source of vitamins, minerals and fiber but also contains protective components so called phytonutrients, has an antioxidant and antimicrobial effects. Daily intake of vegetables offers many health benefits, helps to improve health for example the function of digestive and immune system, reduces the risk of various diseases and so we should take care to its regular consumption. It is widely used, except that it is the basic raw material for the preparation of foods and is also an important raw material for the processing industry. Nowadays has become environmental pollution by heavy metals as a big problem. The contamination of water, soil as well as air pollution by heavy metals negatively affects agricultural production and production of non-harmful to health, safe and quality food, which may be adverse effects on human health. Therefore, it is important that we devote this issue more attention. The aim of this work was to identify and determine content of heavy metals in selected vegetables. Defined objectives have been achieved by analyzing of selected species samples of root from brassica vegetables: carrot (*Daucus carota* L. ssp. *sativus*), parsley (*Petroselinum hortesne HOFFM* conv. *radicosum*), kohlrabi (*Brassica oleracea* L. var. *gongylodes*), celery (*Apium graveolen*s L. var. *rapaceum*) and beetroot (*Beta vulgaris* L. var. *conditiva* ssp. *vulgaris*). The crops were bought in local market. The obtained results were compared with the results obtained from analyzes of vegetables that were grown in home conditions respectively from markets of local growers. All crops were grown in Slovak Republic. By using Varian AA 240FS and AAS method were analyzed the contents of risk metals in selected vegetables. It was confirmed that in selected types of vegetables analyzed element was not exceeded the limit values established by *Codex Alimentarius* of Slovak Republic. From the results, also can be concluded that higher contents of heavy metals (Cu, Mn, Ni, Cd, Pb) were mostly in samples from home gardeners than in samples came from local market.

Keywords: heavy metals; vegetables; contamination; local market

INTRODUCTION
Vegetable is a fundamental part of the food chain and a typical component of a wide range of the dishes. Vegetable has an important place in a rational human nutrition for its high biological and low-energy value **(Uher, 2011).**

In the view of the attractiveness to consumers is significant diversity of aromas, flavors, species and varieties with the possibility of its culinary use. On the other hand, the nutritional value it is important to its good and quick digestibility **(Kopec, 2010)**.

Vegetables, as an important source of chemo protective substances, have irreplaceable position within the food of plant character **(Hegedűsová et al., 2015)**.

Vegetable is very important in human nutrition because it ensures adequate intake of most vitamins, minerals, fiber and phytochemical substances. The consumption of vegetables in the daily diet is nearly related with a number of positive health effects, good health, a lot of positive effects to gastrointestinal system, reduces the risk of heart disease, stroke, anemia and chronic diseases such as diabetes and some forms of cancer **(Dias, 2012)**.

Carrot is a huge source of pro-vitamin A and also a good source of fiber and trace elements as potassium, sodium, magnesium, calcium, and molybdenum. Carotenoids, flavonoids, phenolic compounds, and vitamins are contained in carrots and have an effect as antioxidants **(Dias, 2014)**.

Parsley has been used as carminative, gastro tonic, diuretic, antiseptic of urinary tract, anti-urolithiasis, anti-dote and anti-inflammatory and for the treatment of amenorrhea, dysmenorrhea, gastrointestinal disorder, hypertension, cardiac disease, urinary disease, otitis, sniffle, diabetes and also various dermal disease in traditional and folklore medicines **(Farzaei et al., 2013)**.

Celery contains vitamin C and other materials that are health enhancing substances such as phalides, which lowers cholesterol and coumarins that helps prevent cancer. Celery seeds of anti-rheumatism, sedative, antiseptic urinary tract, increased excretion of uric acid, blood pressure lowering, to some extent against fungal diseases, diuretic, analgesic, anti-inflammatory, detoxification **(Modaresia et al., 2012)**.

Kohlrabi is watery, easily digestible tuber of distinctive taste. The mean of water concentration is 91.7%. It has 3.7% of sugars, 1.6% of protein, 0.2% of fat and 2.2% of fiber. Kohlrabi is rich of glucosinolates that give it the characteristic odor and taste and have anticancer effects **(Uher, 2011).**

Beetroot (*Beta vulgaris* L.) is a member of the *Chenopodiaceae* family, cultivated for its large roots, although leaves are also utilizable. Seeds, roots and leaves of the plant are rich of polyphenols and a water-soluble nitrogen pigments group named betalains. The betalains family represents the principal pigment in beetroot and the characteristic red-violet color is regarded as major attribute for beetroot quality and acceptability **(Ninfali and Angelino, 2013)**.

Environmental contamination with heavy metals is increasingly coming to the fore and it is one of the most serious problems of modern society nowadays. Their riskiness arises from the substantial persistence, toxicity and ability to bio accumulate into environmental components and consequently into the food chain **(Burges et al., 2015; Douay et al., 2013; Roman and Popiela, 2011)**.

Copper is an essential element for many organisms, but in high concentrations it becomes toxic. It has wide application in industry and agriculture **(Bui et al., 2016)**.

Nickel level is low in most foods and vegetables except for a few cases, such as tea plants and *Camillia sinensis* L., which have the ability to accumulate nickel. Nickel is a moderately toxic element compared to other transition metals that can lead to serious illness, including malignant tumours and nasopharynx, lung, and dermatological diseases. However, nickel is an essential element for humans, other animals, and plants **(Jiang et al., 2006; Spears, 1984)**.

According to **Beneš (1994)** many plants tolerate higher cadmium content in the soil (tomatoes, potatoes). Sensitive plants react negatively to a Cd concentration in soil 4 – 13 mg.kg^{-1} (spinach, soybean, tobacco), which is not very high by hygienically point of view. Higher concentrations of cadmium in soil inhibit the uptake of Ca^{2+} and Mg^{2+} by plants.

The plants can be resist to cadmium retention of excess ions in the roots or on the borders of metabolically important organs, reduce activity of excess ions and their transfer to a physiologically inert form, or create alternative exchange reaction that is less sensitive to cadmium. Cadmium accumulation and distribution in plant organs is clearly acropetal character: roots >stems >leaves >fruits (seeds). The highest concentration of cadmium is in root and greenhouse vegetables. Cadmium concentration increases as follows: oat <wheat <bean <pea <sunflower <corn <radish <tomato <carrot <salad **(Kočík, 1995)**.

Short-term exposure to high levels of Pb can cause brain and kidney damage, and gastrointestinal distress, while long-term exposure may affect blood, liver, and the central nervous and reproductive systems. Chronic low level exposure causes serious damage, in particular to the central nervous system, the vasculature and the kidneys **(Gupta et al., 2013)**.

MATERIAL AND METHODOLOGY

The aim of this work was to identify participation of individual heavy metals in selected vegetables from local market (vegetables from home conditions and vegetables from local growers both from Slovak Republic). In this work were analyzed root from brassica vegetables:

1. carrot (*Daucus carota* L. ssp. *sativus*)
2. parsley (*Petroselinum hortesne* HOFFM conv. r*adicosum*)
3. kohlrabi (*Brassica oleracea* L. var. *gongylodes*)
4. celery (*Apium graveolens* L. var. *rapaceum*)
5. beetroot (*Beta vulgaris* L.var. *conditiva* ssp. *vulgaris)*

Sample preparation

Samples of vegetables were washed, dried, then grated. We transfer them to dry in a Petri dishes in the oven Venticel 111 (Czech Republic) at 80 °C to constant weight. Part of the fresh sample was used for the determination of the dry matter by Ultra X (Germany).

Determination of heavy metals (by AAS)

Mineralization of samples (1 – 2 g of dried vegetables) was in a mixture of distilled water with concentrated nitric acid in a ratio 1:1. The weighed samples were put into teflon vessels with 5 cm^3 of distilled water with 5 cm^3 of concentrated nitric acid. Closed vessels with samples were mineralized by microwave digestion unit MARS X-press (USA).

After mineralization were analyzed samples filtered through quantitative filter paper MUNKTELL (Germany) grade 390.84 g.m^{-2} (green) to volumetric flasks (50 cm^3).

Flasks were refilled with distilled water to the mark and after that was the determination of heavy metals by VARIAN AA 240FS (Australia) under the conditions:

Cd – detection limit – 0.001 mg.L^{-1}, sensitivity 0.01 mg.L^{-1}
Pb – detection limit – 0.02 mg.L^{-1}, sensitivity 0.1 mg.L^{-1}
Cu – detection limit – 0.002 mg.L^{-1}, sensitivity 0.03 mg.L^{-1}
Zn – detection limit – 0.006 mg.L^{-1}, sensitivity 0.008 mg.L^{-1}
Co – detection limit – 0.005 mg.L^{-1}, sensitivity 0.05 mg.L^{-1}
Cr – detection limit – 0.003 mg.L^{-1}, sensitivity 0.04 mg.L^{-1}
Ni – detection limit – 0.008 mg.L^{-1}, sensitivity 0.06 mg.L^{-1}
Mn – detection limit – 0.003 mg.L^{-1}, sensitivity 0.02 mg.L^{-1}
Fe – detection limit – 0.005 mg.L^{-1}, sensitivity 0.04 mg.L^{-1}

Analysis determination has not a deviation more than 3%, the gas flow: air: 13.5 L.min^{-1}, acetylene 2.0 L.min^{-1}.

For statistical evaluation of results was used a statistical program STATISTICA 6.0 Cz. The results tested on the level of descriptive statistical evaluation, and overall visual indication of the level factor, variability and deviations were expressed as text. We used T-test at the confidence level $p \leq 0.05$.

RESULTS AND DISCUSSION

The figures showed a comparison of the content of risk metals in selected types of vegetables that were bought in local market and the commercial local shops network and markets of local growers.

Table 1 The process of mineralization – time, temperature (total time 55 minutes).

Stage	Power (W)	Power (%)	Initialization Time (min)	Temp. (°C)	Duration time (min)
Initialization	800	90	15	160	0
Mineralization	800	90	0	160	20
Cooling	–	–	–	–	20

The contents of risk metals were compared with the maximum limit values set by *Codex Alimentarius* of Slovak Republic. The contents of zinc, manganese, cobalt and iron do not have defined limit values in *Codex Alimentarius of SR*.

According to obtained results of copper content can be defined in the order of vegetable species from markets of local growers: parsley >celery >carrot >beetroot >kohlrabi.

According to obtained results of copper content can be defined in the order of vegetable species from commercial local market: parsley >celery >beetroot >carrot >kohlrabi.

The highest copper content was detected in parsley from market with value 1.85 ±0.02 mg.kg^{-1} and the lowest in kohlrabi (0.21 ±0.01 mg.kg^{-1}). The most significant difference between samples of obtained results of copper content in vegetable from market and from local shop network was found in celery.

Mahmood and Malik (2014) identified a high copper content in carrot (5.34 mg.kg^{-1}). The copper content in all types of vegetable was not exceeded the highest permissible limit set by *Codex Alimentarius* of SR.

According to obtained results of zinc content can be defined in the order of vegetable species from markets of local growers: parsley >celery >beetroot >carrot >kohlrabi.

According to obtained results of zinc content can be defined in the order of vegetable species from commercial local market: celery >beetroot >parsley >kohlrabi >carrot.

The lowest zinc content was detected in carrot from local market with value 1.76 ±0.03 mg.kg^{-1}.

Shaheen et al., (2016) obtained in carrot 0.07 mg.kg^{-1} of zinc content. The highest zinc content from both sources was in celery (4.46 ±0.03 mg.kg^{-1}).

According to obtained results of manganese content can be defined in the order of vegetable species from markets of local growers: kohlrabi >parsley >celery >beetroot >carrot.

According to obtained results of manganese content can be defined in the order of vegetable species from commercial local market: kohlrabi > celery > parsley > beetroot > carrot.

The highest manganese content was detected in kohlrabi from market with value 2.66 ±0.03 mg.kg^{-1}and the lowest in carrot (0.55 ±0.02 mg.kg^{-1}). **Shaheen et al., (2016)** identified in carrot 6.98 mg.kg^{-1} of manganese content, which is about 12 times more than the value measured by us.

According to obtained results of iron content can be defined in the order of vegetable species from markets of local growers: parsley >celery >kohlrabi >beetroot >carrot.

According to obtained results of iron content can be defined in the order of vegetable species from commercial local market: parsley >kohlrabi >beetroot >celery >carrot.

The highest iron content compared to all analyzed vegetables, was detected in parsley from local market as well as from market (25.8 ±0.53 mg.kg^{-1}).

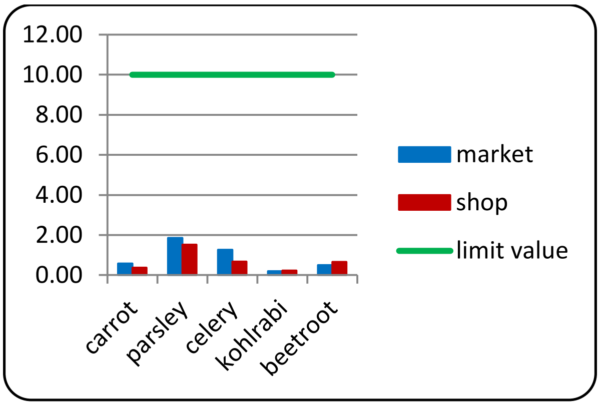

Figure 1 Evaluation of copper content in selected types of vegetables (mg.kg^{-1}), median, n = 6 and comparison with the maximum permissible limits set by *Codex Alimentarius* of SR.

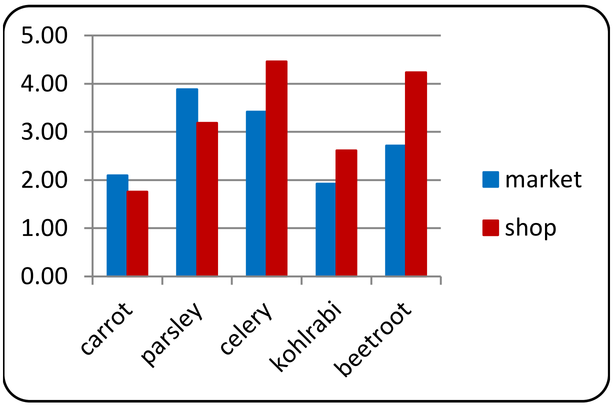

Figure 2 Evaluation of zinc content in selected types of vegetables (mg.kg^{-1}), median, n = 6.

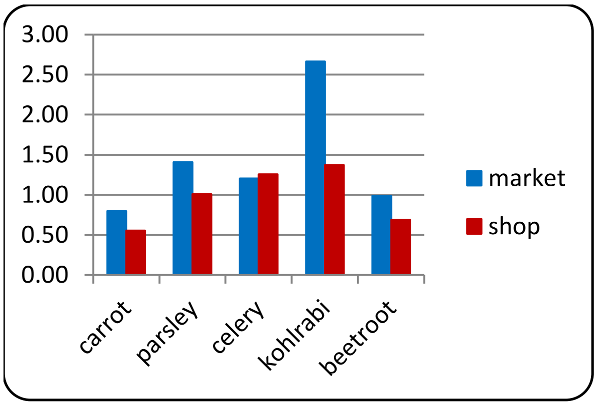

Figure 3 Evaluation of manganese content in selected types of vegetables (mg.kg^{-1}), median, n = 6.

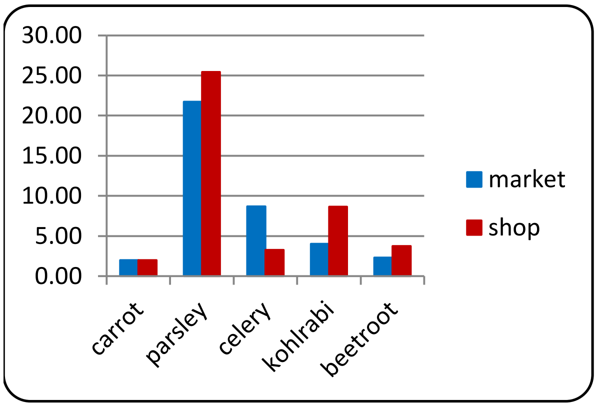

Figure 4 Evaluation of iron content in selected types of vegetables (mg.kg^{-1}), median, n = 6.

In vegetable samples bought in market, except celery, was iron content smaller than in vegetables bought in local market.

According to obtained results of nickel content can be defined in the order of vegetable species from markets of local growers: parsley >celery >kohlrabi >beetroot >carrot.

According to obtained results of nickel content can be defined in the order of vegetable species from commercial local market: celery >parsley >beetroot >kohlrabi >carrot.

The highest nickel content was detected in parsley from market with value 0.419 ±0.02 mg.kg^{-1}. **Guerra et al., (2012)** identified even higher nickel content of parsley (0.70 mg.kg^{-1}). The lowest nickel content was in carrot (0.05 ±0.02 mg.kg^{-1}).

The nickel content in all types of vegetable was not exceeded the highest permissible limit set by *Codex Alimentarius* of SR.

According to obtained results of cobalt content can be defined in the order of vegetable species from markets of local growers: celery >beetroot >kohlrabi >carrot >parsley.

According to obtained results of cobalt content can be defined in the order of vegetable species from commercial local market: kohlrabi >beetroot >parsley >celery >carrot.

The lowest cobalt content was in parsley from market (0.03 ±0.01 mg.kg^{-1}). The highest cobalt content was detected in celery from local market (0.20 ±0.03 mg.kg^{-1}).

The most significant difference between samples of obtained results of cobalt content in vegetable from market and from local market was found in celery and parsley and the lowest significance of difference was in beetroot. **Guerra et al., (2012)** obtained in parsley 0.47 mg.kg^{-1} of cobalt content.

According to obtained results of cadmium content can be defined in the order of vegetable species from markets of local growers: celery >parsley >beetroot >kohlrabi >carrot.

According to obtained results of cadmium content can be defined in the order of vegetable species from commercial local market: beetroot >celery >kohlrabi >carrot >parsley.

The highest cadmium content in selected types of vegetables was detected in beetroot from local market (0.05 ±0.02 mg.kg^{-1}) and the lowest in parsley (0.003 ±0.01 mg.kg^{-1}). **Guerra et al., (2012)** identified high cadmium content in beetroot (0.09 mg. kg^{-1}). The cadmium content in all types of vegetable was not exceeded the highest permissible limit set by *Codex Alimentarius* of SR.

According to obtained results of lead content can be defined in the order of vegetable species from markets of local growers: celery >carrot >beetroot >parsley >kohlrabi.

According to obtained results of lead content can be defined in the order of vegetable species from commercial local market: celery >beetroot >parsley >kohlrabi >carrot.

The lowest lead content was in carrot from local shop network (0.002 ±0.01 mg.kg^{-1}). **Mahmood and Malik**

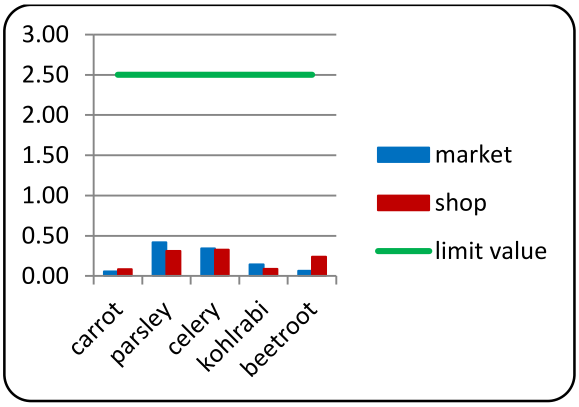

Figure 5 Evaluation of nickel content in selected types of vegetables (mg.kg^{-1}), median, n = 6 and comparison with the maximum permissible limits set by *Codex Alimentarius* of SR.

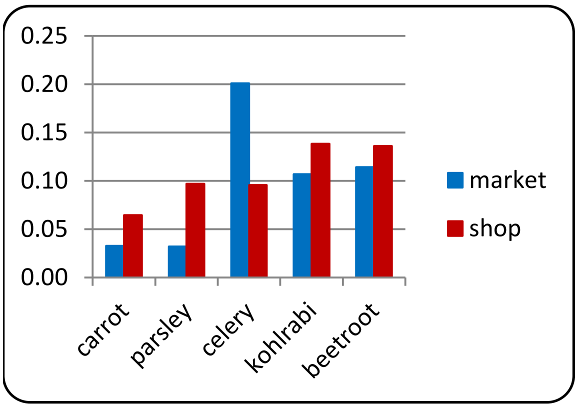

Figure 6 Evaluation of cobalt content in selected types of vegetables (mg.kg^{-1}), median, n = 6.

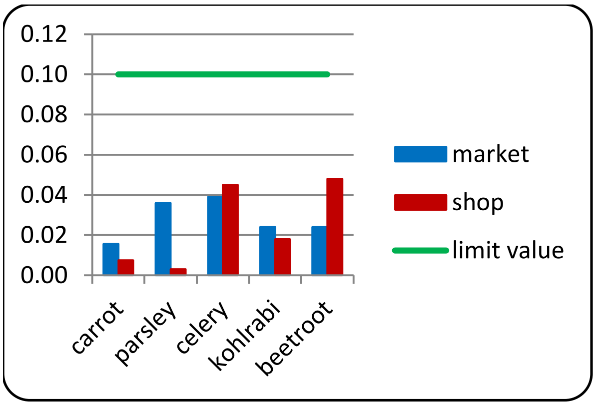

Figure 7 Evaluation of cadmium content in selected types of vegetables (mg.kg^{-1}), median, n = 6 and comparison with the maximum permissible limits set by *Codex Alimentarius* of SR.

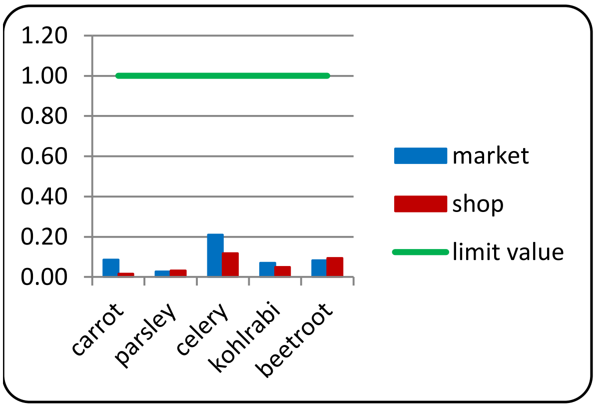

Figure 8 Evaluation of lead content in selected types of vegetables (mg.kg^{-1}), median, n = 6 and comparison with the maximum permissible limits set by *Codex Alimentarius* of SR.

(2014) identified in carrot 0.29 mg.kg^{-1} of lead content. The highest lead content was detected in celery from market (0.21 ±0.02 mg.kg^{-1}).
By evaluation of lead content in all types of vegetable from local shop network can be concluded that highest lead content was detected in celery.

Between samples of obtained results of heavy metals content in vegetable from market and from local shop network was not found significant difference.

CONCLUSION

This work focuses to the contents of risk metals in selected types of vegetable. Vegetable accumulates these elements mainly by roots from polluted water and soil as well as above-ground parts that are exposed to air pollution. A lot of heavy metals are accumulated mostly in the root system of plants.

We have analyzed samples of a root of brassica vegetable, in which it has been measured the content of these risk metals – copper, iron, cadmium, lead, manganese, chromium, zinc, cobalt and nickel.

Samples of carrot from markets of local growers contained the most of zinc content (2.098 ±0.03 mg.kg^{-1}) compared with the other elements in this vegetable, and obtained results shows that the highest zinc content from local market was in celery (4.24 ±0.03 mg.kg^{-1}). From all these evaluated risk elements was detected the highest iron content in parsley (25.45 ±0.53 mg.kg^{-1}), and also in celery (8.69 ±0.02 mg.kg^{-1}) and kohlrabi (8.65 ±0.03 mg.kg^{-1}).

The contents of risk metals were compared with the maximum limit values set by *Codex Alimentarius* of Slovak Republic. By evaluation of obtained results can be concluded that the content no one of analyzed elements does not exceed maximum permissible limits. The obtained results indicated that consumption of these types of vegetable do not pose any risk of heavy metal danger to consumer.

The findings of obtained and evaluated results shows that mostly higher contents of risk metals were in samples of vegetable bought from markets of local growers than in samples from local market.

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