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Elemental Composition of Naturally Growing Wild Edible Mushroom

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ABSTRACT

The aim of this study was to determine the mineral contents of wild grown-edible mushrooms. The potassium (K), magnesium (Mg), calcium (Ca), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd) and lead (Pb) contents of twenty edible mushrooms, collected from Erzincan province, Turkey, were analyzed. The minimum and maximum mineral contents of mushrooms were determined as mg/kg dw for K (930-10370), Mg (424.3-1686.1), Ca (44.2-1669.7), Mn (3.01-37.49), Fe (26.6-258.9), Zn (23.18-83.17), Cu (2.84-128.94), Ni (1.1-18.37), Cd (0.01-59.16) and Pb (ND-1.75) were determined. The potassium content was found to be higher than those of the other minerals in all the mushrooms. Lead and cadmium were present but at concentrations that are not hazardous to human health except for Russula delica. Mushrooms are important in the ecosystem because they are able to biodegrade the substrate, to collect heavy metal and, therefore, use the wastes of agricultural production. The Zn, Cu and Cd concentrations were determined to be highest in Russula delica. It is very important for account of capability of metal accumulation. As a result, it can be used for cleaning metal-contaminated water and soil.

Keywords: Mineral compounds, Toxic mineral, Wild edible mushrooms

INTRODUCTION

Wild growing mushrooms have been consumed as a delicacy in many countries of central and east Europe due to their savorous taste and aroma and species heterogeneity [1,2]. The fruiting bodies of edible wild mushrooms are popular in many countries [3] and demand for this kind of organic food is growing worldwide. As in other countries, mushroom picking in Turkey is very popular [4]. It is assumed that the fruiting bodies of mushrooms are naturally rich in different compounds [2,5]. Consumption of wild and cultivated mushrooms is increasing from year to year [6]. Compared with cultivated mushrooms, the trace element contents in the wild growing species are commonly high, and primarily species-dependent. [7-9].

Extensive research has been carried out on trace elements for searching edible wild growing species accumulating high levels of some nutritional elements, and for investigating the level of risk elements [1,10]. In general, mushroom fruiting bodies, on a dry weight basis, contain about 39.9% carbohydrate, 17.5% protein and 2.9% fats, the rest being the minerals [11].

The macrofungi are collected to make a substantial contribution to food intake. Therefore, it is necessary to know the levels of essential elements in edible mushrooms [12]. Metals, such as iron, copper, zinc and manganese are essential metals, since they play an important role in biological systems. Lead and cadmium are non-essential metals as they are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake is excessively elevated [13]. The uptake of metal ions in mushrooms is different from plants in many ways. The accumulation of metals in macrofungi has been found to be affected by environmental and fungal factors [14]. Amount of organic matter, pH, metal concentrations in soil are among the environmental factors [8,15,16]. It is known that, wild-growing mushrooms may accumulate great concentrations of toxic metallic elements such as mercury, cadmium, lead, copper or arsenic, metalloids and radionuclides [8,17].

Turkey has a large edible mushroom potential and is becoming an important exporter of wild mushrooms. Mushrooms are also collected to make a substantial contribution to food intake [12]. Trace metal levels in wild mushroom samples in Erzincan have not yet been determined. Erzincan is located in the east Anatolia region of Turkey where the climate is dry, with hot summers and cold winters with high production of wild mushrooms. The present work, therefore, aims: (1) to evaluate the metal content in several species of wild edible mushrooms harvested from Turkey, (2) to assess the contribution of mushrooms to the daily intake of several toxic elements, (3) to determine the possibility of evaluated mushrooms as bioindicators of environmental contamination.

MATERIALS AND METHODS

Samples

Macrofungi species were collected during field trips in Erzincan province of Turkey. Colour slides of the macrofungal specimens were taken in their natural habitats and relevant notes were taken about their morphological and ecological features. Then, they were put in specially prepared boxes and brought into the fungarium. After obtaining the macroscopic and microscopic taxonomic data by mycological techniques, they were identified with the help of Breitenbach and Kränzlin [18], Buczacki [19] and Dahncke and Dahncke [20]. Specimens are kept in Fungarium of Yuzuncu Yıl University, Faculty of Science and Art. The habitat and localities of wild edible macrofungi taxa are given in Table 1. After removal of plant and substrate debris with a plastic knife, fresh mushrooms samples were freed from foreign matter and smaller particles using a fine brush. The mushrooms were washed with demineralized water. Samples were air dried for several days and then dried in an oven at 105 for 24 h. Dried samples were homogenized in fine powder using a blinder and stored in precleaned polyethylene bottles for analysis.

Table 1: Taxa of wild edible macrofungi collected from Erzincan region of Turkey

No	Class, Family and taxa of macrofungi	Habitat	KHN no:
	Pezizomycetes		
	Morchellaceae Rchb.		
1	*Morchella esculenta* (L.Pers.)	Erzincan, Üzümlü, Avcılar village, under apple trees	21
2	*Mitrophora semilibera* (DC.) Lév.	Refahiye, Altköy village, under poplar trees	193
	Agaricomycetes		
	Agaricaceae Chevall.		
3	*Agaricus bisporus* (J.E. Large) Imbach	Kemah, centrum, grassy	97
4	*Lentinus strigosus* (Schwein.) Fr.	Erzincan, Sakaltutan, grassy	1115
5	*Coprinus comatus* (O.F. Müll.) Pers.	Erzincan, Açı Su, picnic spot, grassy	1250
6	*Macrolepiota procera* (Scop.) Singer	Refahiye, Doğankent village, in mixed forest	873
	Pleurotaceae Kühner		
7	*Pleurotus eryngii* (DC.) Quél.	Kemaliye, Yalınca village, step	974
8	*Pleurotus ostreatus* (Jacq.) P. Kumm.	Tercan, centrum, on stumps of poplar tree	3
	Tricholomataceae R. Heim ex Pouzar		
9	*Lepista irina* (Fr.) H.E. Bigelow	Üzümlü, Avcılar village, grassy	27
10	*Lepista nuda* (Bull) Cooke	Refahiye, centrum, under pine trees	1070
11	*Lepista personata* (Fr.) Cooke	Tercan, Mercan township, under poplar trees	11
	Strophariaceae Singer & A.H. Sm		
12	*Agrocybe cylindracea* (DC.) Gillet	Erzincan, centrum, on stumps of poplar tree	1219

13	*Agrocybe parecox* (Pers.) Fayod	Kemaliye, Kozlupınar village, in mixed forest	264
14	*Pholiota aurivella* (Batsch) P. Kumm.	Çayırlı, Harmantepe village, on willow Salix sp.	680
	Pluteaceae Kotl. & Pouzar		
15	*Volvariella bombycina* (Schaeff.) Singer	Erzincan, Yamaçlı village, on willow Salix sp.	732
	Boletales		
	Beletaceae Chevall.		
16	*Leccinum scabrum* (Bull.) Gray	Erzincan, Mecidiye village forest, in mixed forest	1129
17	*Leccinum versipelle* (Fr. & Hök) Snell	Refahiye, Doğankent village, in mixed forest	535
	Suillaceae Besl & Bresinsky		
18	*Suillus luteus* (L.) Roussel	Refahiye, Dumanlı Forest, in conifer forest	545
	Russulales		
	Russulaceae Lotsy		
19	*Lactarius deliciosus* (L.) Gray	Refahiye, Doğankent village, under pine trees	616
20	*Russula delica* Fr.	Refahiye, Doğankent village, in mixed forest	640

Methods

Atomic absorption spectrophotometer (Varian Techtron Model AAS 1000, Varian Associates, Palo Alto, CA) was used for the determination of the minerals (Ca, Mg, K, Fe, Zn, Cu, Mn, Pb, Ni and Cd) in dried fruit bodies of macrofungi. Each dried mushroom sample was weighed as 4-5 g and placed in a porcelain crucible and ashed at 550°C for 18-20 h.; then the ash was dissolved in 1ml concentrated HNO_3, evaporated to dryness, heated again at 550°C for 4 h, treated successively with 1 ml HNO_3 and 1 ml H_2O_2 and then diluted with double deionized water up to a volume of 25 ml. Three blank samples were treated in the same way. The species, which were digested in an acid solution of HNO_3, were passed through the AAS system using different lamps, and calibrated with related minerals in different concentrations for different micronutrients [21]. To check for possible contamination by reagents or glassware, blanks containing 4ml of ultrapure concentrated HNO_3 and 4 ml H_2O_2 were run together with analytical samples and every batch of analytical samples was run together with the standard matrix. The values of Ca, Mg, K, Fe, Zn, Cu, Mn, Pb, Ni and cadmium Cd were calculated as mg/kg dw. Detection limit is defined as the concentration corresponding to three times the Standard deviation of ten blanks. Detection limit values of elements as mg/kg in AAS were found to be 0.012 for K, 0.003 for Mg, 0.015 for Ca, 0.029 for Mn, 0.060 for Fe, 0.013 for Zn, 0.041 for Cu, 0.063 for Ni, 0.032 for Cd and 0.10 for Pb. The results were within limits of quantification for above minerals (calculated as 10-fold of standard deviation from ten replicates of the instrumental blank solution) 0, 2, 4, 8 and 16 mg/g or mg/kg, respectively. Correlation coefficients of the mineral result were determined between r=0.9932 and 0.9999. Mushrooms were selected normally harvested for consumption (pileus+stipe). For all the mushroom species, at least three samples were analysed.

RESULTS AND DISCUSSION

Twenty samples of mushrooms from Erzincan where analyzed, showing high variability. Samples taken from different parts of the city may be the cause of this variability. Wild-grown mushrooms are able to accumulate in their fruiting bodies large amounts of both macro and micro-elements that are essential to fungi and its consumers. Mushrooms can also be specifically enriched with toxic elements such as Ni, Cu, Cd and Pb. Potassium (K) and phosphorus (P) are two prevailing elements in fruiting bodies and are usually followed by Ca, Mg, Na and Fe [22,23].

Average metal concentrations expressed as mg/kg (dry weight of mushroom) in fruiting bodies samples used in this study are given in Table 2. The heavy metal concentration in the mushrooms is mainly affected by acidic and organic matter content of their ecosystem and soil [24]. The uptake of metal ions in mushrooms is in many respects different

from plants. For this reason the concentration variations of metals depend on mushroom species and their ecosystems [25].

Table 2: Amounts of total K, Mg, Ca, Mn, Fe, Zn, Cu, Ni, Cd and Pb of wild edible mushrooms from Erzincan region of Turkey (mg/kg dw); ND: Not Detected, SE: Standard Error

No.	Taxa	K	Mg	Ca	Mn	Fe	Zn	Cu	Ni	Cd	Pb
1	*Morchella esculenta*	4511	514.1	73.1	3.21	95.2	23.18	16.39	2.21	0.01	0.76
2	*Mitrophora semilibera*	8184	845.8	499.5	5.43	113.8	46.12	75.51	2.98	2.4	1.4
3	*Agaricus bisporus*	5087	983.1	799.1	9.11	102.6	35.59	31.08	5.95	1.03	1.19
4	*Lentinus strigosus*	5003	490.6	89.2	3.21	54.1	35.06	25.33	1.62	0.09	0.8
5	*Coprinus comatus*	7337	742.7	418.7	14.3	122.1	41.36	29.14	2.6	0.88	0.94
6	*Macrolepiota procera*	5852	1538.8	552.4	9.46	151.5	46.39	22.42	6.98	0.15	1.14
7	*Pleurotus eryngii*	10370	1187.6	1247.8	37.49	258.9	50.62	19.51	3.96	0.54	1.75
8	*Pleurotus ostreatus*	5523	901.7	454.6	7.67	104.5	40.85	33.26	4.07	0.11	1.24
9	*Lepista irina*	5827	804.2	317.1	12.74	127.9	40.54	2.84	1.41	0.03	0.14
10	*Lepista nuda*	6384	705.2	134.3	5.17	100.5	33.32	10.93	2.23	0.2	0.9
11	*Lepista personata*	6864	691.2	147.2	3.01	26.6	54.65	9.79	1.18	0.04	0.17
12	*Agrocybe cylindracea*	7528	1622.5	1669.7	18.86	223.5	66.24	39.24	18.37	0.76	0.61
13	*Agrocybe parecox*	6639	424.3	74.1	7.23	90.9	24.17	21.27	1.11	0.08	0.45
14	*Pholiota aurivella*	7942	1357.2	416.1	7.61	163.6	50.55	42.72	4.98	1.99	ND
15	*Volvariella bombycina*	8495	1183.9	76.6	3.95	51.1	66.43	30.48	2.05	1.14	0.87
16	*Leccinum scabrum*	7171	539.1	201.8	5.13	165.6	30.16	10.37	1.57	0.02	0.54
17	*Leccinum versipelle*	8598	632.2	137.1	14.25	70.5	57.84	102.4	1.57	0.35	1.43
18	*Suillus luteus*	7693	1686.1	565.7	12.95	126.2	58.76	24.33	10.51	0.77	0.39
19	*Lactarius deliciosus*	6350	1376.8	299.2	3.84	60.6	44.88	4.02	1.54	0.06	0.32
20	*Russula delica*	930	532.4	44.2	5.03	36.1	83.17	128.94	8.11	59.16	1
	Mean ± SE	6614.4 ± 64	937.9 ± 30	410.8 ± 39	9.5 ± 4.4	112.3 ± 40.4	46.5 ± 7.1	34 ± 4.8	4.3 ± 0.6	3.5 ± 0.23	0.85 ± 0.12
	Minimum	930	424.3	44.2	3.01	26.6	23.18	2.84	1.11	0.01	ND
	Maximum	10370	1686.1	1669.7	37.49	258.9	83.17	128.94	18.37	59.16	1.75

The contents of trace metals in the samples ranged from 630-10370, 424.3-1686.1, 44.2-1669.7, 3.01-37.49, 26.6-258.9, 23.18-83.17, 2.84-128.94, 1.11-18.37, 0.01-59.16 and nd-1.75 mg/kg dw for K, Mg, Ca, Mn, Fe, Zn, Cu, Ni, Cd, and Pb, respectively. Mushrooms contained a wide range of minerals, particularly iron, zinc, calcium and manganese. The highest K, Mn, Fe and Pb contents were observed in *Pleurotus eryngii* as shown in Table 2. According to the results, the most abundant elements was potassium, (ranging from 930 to 10370 mg/kg dw) and magnesium, respectively. These are followed by calcium. The most variable minerals were iron, zinc and copper, respectively. Pb was the lowest element (ranged between ND and 1.75 mg/kg). Compared to manganese, the amount of cadmium was much lower. It was ranged between 0.01 and 59.16 mg/kg among the mushroom species studied. *Russula delica* has much higher Cd (59.16 mg/kg) than in the other mushrooms.

Potassium content was higher than other minerals in all mushrooms in this study, varying between 930 (*Russula delica*) and 10370 mg/kg dw (*Pleurotus eryngii*). In general, most of the mushrooms studied contained considerably high amounts of minerals. The levels of essential elements in mushroom species were higher than those of toxic elements. Gençcelep et al. [4] reported the potassium contents of wild edible mushrooms as being between 12600

and 29100 mg/kg dw. Wang et al. [26] found that potassium content was between 16000 and 37000 mg/kg in dry matter. Sanmeea et al. [27] reported that potassium accumulation in mushrooms could rise up to 45200 mg/kg. Liu et al. [28] reported that the lowest potassium value (1300 mg/kg dw) was measured in *Melanoleuca gigantea* and *Melanoleuca arcuata*, the highest potassium value (4600 mg/kg dw) was found in *Boletus griseus*. The greatest concentrations of K were obtained in C. *cibarius* (41823.3 mg/kg), whereas the lowest was in *Boletus edulis* (11266.9 mg/kg) [29]. Usual potassium content in mushrooms varies between 20000 and 40000 mg/kg dw [4,10]. The overall data indicates that mushrooms may contain elevated levels of potassium. In this study, potassium levels were lower than reported values in the literature. Showing that mushrooms are an excellent source of potassium in the human diet.

Magnesium content was 424.3 mg/kg dw in *Agrocybe parecox* and 1686.1 mg/kg dw in *Suillus luteus*. The level of magnesium reported in this study was relatively low compared to earlier published reports [11] which was magnesium content ranged from 330 mg/kg dw in *Tricholoma anatolicum* to 6560 mg/kg dw in *Morchella deliciosa*. In our previous study, the concentration levels of Mg in *Morchella vulgaris* 1920 mg/kg, *Helvella lacunosa* 1190 mg/kg, *Lepista nuda* 3410 mg/kg were found [4]. Liu et al. [28] reported that the magnesium contents of the mushrooms ranged from 84 mg/kg dw in *Leucopaxillus giganteus* to 550 mg/kg dw in Macrocybe *gigantea*. Previously reported magnesium contents in mushrooms varied between 800 and 1800 mg/kg dw [10]. The lowest magnesium value, 248 mg/kg dw *Bolereus tomentipes*, was found by Li et al. [30]. Sanmeea et al. [31] reported that mature *Astraeus hygrometricus* had 1600 mg/kg of Mg concentrations. In this study, magnesium concentrations of same mushrooms species were found low. As a result, environmental factors are very important to amount of metal concentrations in mushrooms. Magnesium levels in this study are in agreement with the value reported in the literature.

In the present study, the calcium contents of the mushrooms ranged from 44.2 mg/kg dw in *Russula delica* to 1669.7 mg/kg dw in *Agrocybe cylindracea*. In our previous study, the concentration levels of Ca in *Morchella vulgaris* 870 mg/kg, *Helvella lacunosa* 470 mg/kg, *Lepista nuda* 8800 mg/kg were found [4]. Previously reported calcium contents of mushrooms varied from 100 to 500 mg/kg dw [10]. The calcium contents in our mushroom samples are higher than the values reported in the literature. The accumulation of metals in mushrooms has been found to be affected by environmental and fungal factors. But, it seems to be higher when compared to the concentrations obtained by Sanmeea et al. [31] (100-2400 mg/kg dw). The results of nutritionally valuable minerals show that twenty mushroom species contained high amounts of potassium, calcium, magnesium and iron. Most of them contain little lead, nickel, cadmium or copper. Minerals in the diet are required for metabolic reactions, transmission of nerve impulses, rigid bone formation and regulation of water and salt balance [32].

Manganese was also determined in all mushrooms. The manganese content of the mushrooms studied in the present work ranged from 3.01 mg/kg dw in *Lepista personata* to 37.49 mg/kg dw in *Pleurotus eryngii*. The reported manganese values in the literature for mushrooms were 14.2-69.7 mg/kg, 21.7-74.3 mg/kg and 7.1-81.3 mg/kg, 5.54-135 mg/kg dw [4,33], respectively. The manganese values in this study are found lower than in the literature.

The iron content of the mushrooms ranged from 26.6 mg/kg dw in *Lepista personata* to 258.9 mg/kg dw in *Pleurotus eryngii*. Iron values in mushroom samples (as reported) ranged from 31.3-1190 mg/kg [34], 56.1-7162 mg/kg [12], 50.1-842.0 mg/kg [4], respectively. The iron values in the present study are in lower than with reported values in the literature. It is known that adequate iron in a diet is very important in order to decrease the incidence of anemia.

Mushrooms are known as zinc accumulators and the sporophore: substrate ratio for Zn ranges from 1 to 10 mg/kg [12]. The zinc content was the lowest (23.18 mg/kg dw) in *Morchella esculenta*, whereas it was highest (83.17 mg/kg dw) in *Russula delica*. The reported literature zinc content ranged between 22.10 and 185 mg/kg dw [4,32,35]. Sarıkürkçü [36] found the highest Zn values in *Helvella leucopus* and *Tricholoma auratum* (354 ± 1.9 and 356 ± 2.9 mg/kg, respectively). The lowest Zn content was found in *Lyophyllum decastes* and *Rhizopogon roseolus* (46 ± 0.1 and 47 ± 0.3 mg/kg, respectively). In this study, some mushroom species have higher zinc content more than 50 mg/kg (*Pleurotus eryngii, Lepista personata, Pholiota aurivella, Volvariella bombycina, Leccinum versipelle, Suillus luteus* and *Agrocybe cylindracea*). These mushrooms species were collected from locations near the downtown of Erzincan. Therefore, metal accumulation may be more owing to soil pollution. Zn is an essential nutrient that has an important role in biological systems. Zinc is necessary for the functioning of various enzymes and plays an essential role in DNA, RNA, and protein synthesis. The major symptoms of zinc deficiency are delayed growth and slow maturation [37].

Minimum and maximum values of copper were 2.84 and 128.94 mg/kg dw in *Lepista irina* and *Russula delica*. Copper contents of mushroom samples in the literature have been reported to be in the range of 4.71-51.0 mg/kg [13]

and 10.3-145 mg/kg [34]. Copper contents found in this study parallel those reported in the literature. In this study, *Leccinum versipelle* (102.40 mg/kg) and *Russula delica* (128.94 mg/kg) were collected near the downtown of Erzincan, therefore copper contents of these samples were found higher than the others. In our previous study, the concentration levels of Cu in *Pleurotus ostreatus* 47.1 mg/kg and *Lepista nuda* 26.6 mg/kg were found [4]. Cu is an essential element. Enzymes containing copper are important for the body to transport and use iron. In 1996, a joint FAO/International Atomic Energy Agency/ WHO official report set an upper limit for the safe range of population mean exposures for adults of 0.2 mg/kg body weight per day [37].

Nickel was determined all mushrooms. *Pleurotus eryngii* contained high nickel content with an amount of 1.75 mg/kg dry matter. The reported Ni values for wild-growing mushrooms were 0.4-15.9, 0.4-2, 1.72-24.1 mg/kg [12,32,33], respectively. The Ni levels are generally in agreement with previous studies. The obtained Ni levels in some mushrooms (*Agaricus bisporus, Macrolepiota procera, Agrocybe cylindracea* and *Suillus luteus*) are higher than the allowed amount (0.05-5 mg/kg) of National Academy of Sciences (1975) for plants and foods [38] (Table 2). Nickel has been linked to lung cancer and the tolerable upper intake level for this toxic element is reported as 1 mg/day (FNB, 2001).

Cadmium is known as a principal toxic element, since it inhibits many life processes. Cadmium has been associated with renal damage; cancer and childhood aggression [39]. Mushroom, in particular, can be very rich in cadmium. Cadmium was measured as not detected in *Agrocybe parecox* and it was the highest in *Russula delica* (59.16 mg/kg dw) which is relatively high compared to reported literature data [16,40] Cd levels were found generally lower than 2.0 mg/kg for the other mushrooms species, in this study. Long-term exposure to high levels of Cd may lead to considerable accumulation in the liver and kidneys, particularly the renal cortex, resulting in kidney damage [41]. Thus, cadmium seems to be the most deleterious one among heavy metals in mushrooms. It is acceptable daily or weekly intake may be easily reached by consumption of an accumulating mushroom species [40].

Pb concentrations of mushroom samples were generally low, except *Pleurotus eryngii* with an amount of 1.75 mg/kg dw. The Pb levels of all other samples were not higher compared to the reported Pb values for mushrooms by Tüzen [13] (2.35 mg/kg), Kalaĉ and Svoboda [32] (0.5-20 mg/kg) and Kaya and Bag [35] (2.166 mg/kg). Sarikürkcü [36] found the lowest Pb value in *Lyophyllum decastes* (0.5 ± 0.19 mg/kg). This is followed by *Morchella esculenta* (0.9 ± 0.29 mg/kg). In *Rhizopogon roseolus, Volvoriella gloiocephala* and *Agrocybe cylindracea*, Pb contents were found equal or above 4.0 mg level (6.2 ± 0.44, 5.9 ± 0.11 and 4.0 ± 0.50 mg/kg), respectively. Pb is used for a number of industrial, domestic, and rural purposes for example, in lead batteries and in leaded petrol. A significant source of exposure to lead is via the diet. Lead is a cumulative toxin that can primarily affect the blood, nervous system, and kidneys. In the blood at high concentrations, lead inhibits red blood cell formation and eventually results in anemia [7].

There are differences within individual species on account of capability of metal accumulation. According to Tyler [42], fungal species differences were the most important with respect to accumulation of metals. The substrate such as soil and tree trunks may also contribute to metal concentrations in mushrooms. Mushrooms are a good source of minerals including iron, potassium, calcium, magnesium, manganese, zinc and calcium (Table 2). Clearly, edible mushrooms, in fresh, cooked or processed forms, are a nutritionally sound, tasteful food source for most people and can be a significant dietary component for vegetarians. In fact potassium from fruit and vegetables can reduce blood pressure. The results obtained for trace elements in analyzed mushroom species seem acceptable for human consumption at nutritional levels [42].

Results from over hundreds of original papers, dealing with heavy metals in edible mushrooms show that cadmium, mercury and lead are the toxic metals for human [32]. According to FAO/WHO [37] standards, acceptable intakes of cadmium and lead for an adult are 0.42-0.49 and 1.50-1.75 mg per week, respectively. The trace element concentrations in mushrooms are generally species-dependent [32] and hardly affected by pH or organic matter content of the soil [16].

When we consider the metal concentration of the mushroom species analyzed in this study from the point of view of the health risk, for intake calculation, the Provisional Tolerable Weekly Intake (PTWI) values for Cd and Pb for adults (of 60 kg) are 0.42 and 1.50 mg, respectively. These values are equivalent to 0.06 and 0.21 mg of Cd and Pb on a daily basis. A person with a bodyweight of 60 kg reaches a tolerable daily intake by consumption of a 300g portion of fresh (approximately 30 g dry weight) mushrooms [43]. The metal intakes by a normal (60 kg) consumer in mg/serving for *Mitrophora semilibera*, *Pholiota aurivella* and *Russula delica* were calculated from Table 2 as 0,072 0.597 and 1.775 for Cd. These results do not conform to EU Scientific Committee standards for Cd (toxic

metals). Therefore, the intake of heavy metals (Cd) by consumption of 30 g dry weight of mushrooms daily poses risk at all for the consumer.

Essential and/or heavy metal content of *Russula delica* have previously been reported by several authors [7,11,44-48]. Most of these studies are focused on the mushrooms growing wild in Turkey. According to a study reported by Dursun et al. [47] Al, Ca, Fe, K, Mg and P content of *Russula delica* from central Anatolia have been found in high amounts. Also, Gençcelep et al. [4] reported *Russula delica* had high Zn (89.9 mg/kg) and Cu (30.9 mg/kg) in previous study. Çayır et al. [7] found that *Russula delica* (from Lapseki, Çanakkale, Turkey) had high Cd, Cr, Cu, Pb and Zn, 4.23, 0.38, 164.2, 3.05 and 100.17 mg/kg in dry weight, respectively. Demirbaş [11] shown that *Russula delica* (from East Black Sea region, Turkey) had much high Pb, Cd, Co, As, Ni and Cr, 3.15, 1.14, 0.25, 0.61, 116.0 and 0.88 mg/kg, respectively. This sample is very important for account of capability of metal accumulation.

In conclusion, mineral content of twenty mushrooms collected from Erzincan, Turkey, were determined. The essential elements in this mushroom species were higher than those of toxic elements. The toxic element (Ni, Cd and Pb) contents in much mushrooms species can be considered sufficiently low and therefore have no health risk, but, *Mitrophora semilibera*, *Pholiota aurivella* and *Russula delica* have high toxic element. In addition, *Russula delica* is very important for account of capability of metal accumulation. As a result, it can be used for cleaning metal-contaminated water and soil.

REFERENCES

[1] Falandysz, J., Kunito, T. and Kubota, R., *J Environ Sci Health*, **2008**. 43: p. 1692-11699.
[2] Kalac, P., *Food Chem*, **2010**. 122: p. 2-15.
[3] Kottke, I., et al., *Mycorrhiza*, **1998**. 7: p. 267-275.
[4] Gençcelep, H., et al., *Food Chem*, **2009**. 113: p. 1033-1036.
[5] Rudawska, M. and Leski, T., *Food Chem*. **2005**. 92: p. 499-506.
[6] Dimitrijevic, M.D., Mitic, J.J. and Cvetkovic, J.S., *Eur Food Res Technol*, **2016**. 242: p. 1-10.
[7] Çayır, A., Coşkun, M. and Coşkun, M., *Biol Trace Element Res*, **2010**. 134: p. 212–219.
[8] Svoboda, L., Zimmermannova, K. and Kalac, P., *Sci Total Environ*, **2000**. 246: p. 61-67.
[9] Yamac, M., Yıldız, D. and Sarıkurkcu, C., *Food Chem*, **2007**. 103: p. 263-267.
[10] Kalac, P., *Food Chem*, **2009**. 113(1): p. 9-16.
[11] Demirbaş, A., *Food Chem*, **2000**. 68: p. 415-419.
[12] Isiloglu, M., Yilmaz, F. and Merdivan, M., *Food Chem*, **2001**. 73: p. 163-175.
[13] Tuzen, M., Ozdemir, M. and Demirbas, A., *Food Chem*, **1998**. 63: p. 247-251.
[14] Garcia, M.A., et al., *Arch Environ Contam Toxicol*, **1998**. 34: p. 330-335.
[15] Demirbaş, A., *Food Chem*, **2001**. 75: p. 453-457.
[16] Mendil, D., Uluozlu, O.D. and Tuzen, M., *Food Chem*, **2005**.
[17] Falandysz, J., et al., *Food Chem*, **2003**. 81: p. 21-26.
[18] Breitenbach, J. and Kränzlin, F., Verlag Mykologia. Lucerne.
[19] Buczacki, S., Harper Collins Publishers, UK, **1989**. p. 320.
[20] Dahncke, M.R. and Dahncke, S.M., AT Verlag Aarau, Germnay, **1989**. p. 686.
[21] AOAC, International,USA, **1990**.
[22] Falandysz, J. and Borovička, J., *Appl Microbıol Biotechnol*, **2013**. 97: p. 477-501.
[23] Okoro, I.O. and Achuba, F.I., *Afr J Biotechnol*, **2012**. 11: p. 7720-7724.
[24] Gast, C.H., Jansen, E. and Bierling, J., *Chemosphere*.**1988**. 17: p. 789-799.
[25] Seeger, R., *Deutsche Apotheke Zeitschrift*, **1982**. 122: p. 1835-1844.
[26] Wang, X.M., Zhang, J. and Wu, L.H., *Food Chem*, **2014**. 151: p. 279-285.
[27] Sanmeea, R., Dellb, B. and Lumyongc, P., *Food Chem*, **2003**. 82: p. 527-532.
[28] Liu, H., Zhang, J. and Li, T., *Biol Trace Element Res*, **2012**. 147: p. 341-345.
[29] Cvetkovic, J.S., et al., *Anal Lett*, **2015**. 48: p.2107-2121.
[30] Li, T., Wang, Y.Z. and Zhang, J., *Food Chem*, **2011**. 127: p. 1828-1830.
[31] Sanmeea, R., Dellb, B. and Lumyongc, P., *Food Chem*, **2003**. 82: p. 527-532.
[32] Kalac, P. and Svoboda, L., *Food Chem*. **2001**. 69: p. 273281.

[33] Soylak, M., et al., *Food Chem*, **2005**. 92: p. 649-652.
[34] Sesli, E., and Tuzen, M., *Food Chem*, **1999**. 65: p. 453-460.
[35] Kaya, A. and Bag, H., *Asian J Chem*, **2010**. 22: p. 1515-1521.
[36] Sarikurkcu, C., et al., *Ecol Food Nutr*, **2012**. 51: p. 346-363.
[37] World Health Organization WHO, Italy, **1996**.
[38] National Academy of Sciences, Washington, **1975**. p. 227.
[39] Vetter, J., *Food Chem*, **1993**. 48: p. 207-208.
[40] Kalac, P., Svoboda, L. and Havlickova, B., *J Appl Biomed*, **2004**. 2: p. 15-20.
[41] World Health Organization WHO, Geneva, Switzerland, **1989**.
[42] Tyler, G., *Trans B Mycol Soc*, **1982**. 79: p. 239-245.
[43] Council of Europe (EC). Brussels, Belgium, **2001**.
[44] Konuk, M., Afyon, A. and Yagiz, D., *Fresenius Environ Bull*, **2007**. 16: p. 1359-1362.
[45] Ouzouni, P.K., et al., *Food Chem*. **2009**. 115: p. 1575-1580.
[46] Sesli, E. and Dalman, O., *Asian J Chem*, **2006**. 18: p. 2179-2184.
[47] Dursun, N., et al., *J Sci Food Agric*, **2006**.86: p. 1087–1094.
[48] Sesli, E. and Tuzen, M., *Asian J Chem*, **2006**. 18: p. 1423-1429.