Trace Metals Concentrations in Some Wild Grown Edible Mushrooms from Wooded Area of Romania

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Abstract: - The mushrooms represent an important contribution for the daily necessary in Fe, Mg and Zn of a human body. The trace metals concentrations were established by Inductively Coupled Plasma - Atomic Emission Spectrometry method. The results are varying with the analyzed species of mushrooms between 107.84 and 403.42 mg/kg for Fe, 367.14 to 1624.18 mg/kg for Mg and between 6.98 to 124.30 mg/kg for Zn. Reported to 100 g of fresh mushrooms these concentrations represent 14-121% for Fe, 2.5-21.9% for Mg and 1.2-44.7 for Zn from the daily necessary. The metals concentrations in fruiting body are in correlation one with each others, their absorption being species-dependent.

Key-Words: mushrooms, fruiting body, edible, trace metals, daily necessary.

1. Introduction
In most of the countries, there is a well-established consumer acceptance of cultivated mushroom, such as Agaricus bisporus, Pleurotus spp., Lentinus edodes and other, but some specific groups of people, seasonally, are traditionally eating wild mushrooms [4]. In these countries with a high consumption of wild mushrooms the research has been carried out about the identification of edible species which accumulate high levels of harmful elements.

The mushrooms are consumed because of their chemical and nutritional properties, as for their therapeutic and preventing disease characteristics due to the chemical composition [12, 1]. The bioavailability of iron in mushrooms is therefore high and up to 90% of the iron present can be absorbed by human body [9]. Many mushrooms species are known to accumulate trace metals to a higher level than the plants [10].

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The metals are distributed unevenly within the fruiting body, the highest concentrations have been observed in the spore-forming part, but not in the spore, a lower content in the rest of the cap and the lowest level in the stipe [19]. Also, high level of metals concentration was observed in the vicinity of metals polluted area and metals smelter [8, 18, 3].

Trace elements above threshold concentration level, can cause morphological abnormalities and reduce growth and increase mortality and mutagenic effects in human bodies [13]. Accurate food composition data are estimating the adequacy of essential nutrients intakes and assessing exposure risk from intake of toxic non-essential metals [14, 17].

The present paper investigates the content for some wild-grown edible mushrooms concerning the trace elements like Fe, Mg and Zn, elements essential for the human organism in a low level of concentration.

2. Material and Method

2.1 Species and ecology
Five species of mushrooms were harvested from a wooded area, near Sinaia city, from Bucegi Massif of Carpathian Mountains. All these macrofungi were founded in deciduous forest, at 800 m altitude, relatively close to the road Targoviste - Sinaia. They grown in a cold period, in November, on the soil, but the mycelium was founded also in the mixture of deadwood and leaves from the ground. The analyzed species are edible (Marasmius oreades and Boletus griseus), edible with low nutritive value (Collybia butyracea and Hygrophorus virgineus) or with conditioned edibility (Calvatia excipuliformis – can be used only when is very young).

The harvested mushrooms were mature, with spore forming part, and were collected the whole fruiting bodies, cap and stipe. The species of mushrooms were identified using some guides book [21] and the Internet [23].

2.2 Analytical methods

For each mushroom we sample 6-9 exemplars from different places and the substratum near the mycelium, down to the depth of 5 cm. Both the samples of mushrooms and soil, and them processing were done with plastic, glass and pottery instruments to avoid any...
metal contacts which can influence the final results.

After harvesting, the mushrooms were cleaned by the soil particles, dried at 60 ºC and then grinding to fine powder. The soil root surrounding samples were dried at 40 ºC until the complete process, then grinding to a fine powder and sieved at 250 µm (conform SR ISO 11464).

The estimation of metallic content in the analyzed mushroom and them soil was done by the Inductively Coupled Plasma - Atomic Emission Spectrometry method (ICP-AES). For the analyzes with ICP-AES method, the biological samples (mushrooms) were mineralized, in Berghof microwave digestor, by mixture with 10 ml of nitric acid concentrated 65% and 2 ml of hydrogen peroxide, and for the soil samples were done hot extractions with nitric acid 1:1.

In present paper, the metals contents of mushrooms were established with a 110 Liberty Spectrometer type of Varian brand. To disintegrate the sample in constituents atoms or ions is used a plasma source, which will stir up them on superior energetic layer. They will revert to the initial form by the emission of characteristic energy photon, emission recorded by an optical spectrometer. The radiation intensity is proportional with each element concentration in the sample and is intern calculated by a couple of calibration curves to obtain directly the measured concentration.

The concentrations represent the mean of many exemplars and are expressed in mg of metal related with kg of dry soil or plants.

3 Results and discussion

The mushrooms are very appreciated in the culinary domain because of their concentration in minerals. Besides water (75-95% fresh weight), they has an important content of carbohydrates (39% dry weight), proteins (17.5% dry weight) and a low content of lipids (2.9% dry weight) [11]. The amount of dry matter of mushrooms is species dependent, but also depends on the age and meteorological condition. A mean percentage of dry weights for each species of analyzed mushrooms are: *Marasmius oreades* – 17.5%, *Boletus griseus* – 26.25%, *Collybia butyracea* – 33.59%, *Hygrophorus virgineus* – 18.75% and *Calvatia excipuliformis* – 54.02%.

3.1 Trace metals concentrations

The level of concentration for Fe, Mg and Zn, in the fruiting body of analyzed mushrooms is given in table 1.

The iron concentration the species collected range from 107.84 in *Collybia butyracea* species to 403.42 mg/kg dry weight in *Calvatia excipuliformis*, and the average is 211.83 mg/kg. The range of this metal in the analyzed species of mushrooms is 295.58 mg/kg. These results are in agreement with the reported values from literature: 166-335 mg/kg [6], 50.1-842 [5] and 102.1580 [17].

The average of magnesium concentration in the fruiting body of analyzed mushrooms is 808.90 mg/kg, the minimum values were founded in *Collybia butyracea* species – 367.14 mg/kg, and the highest content shows *Calvatia excipuliformis* 1624.18 mg/kg. The values of magnesium concentrations are in agreement with values reported in literature 900-4540 mg/kg [5] and 400-900 mg/kg [15].

Zinc is one of the important trace metals for a normal growth and development of humans. Mushrooms are known as well zinc accumulators and sporophore: the ratio for zinc ranges from 1 to 10 mg/kg [2, 7]. Zinc content in the analyzed mushrooms from Bucegi Massif has the lowest values for *Boletus griseus* (6.98 mg/kg) and the highest values for *Calvatia excipuliformis* (124.3 mg/kg). The average of zinc concentration in these species of mushrooms is 44.53 mg/kg. Results obtained for the zinc concentration are in accordance with the concentrations from literature which have been reported in the range of 28.6-179.0 mg/kg [15], 43.5-205.0 mg/kg [16] or 45-188 mg/kg [20].

The mean concentrations of essential minerals in the entire fruiting body, across all tested fungi were in order Mg > Fe > Zn.

Table 1 Trace metals in mushrooms species from Carpathian Mountain (mg of metals per kg of dry weight - dw).

<table>
<thead>
<tr>
<th>Species</th>
<th>Fe</th>
<th>Mg</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Marasmius oreades</em></td>
<td>151.70</td>
<td>1011.02</td>
<td>35.81</td>
</tr>
<tr>
<td><em>Boletus griseus</em></td>
<td>136.09</td>
<td>382.02</td>
<td>6.98</td>
</tr>
<tr>
<td><em>Collybia butyracea</em></td>
<td>107.84</td>
<td>367.14</td>
<td>11.37</td>
</tr>
<tr>
<td><em>Hygrophorus virgineus</em></td>
<td>260.11</td>
<td>660.17</td>
<td>20.58</td>
</tr>
<tr>
<td><em>Calvatia excipuliformis</em></td>
<td>403.42</td>
<td>1624.18</td>
<td>124.30</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>211.83 ± 121.65</td>
<td>808.90 ± 525.60</td>
<td>39.80 ± 48.58</td>
</tr>
<tr>
<td>Range</td>
<td>295.58</td>
<td>1257.04</td>
<td>117.32</td>
</tr>
<tr>
<td>Minimum</td>
<td>107.84</td>
<td>367.14</td>
<td>6.98</td>
</tr>
<tr>
<td>Maximum</td>
<td>403.42</td>
<td>1624.18</td>
<td>124.30</td>
</tr>
</tbody>
</table>
Concerning the correlation between the contents of studied metals in the fruiting body of these species of mushrooms we can observe a high degree of correlation between all three essential metals (table 2), with statistically significant differences, p < 0.05 and p < 0.01. This correlation means that the accumulation of each element is dependent on the presence in soil of the other metals, and the uptake is done proportionally between these metals.

Table 2 The correlation between the trace metals in the fruiting body of mushrooms (Pearson’s coefficient)

<table>
<thead>
<tr>
<th></th>
<th>Fe</th>
<th>Mg</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0.8411*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.8872**</td>
<td>0.9562*</td>
<td>1</td>
</tr>
</tbody>
</table>

* p < 0.05, ** p < 0.01

3.2 The mushrooms contribution in the daily physiological necessary for Fe, Mg and Zn.

The average intakes of Fe, Mg and Zn are 18, 400 and 15 mg/day respectively; this amount is likely to pose no risk of adverse effects [22]. In table 3 are calculated the concentrations of these essential metals in the mushrooms reported to 100 g of fresh weight, and in parenthesis are given the percentage of these amounts in the daily physiological necessary for an adult. As we can see, Calvatia excipuliformis has the higher contribution of minerals in the daily necessary, 121% for Fe, 21.9% for Mg and 44.7% for Zn in 100 g of fresh mushrooms. The other species have similar contribution, ranging from 14.7 to 27.0% for Fe, from 2.5 to 4.4% for Mg and from 1.2 to 4.1 for Zn values which are also important for the daily nutrition of humans.

Table 3 Essential metals concentrations in some mushrooms species (mg/100 g of fresh weight); and the percentage contribution for the daily necessary in human body (in parenthesis).

<table>
<thead>
<tr>
<th>Species</th>
<th>Fe (%)</th>
<th>Mg (%)</th>
<th>Zn (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marasmius oreades</td>
<td>2.65 (14.7%)</td>
<td>17.69 (4.4%)</td>
<td>0.62 (4.1%)</td>
</tr>
<tr>
<td>Boletus griseus</td>
<td>3.57 (19.8%)</td>
<td>10.02 (2.5%)</td>
<td>0.18 (1.2%)</td>
</tr>
<tr>
<td>Collybia butyracea</td>
<td>3.62 (20.1%)</td>
<td>12.33 (3.08%)</td>
<td>0.38 (2.5%)</td>
</tr>
<tr>
<td>Hygrophorus virgineus</td>
<td>4.87 (27.0%)</td>
<td>12.37 (3.09%)</td>
<td>0.38 (2.5%)</td>
</tr>
<tr>
<td>Calvatia excipuliformis</td>
<td>21.79 (121.0%)</td>
<td>87.73 (21.9%)</td>
<td>6.71 (44.7%)</td>
</tr>
</tbody>
</table>

4 Conclusion

Calvatia excipuliformis shows the highest values for all three studied essential metals, Fe, Mg and Zn. The lowest values of concentration for Fe and Mg were founded in Collybia butyracea, and for Zn in Boletus griseus.

Between the concentrations of Fe, Mg and Zn in the fruiting body of analyzed mushrooms are a high degree of correlation.

Due to its high percent of dry weight and high values of metals concentrations, Calvatia excipuliformis has the greater contribution of minerals in the daily necessary of humans.

References:
Journals:


Books:


On-line documents: