THE BIOMINERAL CONCENTRATIONS AND ACCUMULATION IN SOME WILD GROWING EDIBLE SPECIES OF MUSHROOMS

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Abstract

Many mushrooms species are known to accumulate metals to a higher level than the plants and are considered as a source of proteins, vitamins – riboflavin, biotin and thiamine, fats, carbohydrates, amino acids and minerals. The trace metals concentrations were established by Inductively Coupled Plasma - Atomic Emission Spectrometry method. The aim of this paper is to determinate the minerals content of some wild growing mushrooms, which may be useful in the phytopharmaceutical biotechnologies in order to obtain important quantities of biominerals accessible for the human body. The results are varying with the analyzed species of mushrooms between 11869.85 and 32088.68 mg/kg for potassium, 240.81 to 716.98 mg/kg for calcium and between 0 to 5350 mg/kg for phosphorus. The highest concentration if potassium was founded in B. griseus species, 32088.68 mg/kg. Only two species, Hygrophorus virgineus and Marasmius oreades show a phosphorus concentration in the fruiting body higher than in soil, indicating the accumulation capacity.

Keywords: potassium, calcium, phosphorus, accumulation, mushrooms

1. INTRODUCTION

Many mushrooms species are known to accumulate metals to a higher level than the plants [10]. Within the fruiting body, the metals are distributed unevenly. 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 [15]. Also, the level of metal concentrations varies with the metal content in the soil. High level of metals concentration was observed in the vicinity of metals polluted area and metals smelter [5, 9, 14].
In various cultures, the mushrooms have been a food supplement, some specific group of people traditionally eating wild mushrooms. They are eaten because of them delicacy and their chemical and nutritional proprieties, as for their therapeutic and preventing disease characteristics due to the chemical composition [2, 12]. Mushrooms are considered as a source of proteins, vitamins – riboflavin, biotin and thiamine [4] -, fats, carbohydrates, amino acids and minerals [7]. Ogundana and Fagade [13] indicated the mushrooms are 16.5% dry matter, which contain 7.4% crude fiber, 14.6% crude protein and 4.48% fat and oil. The protein content of mushrooms is very high, is twice the content in asparagus and potatoes, four time the content in tomatoes and carrots and six times the content in oranges [7]. Their energy value varies according the species and is about equal with that of an apple [1].
The aim of this paper is to determinate the minerals content of some wild growing mushrooms, which may be useful in the phytopharmaceutical biotechnologies in order to obtain important quantities of biominerals accessible for the human body. In addition, by analyzing the bioaccumulation factor of these species we can conclude which species are accumulators and hyperaccumulators for these minerals.

2. MATERIAL AND METHODS

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 Targovisite - Sinaia. They growth in a cold period, in November, on the soil, but the mycelium was founded also in the mixture of litter leaves and shoots from the ground. The analyzed species are edible (*Marasmius oreades* and *Boletus griseus*), edible with low nutritive value (*Collybia butyracea* and *Hygrphorus 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 guides book [3].

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. Samples, 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 clean up by the soil particles, dried at 60 ºC and then grinding to fine powder. The substratum 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 DISCUSSIONS

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%.
The contents of trace metals are related to species of mushrooms, collecting area of the sample, age of fruiting bodies and mycelium, and distance from any source of pollution [8]. Accurate and adequate mushrooms composition data are important to evaluate the intakes of essential nutrients and assessing exposure risk from intake of toxic elements. The average intakes are 1000 mg per day for potassium and calcium and 4000 mg per day for phosphorus. This daily nutrient intake is likely to pose no risk of adverse effects [6]. The results of mineral composition for the analyzed species of mushrooms indicate the potential for their use as a source of good quality food.
Potassium is an essential mineral for the body's growth and maintenance and plays an important role in proper hearth function. In the analyzed species of mushrooms the concentration of potassium is different from one species to another, ranging between 11869.85 mg/kg in *C. excipuliformis* and

32088.68 mg/kg in *Boletus griseus* species. The highest concentration of potassium represents 2526.98 mg/300 g of fresh mushrooms – one meal for an adult. This quantity is about 253 % from daily average intake. In the left hand side of figure 1 we can see that, except *C. excipuliformis*, the concentration of potassium in the substrate, under the fruiting body of mushrooms, is few times lower than the K concentration in the mushroom. This ratio can be expressed as the bioaccumulation factor (the metal concentration in mushrooms reported to the metal content of the soil). For potassium, the bioaccumulation level has high values, over the unit threshold which means that the analyzed species of mushrooms are accumulators and hyperaccumulators for this metal.

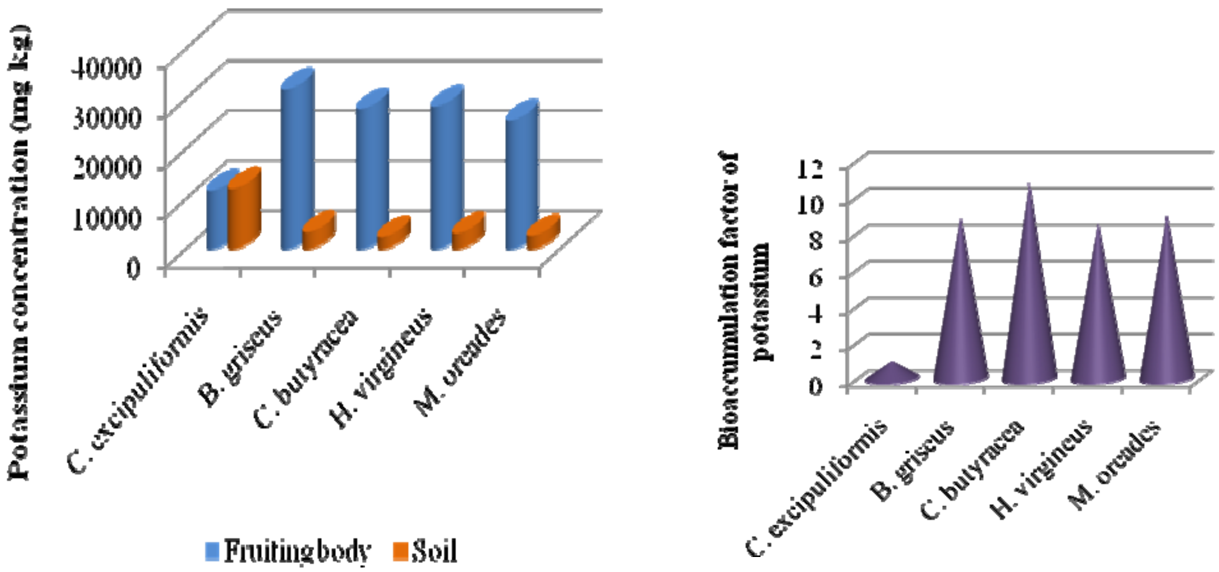

Figure 1 Potassium concentrations in mushrooms and soil, and the bioaccumulation factor

Calcium is needed for so many different functions in the body, for the formation and maintenance of bones, the development of teeth and healthy gums, for blood clotting, stabilizes many body functions and is thought to assist in bowel cancer. It has a natural calming and tranquilizing effect and is necessary for maintaining a regular heartbeat and the transmission of nerve impulses. It helps with lowering cholesterol, muscular growth and the prevention of muscle cramps. Furthermore it also helps with protein structuring in DNA and RNA. It provides energy, breaks down fats, maintains proper cell membrane permeability, aids in neuromuscular activity and helps to keep the skin healthy. Calcium also stops lead from being absorbed into bone.

Mushrooms are not an excellent food concerning the contribution with calcium for the human body, the concentrations in the fruiting body ranging from 240.81 mg/kg in *C. butyracea* to 716.98 mg/kg in *Hygrophorus virgineus* species (fig. 2). The highest concentration of calcium represents only 40.33 mg/300 g of fresh mushrooms, about 4 % from daily average intake. These concentrations are few times lower than the calcium content of the soil where the mean concentration is about 40 g/kg of dry soil. Analyzing this difference, the bioaccumulation factor shows values lower than neither 0.1, which means that mushrooms are nor accumulators for this metal.

Phosphorus is important to keep in balance with calcium and magnesium. It plays a role in every metabolic reaction in the body and is important for the metabolism of fats, carbohydrates, and protein for proper growth and production of energy.

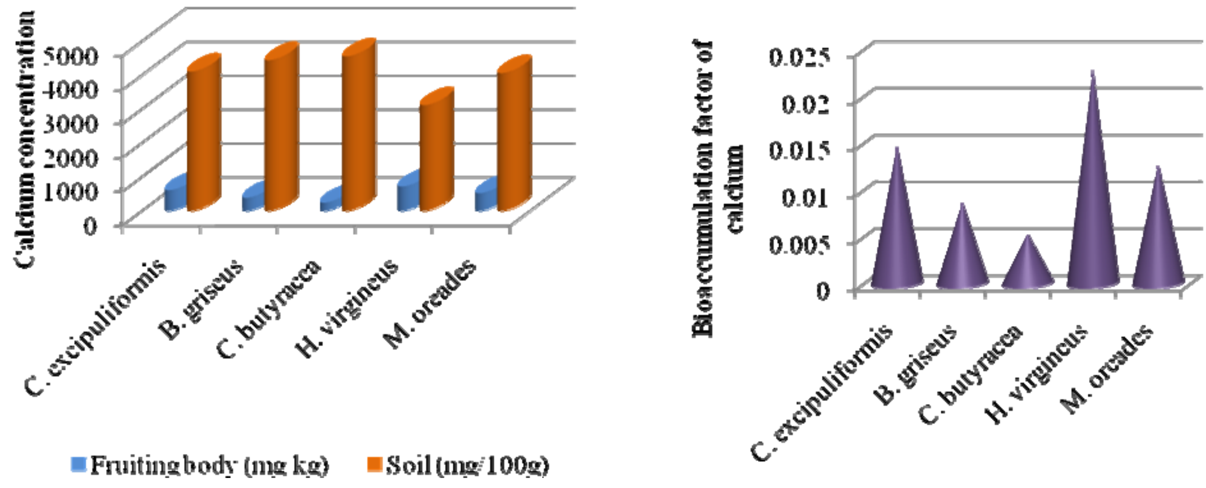

Figure 2 Calcium concentrations in mushrooms and soil, and the bioaccumulation factor

Phosphorus is absorbed through the intestines, transported in the bloodstream, and stored in the bones and teeth. 70% of ingested phosphorus is absorbed. The content of phosphorus varies in a wide range in the analyzed species of mushrooms. In *C. excipuliformis* the phosphorus concentration are under the detection limit of method, but the highest concentration founded was for *Marasmius oreades* species, which show a value of calcium of 5350.19 mg/kg. The highest concentration of phosphorus represents 280.89 mg/300 g of fresh mushrooms, about 7 % from daily average intake.The concentration of phosphorus in substratum varies also in wide range, and we can observe in the left hand side of fig. 3 that the concentration of metal in the fruiting body increases with the decreasing of the phosphorus content in the soil. The bioaccumulation factor has different values for the analyzed species of mushrooms, ranging between 0 and 2.72. Only two of five species are accumulators for this element: *Hygrophorus virgineus* and *Marasmius oreades.*

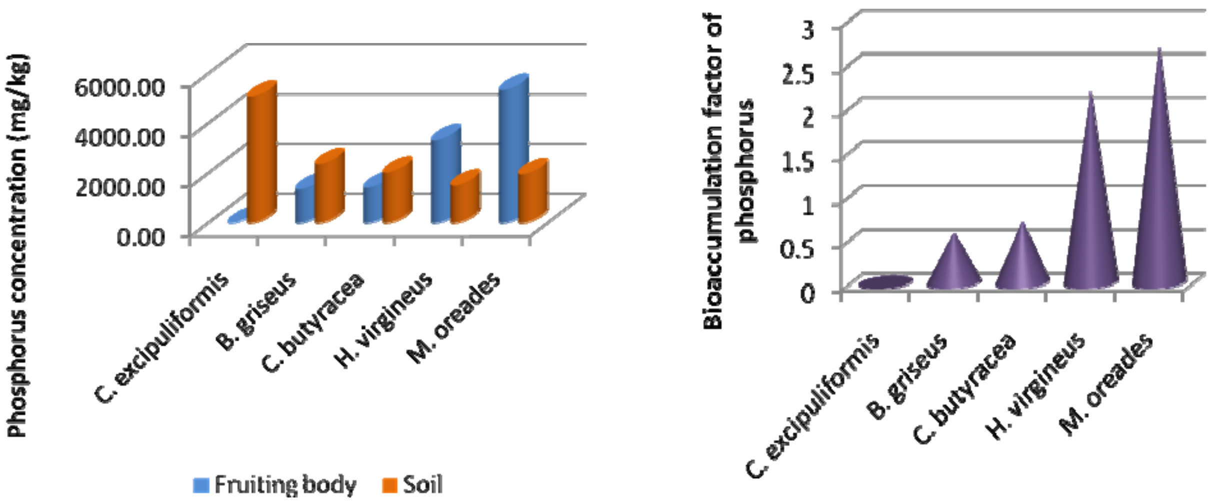

Figure 3 Phosphorus concentrations in mushrooms and soil, and the bioaccumulation factor

4. CONCLUSIONS

For potassium, the concentrations in the fruiting body excel the potassium content in the soil which means that these species of mushrooms are accumulators and hyperaccumulators for K. The highest concentration if potassium was founded in *B. griseus* species, 32088.68 mg/kg.

The concentrations of calcium are not indicating the accumulating capacity of the analyzed species of mushrooms, the highest concentration showing *Hygrophorus virgineus* species, 716.98 mg/kg.

Only two species, *Hygrophorus virgineus* and *Marasmius oreades* show a phosphorus concentration in the fruiting body higher than in soil, indicating the accumulation capacity of these species. The level of phosphorus in the fruiting body was up to 5350 mg/kg.

5. ACKNOWLEDGMENTS

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