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HEAVY METALS AND THE RADIOACTIVITY IN BOLETUS (*Boletus edulis*), AND CHANTERELLE MUSHROOMS (*Cantharellus cibarius*) IN TRANSYLVANIAN AREA

Aurelia COROIAN, Antonia ODAGIU, Zamfir MARCHIȘ, Vioara MIREȘAN, Camelia RĂDUCU, Camelia OROIAN, Adina Lia LONGODOR

University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Faculty of Animal Science and Biotechnologies, 3-5 Mănăştur Street, 400372 Cluj-Napoca, Romania

Corresponding author: zamfirmarchis@usamvcluj.ro

Abstract

Due to the pollution from the environment, the heavy metals also contaminate the mushrooms. The pollution degree depends on several factors such as climate, area of origin, mushroom composition, humidity level, and radioactivity. Samples were collected from the following areas: Sălaj, Cluj, Braşov, Baia Mare, Satu Mare, Bistrița-Năsăud. The content of fat, protein, humidity, heavy metal (Pb and Cd) and fungi radionuclides (Boletus edulis) and chanterelle mushrooms (Cantharellus cibarius) were evaluated. The content of Cs 137 in (Boletus edulis) built in the Baia Mare area and the lowest in the Brasov area. Cs 134 showed the lowest values in yellow sponges compared to dry boletus.

Key words: *Boletus edulis*, *Cantharellus cibarius, Pb, Cd, Cs 137, Cs 134.*

INTRODUCTION

Heavy metals are important pollutants in the environment and can cause problems for organisms and their bioaccumulation in the food chain can have adverse effects on human health. Heavy metals can affect human health through two mechanisms: first by increasing the presence of heavy metals in the air, water, soil and food, and secondly by changing the chemical structure inside the organism (Ejazul Islam, 2007).

The presence of heavy metals in the food chain has been reported in many countries and is being watched with great attention by both the population and government agencies (Ejazul Islam, 2007). The bioaccumulation of heavy metals in the agro-food chain can be extremely dangerous for human health. Edible high-cadmium mushrooms can pose a risk to the health of the consumer (Borui Liu, 2015). The mushrooms throo their composition are considered foods with nutritional benefits beneficial to the human body. It has a high content of carbohydrates, proteins, fats and minerals (Latiff et al., 1996). The mushrooms are commonly used in the diet of people suffering from various diseases, such as hypertension, various cancers, hypercholesterolemia (Talpur et al., 2002; Jeong et al., 2010; Lavi, Friesem, Geresh, Hadar and Schwart, 2006; Sullivan, Smith and Rowan, 1998).

Due to environmental pollution, environmental contaminants, such as heavy metals, are also found in living organisms. Mushrooms have the ability to assimilate the heavy metals, this aspect is greatly influenced by the environmental factors, the area, the chemical composition of the mushrooms (Garcia, Alonso, Fernández and Melgar, 1998).

Due to the fact that the possibility of assimilation of heavy metals is high, the competent authorities in the field of food safety require that these parameters to be determined when the mushrooms are marketed as a raw material for obtaining different mushroom products. A high level of heavy metals may present a toxicological aspect for consumers (Garcia et al., 1998; Zhu et al., 2011).

The climate in Transylvania is favorable to the development of edible wild mushrooms in this part of Romania. The rains in the summer and autumn periods favor a high production of wild edible mushrooms. The legumes in addition to components such as proteins, vitamins, iron, calcium can also contain toxic substances on a wide range of concentrations. The studies in this field show the fact that the accumulation of metals in vegetables can be a direct threat to the human organism (Turkdogan et al., 2003). It has been reported that ingested metals (lead, cadmium, mercury), more than half, come from food of vegetable origin (vegetables, fruits, cereals, mushrooms).

There are several factors that influence the toxicity threshold of heavy metals in the soil-culture system, such as soil type, soil pH, organic matter content, as well as other chemical and biochemical soil parameters. At present, agronomic practices are being pursued in order to minimize the availability of heavy metals in the soil. These practices aim to use organic matter and changing the pH. Such programs can be used in certain areas where heavy metals pollution is not expanded (Ejazul Islam et al., 2007). Heavy metals are potential contaminants for the environment and for human health and can cause problems for the consumer.

At present, throughout the world there is a lot of attention to them, because they can have toxic effects even at quite low limits (Das, 1990). Thus, there have been reports of various human diseases, disorders, malformations due to metal toxicity (Jarup, 2003). Lead can reach the human body by eating food or drinking water containing lead (from the water pipes that were glued with lead); by using care products, from air and water. Lead can affect almost every organ in the body. It mainly affects the nervous system in both children and adults.

Long-term exposure to lead acts to: increased blood pressure, can lead to anemia in the elderly; to decrease the performance of the nervous system, ankles and sensitive wrists; can damage the kidneys. In the case of pregnant women exposed to high amounts of lead, it can lead to spontaneous abortions (ATSDR, 2007). For some heavy metals the cumulative effect is the most significant property, and this effect is met at Hg, Cd, Pb, their toxicity is triggered in the moment of accumulation of a certain amount that can release extremely serious illnesses and irreversible consequences (Helferich, 2001). The purpose of this paper was to evaluate the levels of Pb, Cd, Cs 134 and Cs 137 from wild edible mushrooms (*Boletus edulis*, *Cantharellus cibarius*) from 6 areas in Transylvania.

MATERIALS AND METHODS

A total of 5 samples of dried Boletus (*Boletus edulis*) and 5 samples of dried chanterelle mushrooms (*Cantharellus cibarius*) were collected for each area from Transylvania (Cluj, Brasov, Sălaj, Satu Mare, Baia Mare and Bistriţa-Năsăud).

The samples were dried before performing the analyzes. The following parameters were analyzed: physicochemical parameters (fat, protein and humidity).

Fat and protein was analyzed by the Soxhlet and Gerber method.

The humidity was determined according to SR ISO 24557.

The microbiological parameters analyzed are: (*Salmonella* spp. according to SR ISO 16649-2: 2007; NTG-SR EN ISO 4833: 2003; *Enterobacteriaceae* SR ISO 21528-2:2007; Yeasts and molds SR ISO 21527-2:2009).

Lead was determined according to SR EN 14082: 2003; LOD - 0.05 mg/kg; LOQ - 0.1 mg/kg.

The cadmium was analyzed according to SR-EN 14082:2008, LOD - 0.02 mg/kg; LOQ - 0.04 mg/kg.

Atomic Absorption Spectrometry SAA (AAS) for Lead and Cadmium Level Analysis (*Boletus edulis* and *Cantharellus cibarius*), Cs 137 and Cs 134 Radionuclides were analyzed using gamma-ray spectrometry.

RESULTS AND DISCUSSIONS

The results obtained for the edible wild mushrooms from the Transylvanian areal has shown a similar level of the analized heavy metals with the levels found in literature.

Table 1 presents the mean values and variability for Cs 137 and Cs 134 of *Boletus edulis* in different areas of Transylvania. Cs 137 in *Boletus edulis* varied thus 18.2 ± 1.15 for the analyzed samples from the Cluj area and 44.12 ± 2.03 to those in the Baia Mare area. This is also influenced by the pollution in this area. High values for Cs 137 showed also the samples analyzed in the Satu Mare area (38.20 ± 1.06). Increased values for Cs 137 in *Boletus edulis* are also observed in the Bistriţa-Năsăud area (26.32 ± 1.72), followed by Sălaj (21.32 ± 0.84). The area with the lowest Cs 137 content is Braşov (12.9 ± 0.99), being considered a less polluted area compared to other areas (Table 1).

Table 1. The Cs 137 and Cs 134 content in dried boletus *(Boletus edulis)* colected from different areas of Transylvania

Area	Cs 137		Cs 134	
	X±sx	V%	X±sx	V%
Cluj	18.2±1.15	14.09	2.65±0.27	23.08
Braşov	12.9±0.99	17.18	2.90±0.13	10.24
Sălaj	21.32±0.84	8.85	7.02±0.35	11.10
Satu Mare	38.20±1.06	6.21	6.34±0.25	8.98
Baia Mare	44.12±2.03	10.30	8.54±0.22	5.86
Bistriţa-Năsăud	26.32±1.72	14.61	2.38±0.20	19.01

All values are mean ± SD; n = 5.

Cs 134, similar to Cs 137, show the highest average values in the Baia Mare, Sălaj and Satu Mare areas. Cs 134, shows the lowest values (2.38 ± 0.20) in Bistriţa Năsăud and the highest (8.54 ± 0.22) in Baia Mare. Aspects signaled in the literature regarding the degree of contamination in Baia Mare and Satu Mare are also observed in the results presented in Table 1.

Table 2. The Pb and Cd levels in dried boletus *(Boletus edulis)* colected from different areas in Transylvania

Area	Pb (mg/kg)		Cd (mg/kg)	
	X±sx	V%	X±sx	V%
Cluj	0.17±0.03	32.37	0.18±0.01	13.41
Braşov	0.15±0.01	14.65	0.12±0.01	21.08
Sălaj	0.24±0.03	29.75	1.17±0.04	6.86
Satu Mare	0.28±0.02	5.62	1.26±0.14	24.40
Baia Mare	0.34±0.01	5.62	1.32±0.01	2.53
Bistriţa-Năsăud	0.19±0.02	20.16	0.78±0.05	14.09

All values are mean±SD; n = 5.

Table 2 presents the average values and the variability of the content of Pb and Cd in dried Boletus edulis in different areas of Transylvania.
The highest content of Pb and Cd is in Satu Mare, Baia Mare and the lowest in Braşov and Cluj. The level of Pb in *Boletus edulis* thus varied to 0.15 ± 0.01 in Braşov and 0.34 ± 0.01 in the Baia Mare area.
High values were also observed in the Satu Mare area (0.28 ± 0.02) followed by Sălaj (0.24 ± 0.03). Cd showed the highest level (1.32 ± 0.01) in Baia Mare, followed by Satu Mare (1.26 ± 0.14) and Sălaj (1.17 ± 0.04). The lowest values are in the Bistriţa-Năsăud area (0.78 ± 0.05), followed by Cluj (0.18 ± 0.01) and Braşov (0.12 ± 0.01)..

Table 3. Humidity in dried boletus (*Boletus edulis*) colected from different areas in Transylvania

Parameter	Collection area											
	Baia Mare		Cluj		Braşov		Sălaj		Satu Mare		Bistriţa-Năsăud	
	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%
Fat	0.44±0.02	11.72	0.46±0.02	7.61	0.43±0.02	9.26	0.41±0.01	7.90	0.42±0.02	8.42	0.41±0.01	7.51
Protein	2.86±0.04	3.10	2.92±0.02	1.72	2.70±0.06	4.83	2.74±0.06	5.22	2.82±0.05	3.57	2.60±0.07	5.99
Humidity	16.61±0.44	5.93	16.44±0.60	8.20	15.41±0.33	4.85	17.08±0.33	4.37	17.71±0.14	1.79	14.35±0.24	3.67

All values are mean±SD; n = 5.

Table 3 shows the fat, protein and moisture content of *Boletus edulis* from different areas of Transylvania. The fat varied in the range 0.41 ± 0.01 for *Boletus edulis* in the Bistriţa-Năsăud and Sălaj area and 0.46 ± 0.02 in the Cluj area. The protein presented the lowest average values for the samples in the Bistriţa-Năsăud area (2.60 ± 0.07) the higher values are in Cluj area (2.92 ± 0.02). The humidity varied in the range 14.35 ± 0.24 of Bistriţa-Năsăud and 17.71 ± 0.14 in Satu Mare. Table 4 shows the microbiological parameters of *Boletus edulis* of the collection area.

Table 4. Microbiological parameters from dried boletus (*Boletus edulis)* colected from different areas of Transylvania

	Colection area					
Parameter	Baia Mare	Cluj	Braşov	Sălaj	Satu Mare	Bistriţa-Năsăud
Salmonella spp.	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g
E. coli beta gluc. Positive	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g
TGN	1.3 E+3 ufc/g	1.2E+3 ufc/g	1.5 E+3 ufc/g	1.3 E+3 ufc/g	1.7E+3 ufc/g	1.2E+3 ufc/g
Enterobacteriaceae	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g
Yeasts and molds	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g

Table 5. The content of Cs 137 and Cs 134 from dried chanterelle mushrooms (*Cantharellus cibarius*) collected from different areas

Area	**Cs 137**		**Cs 134**	
	X±sx	V%	X±sx	V%
Cluj	17.38±0.77	9.97	1.50±0.16	23.37
Braşov	18.61±0.44	5.33	1.25±0.09	16.90
Sălaj	24.28±0.39	3.57	4.57±0.36	17.56
Satu Mare	32.40±1.37	9.44	7.08±0.40	12.77
Baia Mare	34.98±0.87	5.56	7.84±0.44	12.48
Bistriţa-Năsăud	22.48±0.98	9.77	1.88±0.17	20.69

All values are mean±SD; n = 5.

Table 5 shows the average level and variability for Cs 137 and Cs 134 from dried chanterelle mushrooms.

The Baia Mare, Satu Mare and Sălaj areas showed the highest average values for Cs 137, respectively 34.98 ± 0.87 in Baia Mare and the lowest in Sălaj (24.28 ± 0.39). The lowest values can be observed in Cluj, Braşov and Bistriţa-Năsăud. These areas are considered less polluted compared to Satu Mare, Baia Mare and Sălaj.

These areas have been polluted in the past due to the industry, and there are currently factories industrial pollutants.

It can be noticed that Cs 137, Cs 134 in the dried chanterelle mushrooms are in the highest quantities in the Baia Mare, Satu Mare and Sălaj areas. Cs 134 in dried chanterelle mushrooms was 7.84 ± 0.44 in Baia Mare, followed by Satu Mare (7.08 ± 0.40). The mean values for Pb in dry chanterelle mushrooms are in the range 0.12 ± 0.01 in Braşov and 0.30 ± 0.01 in Baia Mare. Cadmium is in the range 0.60 ± 0.04 in Braşov and 1.13 ±0.1 in Baia Mare (Table 6).

Table 6. The level of Pb and Cd from dried chanterelle mushrooms (*Cantharellus cibarius*) collected from different areas of Transylvania

Area	**Pb (mg/kg)**		**Cd (mg/kg)**	
	X±sx	V%	X±sx	V%
Cluj	0.14±0.02	27.16	0.76±0.05	15.34
Braşov	0.12±0.01	16.72	0.60±0.04	14.31
Sălaj	0.18±0.01	11.27	0.85±0.08	20.31
Satu Mare	0.25±0.02	14.36	1.05±0.09	18.12
Baia Mare	0.30±0.01	6.45	1.13±0.11	21.57
Bistriţa-Năsăud	0.15±0.01	22.02	0.75±0.05	14.21

All values are mean±SD; n = 5.

Table 7 shows the physico-chemical parameters of dried chanterelle mushrooms.

The fat is in the range (0.50 ± 0.03) for the chanterelle mushrooms in the Baia Mare area and (0.60 ± 0.03) for the Braşov area. The protein varies (1.5 ± 0.06) in Cluj and (1.66 ± 0.06) in Satu Mare.

The humidity varies between 11.43 ± 0.18 in Baia Mare and 12.56 ± 0.21 in Satu Mare. Chanterelle mushrooms have a higher fat content than boletus (Tables 3 and 7).

The protein is higher in dried boletus (*Boletus edulis*) compared to dried chanterelle mushrooms (*Cantharellus cibarius*).

Table 7. Humidity in dried chanterelle mushrooms (*Cantharellus cibarius)* colected from different areas in Transilvania

	Colection area											
Parameter	Baia Mare		Cluj		Braşov		Sălaj		Satu Mare		Bistriţa-Năsăud	
	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%	X±sx	V%
Fat	0.50±0.03	11.45	0.52±0.04	16.37	0.60±0.03	10.04	0.59±0.06	24.18	0.55±0.03	13.54	0.57±0.04	13.59
Protein	1.55±0.05	6.80	1.5±0.067	8.67	1.59±0.05	7.20	1.61±0.07	10.03	1.66±0.06	7.76	1.65±0.04	5.83
Humidity	11.43±0.18	3.54	12.03±0.19	3.48	12.14±0.39	7.24	11.74±0.32	6.07	12.56±0.21	3.71	11.82±0.31	5.82

All values are mean±SD; n = 5.

Table 8. Microbiological parameters from dried chanterelle mushrooms (*Cantharellus cibarius*) colected from different areas in Transilvania

	Colection area					
Parametre	Baia Mare	Cluj	Braşov	Sălaj	Satu Mare	Bistriţa-Năsăud
Salmonella spp.	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g	Absent/25 g
E. coli beta gluc. Positive	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g
NTG	1.5E+3 ufc/g	1.3 E+3 ufc/g	1.7 E+3 ufc/g	1.3 E+3 ufc/g	1.6 E+3 ufc/g	1.4 E+3 ufc/g
Enterobacteriaceae	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g
Yeasts and molds	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g	<100 ufc/g

All values are mean±SD; n = 5.

The results of the microbiological examination for the analyzed samples correspond to the order ANSVSA 27/2011 (Tables 4 and 8).

CONCLUSIONS

The fat content of dried boletus (*Boletus edulis*) regardless of the harvesting area is lower compared to the chanterelle mushrooms (*Cantharellus cibarius*). The protein has higher values for *Boletus edulis* compared to *Cantharellus cibarius*.
The chemical composition of the mushrooms, the fat content, the protein and the humidity, influence the way of heavy metals assimilation. Lead, cadmium, Cs 137 and Cs 134 are in smaller quantities in *Cantharellus cibarius* compared to *Boletus edulis*.

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