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DETERMINATION OF ELEMENTS IN WILD EDIBLE MUSHROOMS: LEVELS AND RISK ASSESSMENT

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ABSTRACT

The paper is focused on monitoring of the content of selected elements (Al, Cd, Cu, Hg, Pb, Se and Zn) in three species of edible mushrooms: *Cantharellus cibarius* Fr., *Suillus luteus* (L.) Roussel and *Imleria badia* (Fr.) Vizzini from three areas in Slovakia (Prašice, Bobrov and Dobroč). Qualitative and quantitative determination of the observed elements was performed by ICP-OES and/or CV-AAS. All results were statistically evaluated at both descriptive and differential analysis level. Due to the fact that picking and subsequent consumption of edible wild mushrooms is popular in Slovakia, the data obtained were evaluated and compared to tolerable weekly intakes defined by WHO. Based on the content of the monitored elements, PTWI values were not exceeded in any of the species from the studied sites. In some cases, however, specific content values, especially Al, but also Cd and Hg were exceeded compared to the average concentrations of elements in mushrooms from uncontaminated areas. In general, it can be stated that regular and long-term consumption of the mushrooms does not pose any health risk to the consumers.

Keywords: Wild edible mushroom, Element, Risk assessment, Environment, Slovakia

INTRODUCTION

Edible wild growing mushrooms, as well as trace elements, are natural components of forest ecosystems. Particularly, wild growing mushrooms play an important role in the cycle of organic matter and trace element because they are able to degrade the organic substrate (saprophytic fungi) and/or coexist with the host organism (mycorrhizal fungi) and thus close the biological cycle in the forest ecosystem (**Gupta *et al.*, 2014; Petkovšek and Pokorny, 2013; Ouzouni *et al.*, 2009**). In combination with their characteristic high bioaccumulative capacity for risk elements (mainly saprophytic fungi) they reduce the content of xenobiotics in other environmental compartments (**Árvay *et al.*, 2017; Kojta *et al.*, 2016; Stefanović *et al.*, 2016; Angelovičová and Fazekašová 2014**) at the expense of increasing content of the contaminants in their fructification organs (**Slávik *et al.*, 2013**). Many studies show that the quality of the environment is a significant factor affecting the content of the risk elements in the above-ground parts of mushrooms, as well as plants and/or products (**Falandysz 2017; Širić *et al.*, 2017; Stanovič *et al.*, 2016; Mleczek *et al.*, 2015; Árvay *et al.*, 2014; Slávik *et al.*, 2014; Tomáš *et al.*, 2014; Mleczek *et al.*, 2013**). Based on these properties, it can be stated that the wild growing mushrooms are an important bioindicator of environmental pollution (**Záhorcová *et al.*, 2016; Árvay *et al.*, 2012**), especially in areas affected by significant industrial activity (**Gao and Chen, 2012**).
Risk elements that are currently an important environmental problem (**Alonso *et al.*, 2000**) get into the fructification organs of mushrooms through the mycelium (**Širić *et al.*, 2016; Rieder *et al.*, 2011**) while their translocation in the fructification organs is diverse (**Zocher *et al.*, 2018**). Scientists assume that metals and/or metalloids are bound to the proteins in the hymenophore that has the highest enzyme activity. Saprophytic mushrooms have higher decomposition ability, as well as increased activity of catalase, which multipliesthe concentration of these elements (**Alonso *et al.*, 2000**).
A long-term and regular consumption of wild edible mushrooms, especially from sites affected by anthropogenic contamination represents the highest health risk due to their high bioaccumulative capacity (**Árvay *et al.*, 2015; 2014**). However, there are different culinary and/or conservation practices that can significantly reduce the content of risk elements in the mushrooms (**Drewnowska *et al.*, 2017; Falandysz and Drewnowska 2017**).
The present paper focuses on the determination of the studied element content (Al, Ag, Cd, Cu, Hg, Pb, Se and Zn) in the above-ground parts of common edible wild growing mushroom species (*Cantharellus cibarius* Fr., *Suillus luteus* (L.) Roussel and *Imleria badia* (Fr.) Vizzini (known in the past as syn. *Boletus badius* (Fr.) Fr.) in three sites (Dobroč, Prašice and Bobrov) that represent areas with varying degrees of environmental burden of the studied elements. Based on the data on the content of the studied elements, we calculated the percentage of tolerable weekly intakes resulting from the regular and long-term consumption of mushrooms (**Kalač, 2010**) defined by the World Health Organization in the case of Al, Cd, Hg and Pb. Such limits are not set for the other elements (Cu, Se and Zn).

MATERIAL AND METHODS

Sample collection and preparation

Samples of the wild edible mushrooms (n=63), were collected in three different sites (Dobroč, Prašice and Bobrov) in Slovakia (Fig. 1). Three mushroom species: *C. cibarius* (n=6+6+6), *S. luteus* (n=9+11+7) and *I. badia* (n=6+6+6) were collected in these sites in 2017. Each sampling point was defined by GPS coordinates. To meet the research objectives, the number of samples collected from each sampling point had to provide at least 100 g of the fresh mushroom samples (10 g of the dry weight). The collected mushrooms were cleaned of dirt with a ceramic knife and temporarily stored in PE sealable containers.
The mushroom samples were cleaned thoroughly in laboratory conditions and dried at the room temperature for about two weeks. Subsequently, the samples were dried at 45 °C for 2 hours in a laboratory drier Venticell 111 (BMT, Czech Republic). After the drying, the samples were homogenized in a porcelain mortar and then the homogenized mushroom samples were stored in sealable PE bags.

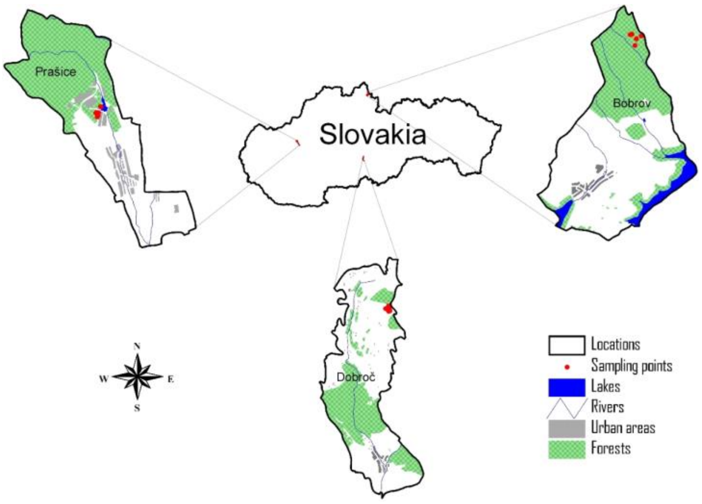

Figure 1 Location of the sampling points in the studied areas

Mineralization

Approximately 0.15–0.20 g was weighed from the prepared samples on analytical balances ABT-120/5DW (Kern & Sohn, Germany) (accurate to 4 decimal places) and transferred to PTFE mineralization tubes. Mineralization was carried out by a pressure microwave digestion on EthosOne (Milestone, Italy) in 5 mL concentrated nitric acid (69 %) (Sigma Aldrich, Germany; trace purity) and 1 mL of 30 % hydrogen peroxide (Sigma Aldrich, Germany; trace purity) with the addition of 2 mL of ddH_2O (18.2 MΩ cm^{-1}; 25 °C, Synergy UV, Merck Millipore, France). After the decomposition, the digestate was filtered through a quantitative filter paper Filtrak 390 (Munktell&Filtrak, GmbH, Bärenstein, Germany) and filled with deionized water to 50 mL.

ICP-OES elemental analysis

Elemental analysis was carried out on Agilent 720 ICP-OES spectrometer (Agilent Technologies Inc., Santa Clara, CA, USA) with axial plasma configuration and with auto-sampler SPS-3 (Agilent Technologies, Switzerland). Detailed experimental conditions were set as follows: RF power 1.45 kW; plasma gas flow 16.0 L min^{-1}; auxiliary gas flow 1.50 L min^{-1} and nebulizer gas flow 0.85 L min^{-1} and CCD detector temperature -35 °C. Signal accusation time 3x3 s for 3 replicates. All mushroom samples were analysed for concentration of 7 elements (Al, Cd, Cu, Pb, Se and Zn). ERM®-CE278k (Mussel tissue; IRMM, Belgium) was used to check the measurement quality. Its recovery values (taking into account the water content) ranged from 85 to 123 % for most of the determined elements.
The total Hg content was determined by CV-AAS method on a selective Hg analyser AMA-254 (AlTec, Praque, Czech Republic) in dried and homogenized mushroom samples. The limit of detection for Hg was set at 1.5 ng kg^{-1} dry weight (DW) and the limit of quantification at 4.45 ng kg^{-1} DW (**Árvay et al., 2015**).

Statistical analysis

All statistical analyses were performed in Statistica 9.0 (StatSoft Inc.). The obtained data on the concentration of the studied risk elements were processed at the level of descriptive statistics (minimum, maximum, mean, median and standard deviation). These data are shown in box plots. The statistical differences between individual species were evaluated using a non-parametric statistical Kruskal-Wallis test at the level of significance $p < 0.05$.

Health risk assessment

In order to assess the potential health risk from the consumption of the mushroom species from the studied sites, the obtained data on the concentration of Al, Cd, Hg and Pb were firstly calculated to fresh matter (**Kalač, 2010**). Subsequently, the percentage excess of tolerable weekly intakes per person weighing 70 kg for Al (140 mg $person^{-1}$ $week^{-1}$), Cd (0.44 mg $person^{-1}$ $week^{-1}$), Hg (0.28 mg $person^{-1}$ $week^{-1}$) and Pb (1.75 mg $person^{-1}$ $week^{-1}$) (**JECFA, 2012**; **JECFA, 2011**), taking into account the average consumption of "*Other vegetables and mushrooms*" in Slovakia that was 0.19 kg $person^{-1}$ $week^{-1}$ in 2015 (**Statistical Organization of Slovak Republic, 2016**) were calculated according to the following formula.

$$\%\mathrm{PTWI} = \frac{\text{element content (FW)} \times 0.19}{PTWI_{element}} \times 100$$

where: *%PTWI* – percentage of the provisional tolerable weekly intake; *element content (FW)* – content of the element in mg kg^{-1} fresh weight; *0.19* – average mushroom consumption in Slovakia (kg^{-1} $person^{-1}$ $week^{-1}$); $PTWI_{element}$ – the value of provisional tolerable weekly intake for the studied element.

RESULTS AND DISCUSSION

In the present paper, we focused on monitoring of the content of selected elements in the above parts of three different species of edible mushrooms from three different areas in Slovakia (Prašice, Bobrov and Dobroč). These three locations are characterized by different environmental loads that were reflected in the contents of the monitored elements. All data are shown in Tables 1 to 3 and their mutual comparison in the Figure 2.

Aluminium

Aluminium is one of the toxic elements, and its concentration in mushrooms can vary significantly. The results showed a wide range of Al concentration that depended on the site and a particular species of the edible wild-growing mushrooms. The highest average Al content was recorded in *C. cibarius* samples in the Prašice area. Despite the highest observed concentration of Al in a particular sample (1888 mg kg^{-1} DW) the average concentration was 394±753 mg kg^{-1} DW, confirmed by the statistical analysis with significance level $\alpha = 0.05$ (Table 4). The relatively high value of the standard deviation points to the non-parametric distribution of the Al concentration in the samples from the Prašice site, which is probably due to the local increase in the Al concentration. In other areas, the Al content was as follows: Bobrov: 301±60.7 mg kg^{-1} DW; Dobroč: 161±22.9 mg kg^{-1} DW. In the case of *S. luteus* samples, the situation was different at the Prašice site. Here, the concentration of Al at the median level was significantly higher than in the samples of *C. cibarius* (1042±694 mg kg^{-1} DW). At the remaining two sites the Al content in *C. cibarius* was almost identical (Table 2). Table 3 shows Al contents in *I. badia* from the studied sites, where the Al contents were significantly lower, especially in Prašice (93.7±210 mg kg^{-1} DW) and Bobrov (20.9±34.5 mg kg^{-1} DW). Almost identical contents of Al compared to the previous species were recorded in samples from Dobroč (172±81.7 mg kg^{-1} SH). The values of Al concentrations are in general higher than those obtained by **Drewnowska and Falandysz (2015)** and **Kalač (2010)**, who reported the Al concentrations in samples of edible wild-type mushrooms at the level of 100-230 and 150-370 mg kg^{-1} DW. It is probably due to a higher environmental load of Al (**Falandysz et al., 2008**).

Cadmium

Cadmium is one of the most toxic elements in the environment. It has a very high persistence and edible wild-growing mushrooms are characterized by its high bio accumulative capacity (**Vollmann et al., 2015; Kalač and Svoboda, 2000**). The content of Cd in the studied samples had a very wide range, probably due to environmental as well as species differences. The content of Cd in *C. cibarius* samples was 1.15±0.66 mg kg^{-1} DW in the Prašice site, 0.62±0.09 mg kg^{-1} DW in the Bobrov site and 0.28±0.18 mg kg^{-1} DW in samples from the Dobroč site. The Cd content in samples of *S. luteus* was higher compared to the previous species. The Cd content was 0.85±0.50 mg kg^{-1} DW in Prašice, 10.2±1.24 mg kg^{-1} DW in Bobrov and 1.35±0.53 mg kg^{-1} DW in Dobroč. In the case of *I. badia* samples, the Cd content was comparable to *C. cibarius* samples (Prašice: 3.88±2.01 mg kg^{-1} DW, Bobrov: 2.91±1.78 mg kg^{-1} DW, Dobroč: 1.61±1.91 mg kg^{-1} DW). Compared to the findings of other authors, the results, especially from the Bobrov site, differs significantly in *S. luteus* samples. **Chudzyński and Falandysz (2008)** reported an average Cd content of 5.90 mg kg^{-1} DW in *S. grevillea* samples. Average values of the Cd content in *Suillus* spp. are below 1.00 mg kg^{-1} DW in uncontaminated areas (**Szynkowska et al., 2008**). Statistically significant differences in Cd content were found between sites Prašice-Bobrov and Bobrov-Dobroč ($\alpha = 0.05$).

Copper

Copper belongs to the essential trace elements. The background concentration of Cu is 20-100 mg kg^{-1} DW in edible wild-growing mushrooms. The average concentrations of Cu in our samples are in accordance to the findings of several authors (**Alonso et al., 2003; Tüzen et al., 2007**). No exceedance of 100 mg kg^{-1} DW was detected in any of the samples. The Cu content in *C. cibarius* samples differed in individual sites. The lowest concentrations were recorded in Prašice (16.7±1.60 mg kg^{-1} DW). The Cu concentration in the remaining two sites was more than two-fold (Bobrov: 48.7±3.86 mg kg^{-1} DW, Dobroč: 56.1±5.93 mg kg^{-1} DW). In the case of Cu concentration in *S. luteus*, the variability at the mean level was substantially more equal than in the previous species, however, the ranges of the measured values varied widely. The Cu content was at the following concentrations: Prašice: 27.8±13.2 mg kg^{-1} DW, Bobrov: 36.2±5.36 mg kg^{-1} DW and Dobroč: 28.4±4.67 mg kg^{-1} DW. In the case of the last site, the situation was similar to that of *C. cibarius*, but the lowest values were measured in the Dobroč site, where the Cu concentrations were half the values of the first two sites (Table 3). The results obtained in the studied species are similar to those found by **Alonso et al. (2003) and Tüzen et al., (2007**), who recorded 25-75 mg kg^{-1} DW of Cu in the samples of *C. cibarius* and 25-50 mg kg^{-1} DW of Cu in *S. granulatus*, respectively.

Mercury

Mercury, like Cd, is one of the most toxic elements. Its usual content in edible wild-growing mushrooms ranges from 0.50-10.0 mg kg^{-1} DW, depending on the species and/or locality (**Kalač and Svoboda, 2000**). The Hg content in all samples from the studied sites was in a relatively narrow interval. The Hg content in *C. cibarius* samples was as follows: Prašice: 0.99±1.93 mg kg^{-1} DW, Bobrov: 1.25±1.16 mg kg^{-1} DM and Dobroč: 0.57±2.27 mg kg^{-1} DW; in samples of *S. luteus*: Prašice: 0.13±0.48 mg kg^{-1} DW, Bobrov: 0.58±2.27 mg kg^{-1} DW and Dobroč: 0.14±2.61 mg kg^{-1} DW; in samples *I. badia*: Prašice: 0.42±0.36 mg kg^{-1} DW, Bobrov: 1.02±0.40 mg kg^{-1} DW and Dobroč 0.48±1.52 mg kg^{-1} DW. The results showed that Hg content was highest in all studied species in the Bobrov site, which was reflected by the highest measured concentrations in individual mushroom samples.

Lead

Generally, the lead content in edible wild-growing mushrooms from uncontaminated areas ranges from 1.00 to 10.0 mg kg^{-1} DW (**Kalač and Svoboda, 2000**). The average Pb content does not pose any health risk (**Kalač, 2010**). The Pb content in the *C. cibarius* samples ranged as follows: Prašice: 0.89±1.43 mg kg^{-1} DW, Bobrov: 0.66±0.36 mg kg^{-1} DW and Dobroč: 0.21±0.31 mg kg^{-1} DW. In the case of S. *luteu* it was as follows: Prašice: 0.34±0.35 mg kg^{-1} DW, Bobrov: 0.30±0.28 mg kg^{-1} DW and Dobroč: 0.16±0.20 mg kg^{-1} DW. In the case of the last species *I. badia*, the situation was as follows: Prašice: 0.12±0.17 mg kg^{-1} DW, Bobrov: 0.07±0.14 mg kg^{-1} DW and Dobroč: 0.33±0.28 mg kg^{-1} DW. The results showed that the Pb content in the studied species from the monitored sites is in the lower part of the range reported by **Kalač and Svoboda (2000)**. In some samples of *C. cibarius* from Prašice, the Pb concentration was higher as reported by **García et al. (2009)**. However, the Pb content in *S. luteus* did not exceed values of 1.00-2.00 mg kg^{-1} DW reported by **Rudawska and Leski (2005)**.

Selenium

Selenium belongs to elements with antioxidant properties (**Ducsay et al., 2016**). It also has an antagonistic effect on the toxic impacts of methylmercury (**Falandysz et al., 2003**). The content of Se in mushrooms varies considerably among species, usually averaging at 2.00 mg kg^{-1} DW (**Kalač, 2010**). *C. cibarius* belongs to species with the lowest bioaccumulative capacity for Se (**Szynkowska et al., 2008**), which was also shown by our results. The Se content in Prašice was 1.43±3.03 mg kg^{-1} DW, Bobrov: 1.35±0.34 mg kg^{-1} DW and Dobroč: 1.01±0.86 mg kg^{-1} DW. The high variability of Se content in the samples of *C. cibarius* from Prašice were caused by a high concentration of this element in one sample (8.07 mg kg^{-1} DW). In the case of *S. luteus*, the Se content was as follows: Prašice: 0.70±1.07 mg kg^{-1} DW, Bobrov: 1.59±0.75 mg kg^{-1} DW and Dobroč: 5.24±1.98 mg kg^{-1} DW. The results shown a higher bioaccumulative capacity of *S. luteus* compared to the previous species. These findings were confirmed by **Tüzen et al. (2007)** who reported the Se content *S. granulatus* ranging from 5.00 to 10.0 mg kg^{-1} DW. The content of Se in *I. badia* was higher compared to the previous species. In the Prašice site, the Se content was 1.51±1.08 mg kg^{-1} DW, Bobrov: 2.21±1.32 mg kg^{-1} DW and Dobroč: 11.2±10.6 mg kg^{-1} DW. These values are significantly higher compared to the findings of **Szynkowska et al. (2008)**, who reported the Se content in *X. badius* below 0.50 mg kg^{-1} DW, probably due to the increased local concentration of this element in the substrate. Statistically significant differences of Se content were found between Prašice-Dobroč and Dobroč-Bobrov.

Zinc

Zinc is a micronutrient and therefore its content in edible wild-growing mushrooms is higher than previously evaluated elements. According to **Kalač (2010)**, the average Zn content in mushrooms from uncontaminated areas ranges from 25.0 to 200 mg kg^{-1} DW. The Zn content can be significantly higher in mushrooms grown in the vicinity of zinc smelter (**Colin-Hasen et al., 2002**). In our samples, the average Zn content was in the standard range, however, in some samples from the Prašice site it was significantly higher. Zn content in *C. cibarius* samples from Prasice was 69.3±16.2 mg kg^{-1} DW, Bobrov: 73.5±5.17 mg kg^{-1} SH and Dobroč 94.0±6.35 mg kg^{-1} DW. In the case of *S. luteus*, the situation was different. In samples from Prašice, the content was 98.8±123 mg kg^{-1} DW, Bobrov: 92.3±3.82 mg kg^{-1} DW and Dobroč: 95.1±12.4 mg kg^{-1} DW. The high standard deviation from the Prašice site was caused by a high content of Zn in one sample (452 mg kg^{-1} DW), which was probably caused by local contamination of the substrate. In the case of *I. badia*, the Zn content was 90.3±145 mg kg^{-1} DW with maximum concentration of 411 mg kg^{-1} DW in the Prašice site, 140±38.3 mg kg^{-1} DW in Bobrov and 62.7±34.0 mg kg^{-1} DW in Dobroč.

Table 1 Content of the studied elements in fruit bodies of *C. cibarius* Fr. (mg kg^{-1} DW)

	Al	Cd	Cu	Hg	Pb	Se	Zn
				mg kg^{-1} DW			
Prašice	394±753	1.15±0.66	16.7±1.60	0.99±1.93	0.89±1.43	1.43±3.03	69.3±16.2
(n=6)	292-1888	1.08-2.55	14.3-19.2	0.77-5.75	0.22-4.13	ND-8.07	49.7-86.7
Bobrov	301±60.7	0.62±0.09	48.7±3.86	1.25±1.16	0.66±0.36	1.35±0.34	73.5±5.17
(n=6)	259-410	0.51-0.76	41.3-53.0	0.07-3.34	ND-1.10	0.75-1.56	66.7-80.6
Dobroč	161±22.9	0.28±0.18	56.1±5.93	0.57±2.27	0.21±0.31	1.01±0.86	94.0±6.35
(n=6)	123-187	0.04-0.51	48.2-66.0	0.14-5.93	ND-0.85	0.39-2.54	92.8-108

ND: not detected

Table 2 Content of the studied elements in fruit bodies of *S. luteus* (L.) Roussel (mg kg^{-1} DW)

	Al	Cd	Cu	Hg	Pb	Se	Zn
				mg kg^{-1} DW			
Prašice	1042±694	0.85±0.50	27.8±13.2	0.13±0.48	0.34±0.35	0.70±1.07	98.8±123
(n=11)	217-2246	0.50-2.16	23.0-70.0	0.05-1.29	ND-0.86	ND-3.74	61.4-452
Bobrov	315±388	10.2±1.24	36.2±5.36	0.58±2.27	0.30±0.28	1.59±0.75	92.3±3.82
(n=7)	157-1083	7.93-11.0	26.8-39.8	0.03-5.74	ND-0.79	0.10-1.89	84.0-95.6
Dobroč	175±63.5	1.35±0.53	28.4±4.67	0.14±2.61	0.16±0.20	5.24±1.98	95.1±12.4
(n=9)	142-301	0.53-1.98	24.4-38.8	0.05-8.06	ND-0.49	2.36-9.31	78.2-118

ND: not detected

Table 3 Content of the studied elements in fruit bodies of *I. badia* (Fr.) Vizzini (mg kg^{-1} DW)

	Al	Cd	Cu	Hg	Pb	Se	Zn
				mg kg^{-1} DW			
Prašice	93.7±210	3.88±2.01	42.0±6.20	0.42±0.36	0.12±0.17	1.51±1.08	90.3±145
(n=6)	51.6-558	1.63-6.77	34.8-50.5	0.09-1.11	ND-0.37	ND-2.65	79.4-411
Bobrov	20.9±34.5	2.91±1.87	43.8±13.5	1.02±0.40	0.07±0.14	2.21±1.32	140±38.3
(n=6)	13.5-103	0.36-5.04	14.5-51.3	0.82-1.90	ND-0.36	ND-3.03	61.3-174
Dobroč	172±81.7	1.61±1.91	21.4±7.30	0.48±1.52	0.33±0.28	11.2±10.6	62.7±34.0
(n=6)	110-352	ND-4.93	17.4-36.8	0.22-4.15	0.03-0.81	2.93-28.9	37.9-122

ND: not detected

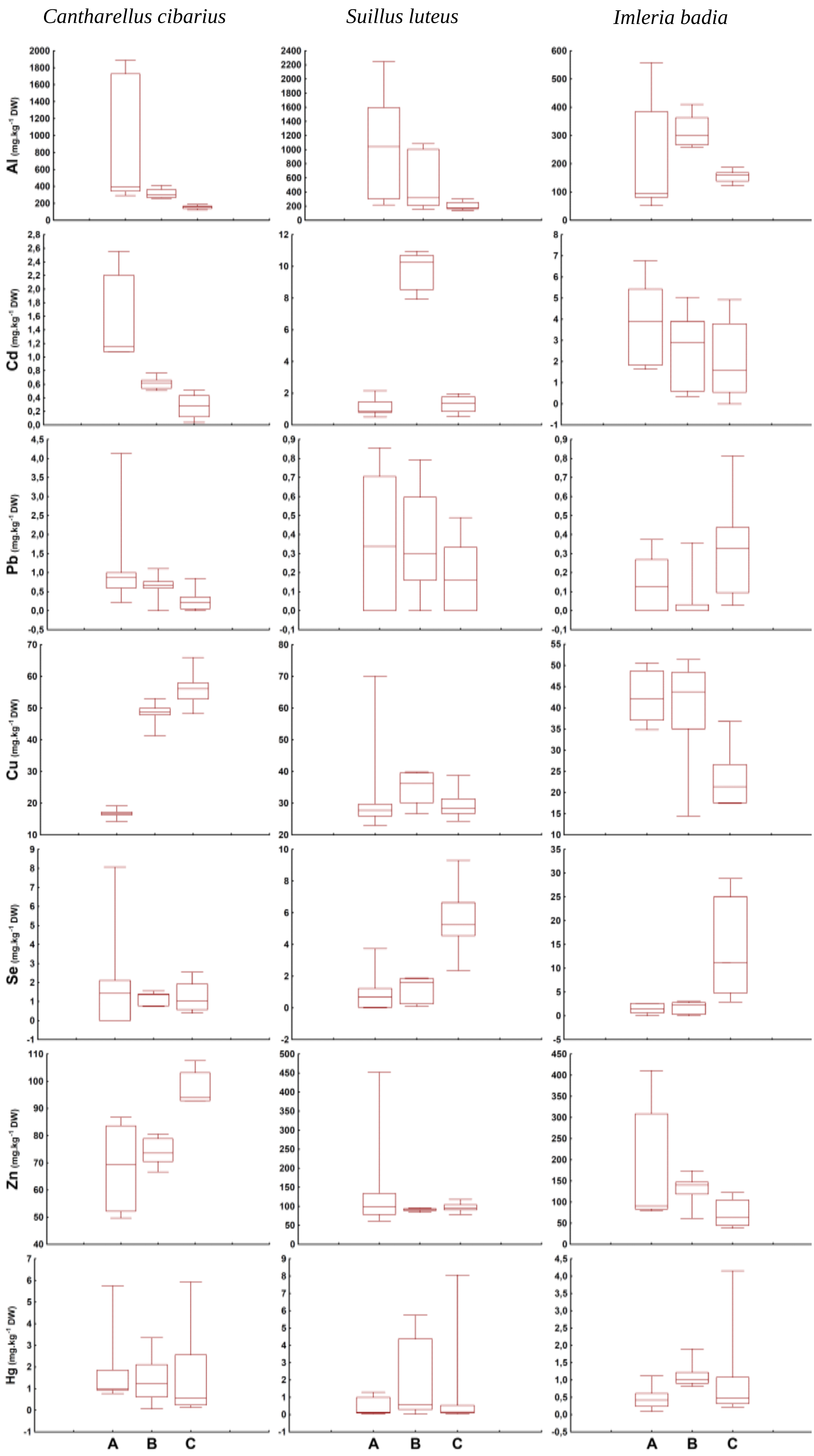

Figure 1 Comparison of the element contents in the studied mushroom species in the three sites

Table 4 P-values showing statistical significance of the studied element differences between individual sites

		Prašice	Dobroč
Dobroč	**Al**	0.0027*	
Bobrov		0.1515	0.1528
Dobroč	**Cd**	0.6088	
Bobrov		0.0014*	0.0025*
Dobroč	**Cu**	0.8743	
Bobrov		0.0842	0.1528
Dobroč	**Hg**	0.9929	
Bobrov		0.3389	0.5070
Dobroč	**Pb**	0.8048	
Bobrov		0.9953	0.7358
Dobroč	**Se**	0.0007*	
Bobrov		0.3389	0.0025*
Dobroč	**Zn**	0.9803	
Bobrov		0.8722	0.4429

*: statistically significant differences at the level of significance α=0.05

Risk assessment

Consumption of common edible wild mushrooms is a tradition in Slovakia and therefore we consider it necessary to assess a potential health risk resulting from a regular and long-term consumption of mushrooms. Provisional tolerable weekly intake (PTWI) was evaluated in each species. PTWI is defined by the WHO for Al, Cd, Hg and Pb. The theoretical health risk resulting from consumption of the studied species was estimated for a person weighing 70 kg that consumes according to the Statistical Office of the Slovak Republic (2016) per year 0.19 kg of "*other vegetables and mushrooms*" per week.
The calculated percentage values of the tolerable intake for the studied elements are shown in Table 5. The results showed that the PTWI values were not exceeded in any of the species. The highest value was recorded in *S. luteus* from the Bobrov site, however, it was still well below the limit value. In general, it can be stated that from the site point of view the risk was as follows: Bobrov>Prašice>Dobroč.
In terms of PTWI for the studied elements it was as follows: Cd>Hg>Al>Pb. The international legislation does not define health risk limits for Cu, Se and Zn.

Table 5 Percentage of the Provisional tolerable weekly intake values (mg person^{-1} week^{-1}) in the studied mushroom species

		Prašice	Bobrov	Dobroč
Al (140)	***C. cibarius***	5.35	4.09	2.19
	S. luteus	14.1	4.28	2.38
	I. badia	1.27	0.28	2.33
Cd (0.44)	***C. cibarius***	4.97	2.68	1.21
	S. luteus	3.67	44.0	5.83
	I. badia	16.8	12.6	6.95
Hg (0.28)	***C. cibarius***	6.72	8.48	3.87
	S. luteus	0.88	3.94	1.02
	I. badia	2.85	6.92	3.26
Pb (1.75)	***C. cibarius***	0.97	0.72	0.23
	S. luteus	0.37	0.33	0.17
	I. badia	0.13	0.08	0.36

CONCLUSION

The paper focused on monitoring of the contamination level of three species of edible wild-growing mushrooms: *C. cibarius*, *S. luteus* and *I. badia* from Prašice, Bobrov and Dobroč sites with risk elements (Al, Cd, Cu, Hg, Pb, Se and Zn). Aluminium exceeded values published in the literature in some cases, especially at the Prašice site. Based on the PTWI results, the concentrations of mercury and cadmium were relatively high in some cases. The concentration of lead did not exceed the limit values in any location. The concentration of the studied risk elements did not exceed the WHO limit values in any of the cases. Consumption of mushrooms from the Bobrov site might pose a potential risk in terms of Cd content. However, in general, it can be concluded that the consumption of the studied mushroom species from all sites does not present any health risk arising from their regular consumption.

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