

THE CONTENT OF SILVER, ALUMINUM, AND ZINC IN WILD EDIBLE MUSHROOM *MACROLEPIOTA PROCERA*

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ABSTRACT

The content of selected elements (Ag, Al, and Zn) in wild edible Parasol mushroom (*Macrolepiota procera* Scop. Singer) collected from five sites in Slovakia – Lazy pod Makytou, Lozorno, Nemečky, Tesáre, and Zbyňov was investigated. The element analysis was determined using the ICP-OES method. The average concentrations of Ag, Al, and Zn in *M. procera* caps ranged as follows: 0.41 – 3.23, 16.6 – 113, and 73.4 – 111 mg kg⁻¹ dry weight, respectively. Also, Spearman's correlation test was used to determine the correlations between Parasol mushroom caps and stems in the content of Ag, Al, and Zn. Subsequently, the obtained data on the content of the monitored elements in *M. procera* caps were used for the evaluation of health risks arising from the consumption of *M. procera*. Although mushrooms are an important part of the diet, they are consumed mainly as a seasonal delicacy therefore, the intake of the monitored elements from the consumption of *M. procera* may be limited. Regular and long-term consumption of *M. procera* caps from investigated sites does not pose any health risks to the consumers.

Keywords: Parasol mushroom; potential risk elements; essential element; consumption; health risk

INTRODUCTION

Mushrooms are one of the most diverse and economically important species on Earth. They are a significant part of the ecosystem and important inclusions for the human diet (Painuli, Semwal and Egbuna, 2020; Singh, Lallawmsanga and Passari, 2018). The consumption of edible wild-grown mushrooms is widespread in many European countries, mainly due to the diversity of species and their culinary characteristics (Kalač, 2016). Mushrooms are popular not only for their texture and taste but also for their chemical and nutritional composition (Mallikarjuna et al., 2013). They are considered as a rich source of proteins, carbohydrates, minerals, and vitamins while they are low in fat and energy value (Painuli, Semwal and Egbuna, 2020; Atri et al., 2019; Singh, Lallawmsanga and Passari, 2018; Chatterjee et al., 2017).

However, wild-grown mushrooms may contain high concentrations of both essential and risk elements to humans (Singh, Lallawmsanga and Passari, 2018; Stefanović et al., 2016; Falandysz and Borovička, 2013; Kalač, 2010; Kalač, 2009). Many previous studies have revealed the high ability of edible wild-growing mushrooms to accumulate various elements present in the biosphere even at trace levels, especially risk elements and radionuclides (Slávik et al., 2016; Záhorcová et al., 2016; Árvay et al., 2015a; Miššík et al., 2015). In some cases, a

certain mushroom species can accumulate specific trace elements, whereas the concentrations in fruiting bodies being at least 100-times higher than concentrations of the respective element in other plant species on the same substrate (Chatterjee et al., 2017). Risk elements are not biodegradable, and even in trace amounts, they tend to accumulate in wild edible mushrooms and subsequently enter the food chain (Singh et al., 2008). Their presence in the food chain poses a risk to human health. Long-term exposure and accumulation of risk elements in the body can lead to harmful effects on human health (Árvay et al., 2017; Dixit et al., 2015).

In general, the accumulation of elements in mushrooms is influenced primarily by internal factors (species-dependent) and soil factors (soil geochemistry, soil pollution) (Falandysz et al., 2017; Mallikarjuna et al., 2013; Giannaccini et al., 2012). Wild-growing mushrooms are involved in biogeochemical processes - element cycle and transformation of inorganic and organic substrates. The ability to accumulate elements in fruiting bodies of mushrooms is very important from an ecological point of view – cycling the elements, transformation of inorganic and organic substrates (Kuldo et al., 2014; Falandysz and Borovička, 2013). Although the ability to accumulate risk elements in wild edible mushrooms finds application in the process of bioremediation and environmental pollution monitoring, it can also pose a potential health risk to

consumers (Chatterjee et al., 2017; Falandysz and Borovička, 2013).

Macrolepiota procera (Scop.) Singer, also known as Parasol mushroom (Figure 6), is a wild edible mushroom widespread in temperate and sub-tropical regions such as Thailand, India, and Europe (Falandysz et al., 2017; Stefanović et al., 2016; Kuldo et al., 2014). *M. procera* is one of the most favourite wild edible mushrooms for consumers in Central Europe, including Slovakia (Kalač, 2016). Especially caps of *M. procera* are highly valued due to their taste and aroma in both cooked and fresh states (Falandysz et al., 2017). Many previous studies reported bioaccumulation property of *Macrolepiota procera* for Ag, Cd, Cu, Hg, Mg, Na, K, and Zn (Falandysz et al., 2017; Stefanović et al., 2016; Árvay et al., 2015a; Kuldo et al., 2014; Giannaccini et al., 2012; Gucia et al., 2012a). Due to its high bioaccumulation capacity, a long-term and regular consumption of wild edible mushrooms, especially from sites affected by anthropogenic contamination, represents the highest health risk to consumers (Árvay et al., 2015b; 2014).

This study is focused on monitoring the element's contents (Ag, Al, and Zn) in different morphological parts of Parasol mushroom (*Macrolepiota procera* Scop. Singer) collected from selected five sites in Slovakia – Lazy pod Makytou, Lozorno, Nemečky, Tesáre, and Zbyňov. Selected elements belong to 3 different groups of elements: Ag – element with detrimental health effects, Al – nutritionally non-essential element, and Zn – essential trace element. Higher concentrations of the monitored elements may have adverse effects on human health, therefore, the potential health risks arising from regular and long-term consumption of *M. procera* caps from selected localities were evaluated based on the obtained contents of monitored elements.

Scientific hypothesis

Increasing age of the mycelium and a prolonged interval between fructifications significantly elevate the contents of many elements in fruiting bodies, and higher levels usually occur in caps than in stems of wild-growing mushrooms.

Caps of wild-grown mushrooms are collected and eaten most often than stems therefore, they may represent a potential source of risk elements in the human diet in terms of long-term consumption.

MATERIAL AND METHODOLOGY

Samples

The samples of Parasol mushroom (*Macrolepiota procera* Scop. Singer) (n = 50) were collected from five selected sites in Slovakia – Lazy pod Makytou, Lozorno, Nemečky, Tesáre, and Zbyňov (Figure 1) during harvesting season (September – October) in 2018.

During the collection of mushroom samples, several principles were followed. The whole fruit body was cleaned up from any organic and inorganic debris and placed into a paper bag for transportation.

In the Slovak republic, five levels of environmental quality are determined, from the high-quality level of the environment to the highly disturbing level. Investigated localities, Lazy pod Makytou and Tesáre belong to the 1st environmental quality – regions with the undisturbed environment. The three other locations, Lozorno, Nemečky, and Zbyňov, belong to the 2nd environmental quality – regions with moderately disturbed environments in Slovakia (Ministry of Environment of the Slovak Republic, 2016). Each sampling point was identified by using GPS coordinates (Table 1).

Chemicals

HNO₃ (nitric acid, 69%, Sigma Aldrich, Germany; trace purity); H₂O₂ (hydrogen peroxide, 30%, Sigma Aldrich, Germany; trace purity).

Biological material

Parasol mushroom (*Macrolepiota procera* Scop. Singer).

Instruments

Venticell 111st (BMT, Czech Republic), ABT-120/5 DW (Kern & Sohn, Germany), EthosOne (Milestone, Italy), Agilent ICP-OES 720 (Agilent Technologies, USA).

Laboratory Methods

ICP-OES (Árvay et al., 2019).

Description of the Experiment

Sample preparation: In laboratory conditions, the mushroom samples were divided into two parts – cap and stem and dried at 40 °C in Venticell 111st (BMT, Czech Republic). Thoroughly dried mushroom samples were homogenized in porcelain mortar (cap and stem separately) and stored in PE bags until analysis.

Number of samples analyzed: 50

Number of repeated analyses: 1

Number of experiment replication: 2

ICP-OES

Before the analysis of risk elements, the samples of biological material were mineralized. Approximately 0.15 – 0.20 g of homogenized sample was weighted on analytical balances ABT-120/5 DW (Kern & Sohn, Germany) and put into PTFE mineralization tubes. Mineralization was performed by a pressure microwave digestion on EthosOne (Milestone, Italy) using 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 1 mL of deionized distilled water (ddH₂O). Subsequently, the digestate was filtered through a quantitative filter paper Filtrak 390 (Munktell&Filtrak, GmbH, Bärenstein, Germany) and filled with ddH₂O to 50 mL.

Table 1 Characteristics of sampling sites.

Locality	n	Coordinates (VGS 84)		Altitude (m)
Lazy pod Makytou	12	49.244400	18.225650	542
Lozorno	8	48.335600	17.063083	220
Nemečky	6	48.683833	18.105333	298
Tesáre	15	48.604333	18.073000	251
Zbyňov	9	49.124650	18.639466	378

Note: n – number of samples.

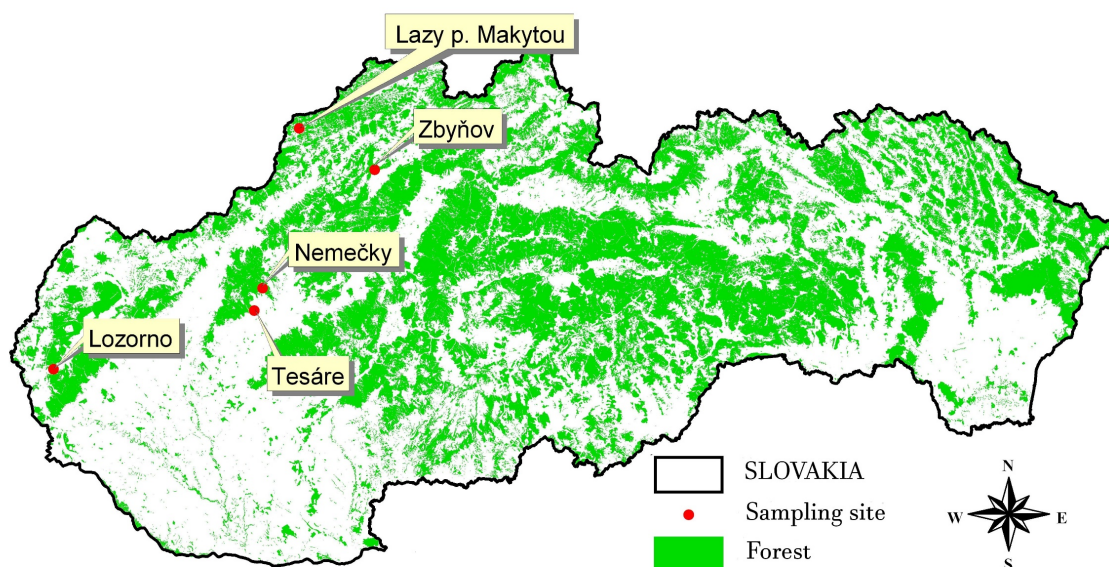


Figure 1 Map of monitored sites in Slovakia.

In samples thus prepared, the analysis of the content of risk elements was performed by inductively coupled argon plasma emission spectrometry (ICP-OES) on Agilent ICP-OES 720 (Agilent Technologies, USA) (Árvay et al., 2019).

Health risk assessment

Potential health risks from the consumption of the Parasol mushroom were evaluated based on Provisionally Tolerable Weekly Intake of Al (140 mg person⁻¹ week⁻¹) (JECFA, 2012) per person weighed 70 kg. Because no limit is set up for Ag, this element was not included in the health risk assessment.

Obtained data of concentrations of Ag, Al, and Zn were calculated to fresh matter (Kalač, 2009). Because the caps of *M. procera* are consumed most often, the contents of monitored elements in caps were included in the calculation.

According to the Statistical Office of the Slovak Republic (2020), the consumption of "Other vegetables including mushrooms" is at the level of 0.26 kg person⁻¹ week⁻¹, which was taken into account in calculation the exceedance of the PTWI value for Al according to the following equation (1):

$$PTWI(\%) = \frac{\text{element content (FW)} \times 0.26}{PTWI_{Al}} \times 100 \quad (1)$$

where:

PTWI(%) – a percentage of the provisional tolerable weekly intake; element content (FW) – the content of the element (caps) in mg kg⁻¹ of fresh weight; 0.26 – average weekly consumption of mushrooms in Slovakia (kg person⁻¹ week⁻¹); PTWI_{Al} – the value of provisional tolerable weekly intake of Al (140 mg person⁻¹ week⁻¹).

In the case of Zn, the value of recommended dietary allowance (RDA) – 10 mg person⁻¹ day⁻¹ (Act No. 1169/2011) per person weighed 70 kg was considered. The percentage value of RDA of Zn was calculated using the average consumption of "Other vegetables including mushrooms" according to the Statistical Office of the Slovak Republic (2020) (0.04 kg person⁻¹ day⁻¹) based on the following equation (2):

$$RDA(\%) = \frac{\text{element content (FW)} \times 0.04}{RDA_{Zn}} \times 100 \quad (2)$$

where:

RDA(%) – a percentage of the recommended dietary allowance; element content (FW) – the content of the element (caps) in mg kg⁻¹ of fresh weight; 0.04 – average daily consumption of mushrooms in Slovakia (kg person⁻¹ day⁻¹); RDA_{Zn} – the value of recommended dietary allowance of Zn (10 mg person⁻¹ day⁻¹).

Statistical Analysis

The obtained results on the content of Ag, Al, and Zn were characterized using descriptive statistics. From the data, the minimum, maximum, average value, and standard deviation (SD) were calculated. The processed data for each monitored element in Parasol mushroom (*Macrolepiota procera* Scop. Singer) from individual localities are shown in tables as average ± standard deviation (SD). The dataset was tested for normality. Subsequently, a non-parametric Kruskal-Wallis test was used to determine the statistical differences among monitored localities ($p < 0.05$). To determine the relationship between anatomical parts of Parasol mushroom, Spearman's correlation test was used. All data processing and graphical presentations were performed using RStudio (2020) software package.

RESULTS AND DISCUSSION

The content of three selected elements (Ag, Al, and Zn) in wild edible mushrooms (*Macrolepiota procera* Scop. Singer) was collected from five different sampling sites in Slovakia (Lazy pod Makytou, Lozorno, Nemečky, Tesáre, and Zbyňov) was investigated. All presented results are expressed in mg kg⁻¹ dry weight (DW).

Silver

Parasol mushroom (*Macrolepiota procera* Scop. Singer) has a high potential for accumulation of silver even in the unpolluted areas (Stefanović et al., 2016; Kuldo et al., 2014; Falandysz and Borovička, 2013). The concentration of Ag in samples from monitored areas varied from 0.22 to 6.27 mg kg⁻¹ DW in caps and from 0.05 to 5.46 mg kg⁻¹ DW in stems of *M. procera* (Table 2). The average concentration of Ag in *M. procera* caps decreased in the order of Tesáre > Lozorno > Nemečky > Lazy pod Makytou > Zbyňov.

The highest average concentration of Ag was detected in locality Tesáre (3.23 ±1.75 and 2.46 ±1.35 mg kg⁻¹ DW in caps and stems, respectively). The average concentration of Ag in cap samples from Lazy pod Makytou (0.54 ±0.19 mg kg⁻¹ DW) is very similar to results reported by Vukojević, Đurđić and Mutić (2019) in samples of *M. procera* originating from the Goč Mountains in Serbia (0.53 ±0.30 mg kg⁻¹ DW). In general, our obtained results are comparable with many previous studies (Mleczek et al., 2020; Falandysz et al., 2017; Kojta et al., 2016; Mleczek et al., 2016; Stefanović et al., 2016; Kuldo et al., 2014; Gucia et al., 2012a; Gucia et al., 2012b; Jarzyńska et al., 2011). The content of elements depends on the element content in the soils, but the bioavailability of elements is

significantly influenced by other factors such as soil pH, Eh, etc. (Stefanović et al., 2016). Higher concentrations in mushroom samples from locality Tesáre can be related to higher content of Ag in soil substrate and soil properties, which were not studied in this research.

To compare the concentrations of Ag in individual anatomical parts of *M. procera*, the stem samples from Lazy pod Makytou, Lozorno, and Zbyňov contained higher amounts of Ag than caps. These results agree with some previous studies (Stefanović et al., 2016; Kuldo et al., 2014; Gucia et al., 2012a, Falandysz et al., 2008). Although the biological significance of Ag accumulation in *M. procera* is unclear, it can be attributed to a defensive effect against pathogenic microscopic fungi, bacteria, insect larvae, or gastropods. High concentrations of Ag can be found in *M. procera*, even from unpolluted areas (Stefanović et al., 2016; Falandysz and Borovička, 2013).

The statistically significant differences (p <0.05) were observed between locality Tesáre and all other monitored localities. In samples from Tesáre, the highest content of Ag was detected. All statistical differences are shown in Figure 2.

Aluminum

In some species of wild edible mushrooms a wide range of Al was recorded (Kalač, 2016). According to the values presented in Table 2, the Al concentration in *Macrolepiota procera* ranged from ND (not detected) to 335 mg kg⁻¹ DW in caps and from 8.93 to 2441 mg kg⁻¹ DW in stems. The average concentration of Al in caps from the monitored sites decreased in the order of Nemečky > Tesáre > Lazy pod Makytou > Zbyňov > Lozorno.

Table 2 Content of Ag, Al, and Zn (mg kg⁻¹ DW) in *Macrolepiota procera* caps and stems from selected localities.

Element	Ag		Al		Zn	
	Average ±SD range					
Locality	Cap	Stem	Cap	Stem	Cap	Stem
Lazy pod Makytou	0.54 ±0.19	1.30 ±0.47	46.8 ±50.9	31.5 ±16.7	77.0 ±16.3	51.3 ±8.1
	0.28 – 0.85	0.61 – 2.21	ND – 191	9.97 – 69.4	44.5 – 102	38.4 – 65.2
Lozorno	1.58 ±1.58	1.96 ±1.40	16.6 ±6.9	91.4 ±69.4	111 ±31.7	61.0 ±11.7
	0.35 – 5.42	0.55 – 4.76	7.88 – 29.3	21.2 – 231	62.0 – 170	32.7 – 75.2
Nemečky	1.57 ±0.88	1.03 ±0.58	113 ±103	453 ±491	78.4 ±33.7	42.2 ±8.2
	0.28 – 3.06	0.05 – 1.94	39.9 – 335	51.1 – 1412	33.7 – 139	26.3 – 52.9
Tesáre	3.23 ±1.75	2.46 ±1.35	73.5 ±52.5	428 ±583	73.4 ±16.7	47.2 ±8.0
	0.75 – 6.27	0.96 – 5.46	21.6 – 213	68.5 – 2441	49.4 – 105	29.2 – 62.3
Zbyňov	0.41 ±0.16	0.76 ±0.40	19.7 ±24.9	35.7 ±30.3	90.9 ±11.8	55.6 ±5.2
	0.22 – 0.67	0.31 – 1.63	0.56 – 74.7	8.9 – 84.2	80.2 – 120	47.2 – 61.6

Note: ND – Not Detected.

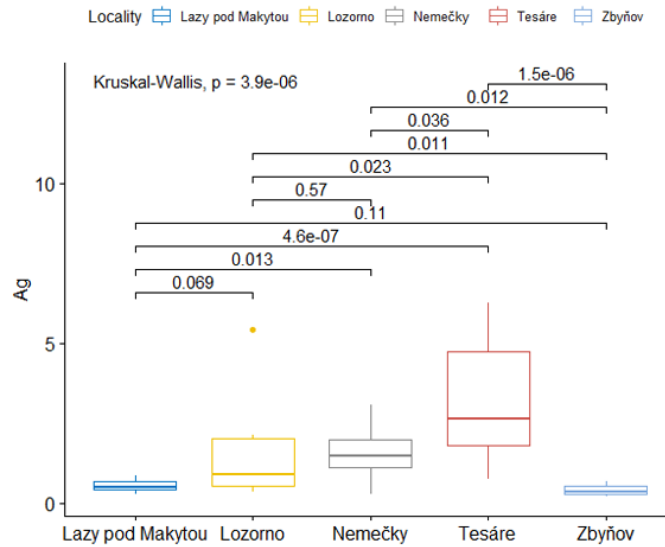


Figure 2 Statistical differences in the content of Ag (mg kg⁻¹ DW) in *M. procerá* among monitored localities.

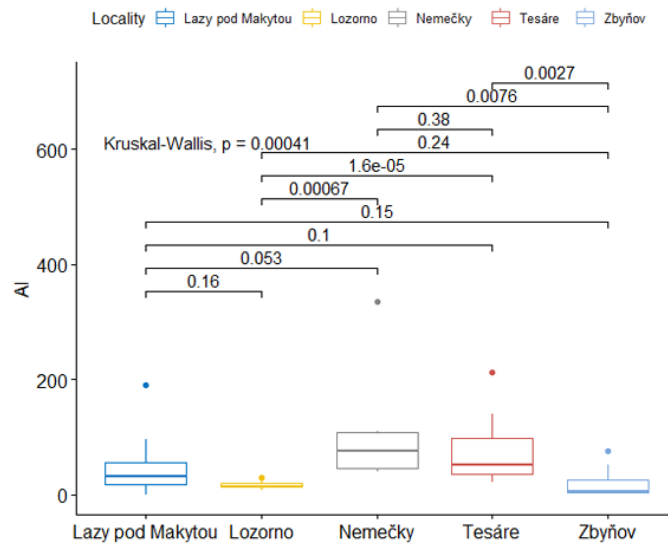


Figure 3 Statistical differences in the content of Al (mg kg⁻¹ DW) in *M. procerá* among monitored localities.

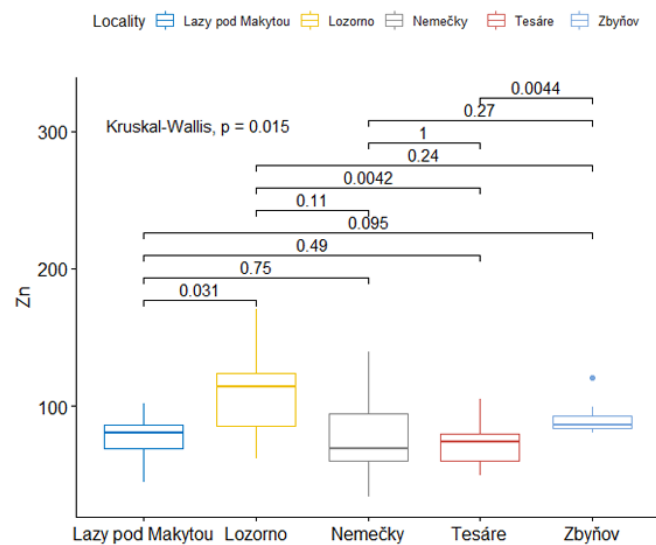


Figure 4 Statistical differences in the content of Zn (mg kg⁻¹ DW) in *M. procerá* among monitored localities.

Table 3 Percentage values of PTWI (Al) and RDA (Zn) after consumption of *M. procera* from monitored sites.

Locality	PTWI _{Al}	RDA _{Zn}
Lazy pod Makytou	0.87	3.08
Lozorno	0.31	4.43
Nemečky	2.10	3.13
Tesáre	1.37	2.94
Zbyňov	0.37	3.64

Note: PTWI_{Al} – Provisional Tolerable Weekly Intake of Aluminum; RDA_{Zn}: Recommended Dietary Allowance of Zinc.

The highest average concentration of Al was detected in locality Nemečky (113 ±103 and 453 ±491 mg kg⁻¹ DW in caps and stems, respectively). The average content of Al in *M. procera* caps in locality Tesáre (73.5 ±52.5 mg kg⁻¹ DW) is comparable with the results reported by Kojta et al. (2016) and Kuldo et al. (2014). The lowest average concentrations of Al were detected in samples from locality Lozorno and Zbyňov (16.6 and 19.7 mg kg⁻¹ DW, respectively). A similar average concentration was reported by Mleczek et al. (2020) (14.7 mg kg⁻¹ DW).

The concentration of Al in wild edible mushrooms from unpolluted areas usually ranges from 20 to 150 mg kg⁻¹ DW (Kalač, 2010). Some samples from the monitored sites – Lazy pod Makytou, Nemečky, and Tesáre contained higher concentrations of Al. The highest concentration of Al in the cap was measured in the sample from Nemečky (335.3 mg kg⁻¹ DW). However, the average concentrations of Al in *M. procera* caps from the monitored localities were not above the limit of 150 mg kg⁻¹ which is reported by Kalač (2010). In samples from 4 sampling sites (Lozorno, Nemečky, Tesáre, and Zbyňov), higher concentrations of Al were detected in stems than in caps of *M. procera*, which is in agreement with several previous studies (Kojta et al., 2016; Gucia et al., 2012a; Jarzyńska et al., 2011).

According to Kalač (2010), increasing the age of mycelium and a long interval between fructifications significantly elevate the contents of many elements in fruiting bodies of wild-growing mushrooms. Moreover, most elements are unequally distributed in the fruit body (Kalač, 2019). As aluminum is a widespread element in soils (Kabata-Pendias and Mukherjee, 2007), relatively high content of Al may be detected in *M. procera*. However, the content of Al in soil substrate was not investigated in this research.

The statistically significant differences ($p < 0.05$) in the content of Al were observed between locality Zbyňov and two other localities (Tesáre and Nemečky) and also between locality Lozorno and localities Tesáre and Nemečky, respectively. All statistical differences are shown in Figure 3.

Zinc

Zinc, as an essential trace element is a bioavailable element for all organisms and plays an important role in various biological reactions (Sarikurku et al., 2020; Simon, 2014). Wild edible mushrooms are usually rich in Zn (Falandysz and Borovička, 2013) and their content is normally between 25 and 200 mg kg⁻¹ DW (Kalač, 2016). In monitored samples of *M. procera*, the concentration of Zn ranged from 33.7 to 170 mg kg⁻¹ DW in caps and from 26.3 to 75.2 mg kg⁻¹ DW in stems (Table 2). The average

concentration of Zn in *M. procera* caps decreased in the order Lozorno > Zbyňov > Nemečky > Lazy pod Makytou > Tesáre.

According to Alonso et al. (2003) zinc tends to accumulate in various anatomical parts of *M. procera*. The highest average concentration of Zn was detected in locality Lozorno (111 ±31.7 and 61.0 ±11.7 mg kg⁻¹ DW in caps and stems, respectively). Mleczek et al. (2020) (135 mg kg⁻¹ DW) and Giannaccini et al. (2012) (124.7 ±67.9 mg kg⁻¹ DW) reported higher concentrations of Zn in *M. procera* than in our samples. Higher content of Zn was also detected in samples of *M. procera* from Slovak Paradise National Park, where the average value of Zn was 177 ±138 mg kg⁻¹ DW (Árvay et al., 2015a). Sarikurku et al. (2020) reported the content of Zn in *M. procera* at the level of 60 mg kg⁻¹ DW. High concentrations of Zn in mushrooms from uncontaminated areas may be due to its essentiality (Árvay et al., 2014).

The highest average concentration of Zn in *M. procera* caps (111 ±31.7 mg kg⁻¹ DW) was detected in the locality Lozorno. This phenomenon may be due to the higher content of Zn in soils in this locality (Linkeš et al., 1997) compared to other monitored sites, which was not investigated in this research. A similar average concentration of Zn was reported in previous studies (Mleczek et al., 2020; Kojta et al., 2016; Gucia et al., 2012a; Gucia et al., 2012b; Jarzyńska et al., 2011).

The content of Zn is different in individual anatomical parts of the fruiting body. The richest sources of Zn are spore-forming parts of the fruiting body (Kalač, 2016; Borovička and Řanda, 2007). Some authors also reported higher concentrations of Zn in caps than in the stems of *M. procera* (Kuldo et al., 2014; Gucia et al., 2012a; Falandysz et al., 2008), which is confirmed by the obtained results (Table 2).

The statistically significant differences ($p < 0.05$) in the content of Zn were observed between locality Lozorno and localities Lazy pod Makytou and Tesáre and also between locality Zbyňov and two other monitored localities (Tesáre and Nemečky). All statistical differences are shown in Figure 4.

Correlations

The linear regression and Spearman's correlation test were used to determine the relationships of the content of Ag, Al, and Zn between Parasol mushroom cap and stem (Figure 5). By comparing the contents of the monitored elements in individual anatomical parts of *M. procera*, a strong dependence between the stem and cap was found. The he strongest correlation between cap and stem was observed in the content of Ag (R = 0.69).

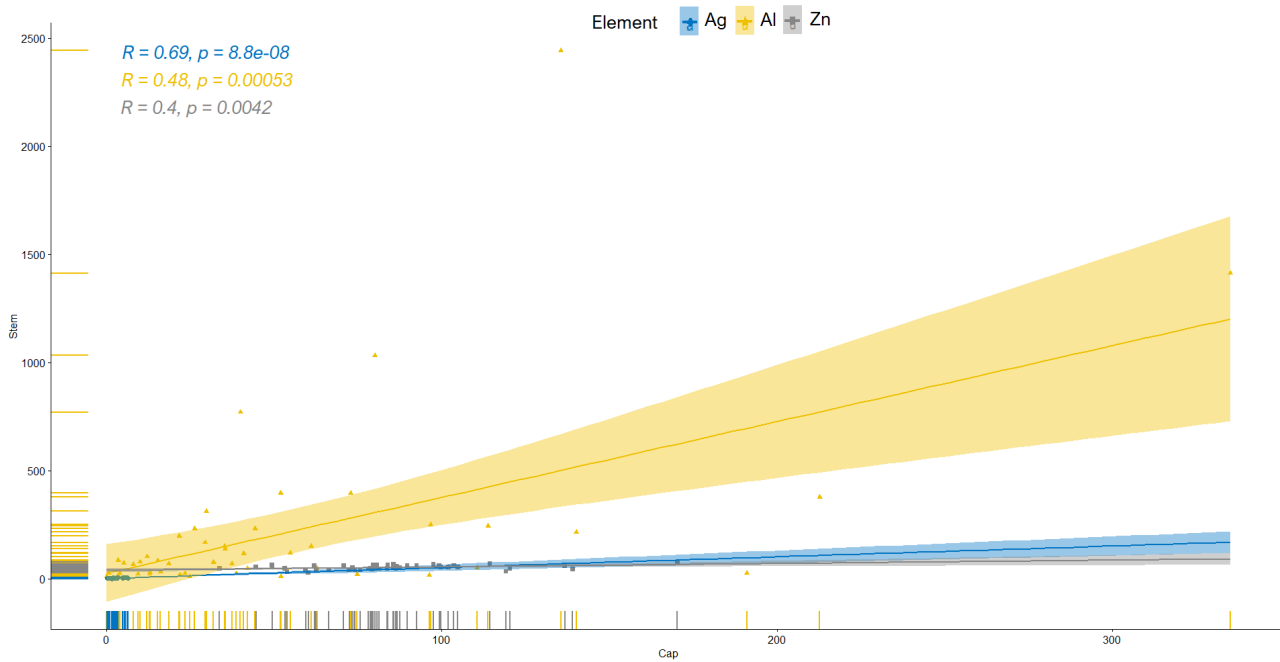


Figure 5 Relationship between cap and stem of *M. procera* in the content of monitored elements.



Figure 6 Parasol mushroom (*Macrolepiota procera* Scop. Singer).

Health risk assessment

The monitored sites are popular localities for collecting mushrooms in Slovakia therefore, the potential health risk caused by regular and long-term consumption of wild edible mushroom *M. procera* was evaluated. Tolerable weekly intake in case of Al and daily intake of Zn from *M. procera* consumption was evaluated for a person of 70 kg weight that consumes 13.3 kg of “other vegetables and mushrooms” per year according to the **Statistical Office of the Slovak Republic (2020)**. As a reference data were used values of Provisional Tolerable Weekly Intake (PTWI) for Al and Recommended Dietary Allowance (RDA) for Zn. The health risk assessment of Ag from *M. procera* consumption was not evaluated, because no PTWI limit is set up for Ag. The contents of monitored elements in fresh weight were used for the calculation. The percentage values of PTWI_{Al} and RDA_{Zn} were calculated (Table 3).

Aluminum is a relatively abundant element in soils (**Kabata-Pendias and Mukherjee, 2007**). The concentrations of Al in mushrooms are comparable or in some cases even higher than in many plant foods (**Kalač, 2016**). Aluminum is one of the nutritionally non-essential elements (**Kalač, 2019**). Its intake is through food. Aluminum is relatively easily excreted from the body, mainly in the urine, but in kidney disorders, it can be accumulated in brain cells and bones (**Liptáková, Prachar and Valík, 2015; Kabata-Pendias and Mukherjee, 2007**).

The values of PTWI_{Al} from *M. procera* consumption ranged from 0.31 (Lozorno) to 2.10% (Nemečky). Results showed that the content of Al in *M. procera* caps was not above the PTWI limit for Al. It can be stated that the health risk from consumption of *M. procera* in case of Al decrease in order Nemečky > Tesáre > Lazy pod Makytou > Zbyňov > Lozorno. However, the intake of Al from mushroom consumption may be limited due to their usually low consumption (**Kalač, 2016**).

Zinc is an essential trace element required for the proper growth, development, and function of the human body. Despite the necessity of zinc, its excessive intake is inappropriate. At high concentrations, Zn causes toxic effects such as disorders of metabolism of Cu and Fe (**Liptáková, Prachar and Valík, 2015**).

In the case of the trace element – Zn, its daily intake from consumption of *M. procera* was in the range of 2.94 (Tesáre) – 4.43% (Lozorno) of recommended dietary intake. The content of Zn in *M. procera* caps was not above the value of recommended daily intake of Zn. Therefore, by consuming 0.04 kg of Parasol mushroom caps from monitored localities, the consumer will not exceed the specified RDA value of Zn.

CONCLUSION

This study provides information on the content of three elements: silver, aluminum, and zinc in wild edible Parasol mushroom (*Macrolepiota procera* Scop. Singer) collected from five different sites in Slovakia (Lazy pod Makytou, Lozorno, Nemečky, Tesáre, and Zbyňov). Caps of *M. procera* are the richest in Ag and Zn content. *M. procera* stems contained the most aluminum compared to caps. Spearman's correlation test confirmed a strong relationship in element content between cap and stem of *M. procera*. Investigated localities are popular sites for collecting mushrooms in Slovakia therefore, the health risk for

mushroom consumers was evaluated. The concentrations of Al and Zn in *M. procera* caps were not above the determined limit of PTWI_{Al} and RDA_{Zn}, respectively. Since mushrooms are not an essential component of the human diet and they are a seasonal delicacy, the intake of Ag, Al, and Zn from the consumption of *M. procera* caps may be limited. This study showed that regular and long-term consumption of *M. procera* from monitored sites does not represent any health risk to the consumers.

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