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Chemical Composition of Four Wild Edible Mushroom Species Collected From Southwest Anatolia

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ABSTRACT
Four different species of wild edible mushrooms (*Armillaria mellea*, *Infundibulicybe geotropa*, *Meripilus giganteus* and *Sparassis crispa*) representing four different families (*Physalacriaceae*, *Tricholomataceae*, *Meripilaceae* and *Sparassidaceae*) growing in southwest regions of Anatolia were analyzed for their Fe, Na, K, Zn, Cu, Cd and Pb contents and ash, dry matter, protein, and fat levels. All mineral concentrations were determined on a dry weight basis (d.w.). The mineral content of mushroom samples ranged from 54.00 to 112.33 µg/ g d.w. for Fe, 66.50 to 117.33 µg/ g d.w. for Na, 32.33 to 117.00 µg/ g d.w. for K, 47.40 to 87.40 µg/ g d.w. for Zn, 54.30 to 74.67 µg/ g d.w. for Cu and not detected for Cd and Pb. Na content was higher than other minerals in all mushroom species. This research proves that wild edible fungi can be used in well-balanced diets due to their nutritive values. Also, their heavy metal contents (Pb, Cd) shows that collection areas are not polluted, therefore all collected mushroom species can be unreservedly consumed without any health risk.

Keywords: *Mineral contents, wild mushrooms, Turkey*

1. INTRODUCTION

Minerals occur naturally in the environment and are present in rocks, soil, plants and animals. Minerals occur in different forms: as ions dissolved in water, as vapours or as salts or minerals in rock, sand and soil. They can also be bound in organic or inorganic molecules, or attached to particles in the air. Both natural and anthropogenic processes emit metals into air and water. It is already generally known that some living organisms possess the ability to take up and accumulate, in their structures, certain elements especially metals, at high concentrations [1].

Fungi are present almost everywhere and they are important in ecosystems because they are able to biodegrade the substrate [2, 3]. Mushrooms have been a food supplement in various cultures for a long time. Edible mushrooms are cultivated and consumed by many people around the world. All essential amino acids for human health are present as well as water-soluble vitamins and all the essential minerals [4]. In addition, some mushrooms are reputed to possess due to properties of antioxidant, antimicrobial, antiallergenic and anticancer [5, 6, 7]. On the other hand, mineral concentrations in mushrooms are considerably higher than those in agricultural crops. Macrofungi possess a very effective mechanism that enables them readily to

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take up some minerals from the ecosystem compared to green plants growing in similar conditions [8]. Recently, some studies have drawn attention to the occurrence of the mineral contents of macrofungi [9, 10, 11]. The concentrations of minerals in macrofungi were found to depend on the physiology of the species and particularly on its ecosystem pattern [12].

High accumulating ability observed in several species promoted their screening as bioindicators. Several works were reviewed with the conclusion that no macrofungi species can be considered as an exact indicator of environmental metal pollution but their fruiting bodies can be useful for distinguishing between polluted and unpolluted areas [13].

In Turkey, there are about 2388 species of fungi that can be considered as macrofungi [14]. South and southwest parts of Anatolia have a mild and rainy climate in spring and autumn, providing ideal conditions for fungal growth. However, enough researches have not been carried out dealing with mineral content of these organisms. Therefore, it is necessary to investigate the mineral contents in wild edible species, given the fact that many of them are known to accumulate high levels of heavy metals, such as cadmium, lead, mercury etc. [15]. These elements are known to have severe toxicological effects on human health even at very low concentrations. The minerals are of great biochemical interest and having nutritional and clinical importance also. The content of minerals is related to species of mushroom, collecting site of the sample, age of fruiting body and distance from sources of pollution [16].

There are no information is available about chemical composition of *Armillaria mellea*, *Infundibulicybe geotropa*, *Meripilus giganteus* and *Sparassis crispa* collected from southwest Anatolia. Thus, this research will be a contribution to the literature from the point of interesting ratios for both Turkey and world consumption. The objective of this study was to determine the relative nutritive qualities of some wild edible mushroom species above mentioned.

2. MATERIALS AND METHODS

2.1. Mushroom samples

In this study, 40 samples of wild macrofungi corresponding to four different species (*Armillaria mellea*, *Infundibulicybe geotropa*, *Meripilus giganteus* and *Sparassis crispa*) were analyzed for their chemical composition. Origin and habitat information of these macrofungi has given in Table 1. All of the analyzed mushrooms were identified as edible macrofungi belonging to class *Basidiomycetes*. In the experiments, iron, sodium, potassium, zinc, copper, lead and cadmium bioaccumulations, ash, dry matter, protein, and fat levels of the fruit bodies of wild mushrooms were determined. The samples of the above four different species (4 species x 10 samples from each species = 40) were collected from southwest regions of Anatolia in 2007 - 2008. In these regions the forests are mixed, consist of areas dominated mainly by pine, cedar and oak trees. All macrofungi samples were deposited in the Ali Koçman Vocational High School, Muğla University, Turkey.

Table 1**.** Origin and habitat of macrofungi species

Species	**Origin and Habitat**
Armillaria mellea (Vahl) P. Kumm.	Isparta; in *Pinus brutia* forest
Infundibulicybe geotropa (Bull.) Harmaja	Muğla; in Babadağ village
Meripilus giganteus (Pers.) P. Karst.	Isparta; in Kovada National Park
Sparassis crispa (Wulfen) Fr.	Aydın; Koçarlı, on *Pinus brutia*

2.2. Analytical methods

The following components were determined on oven-dried material (98^{0}C) using AOAC [17] methods: ash, from the incinerated residue obtained at 550^{0}C after 3 h; crude protein (N x 6.25) by Kjeldahl, crude fat by Soxhlet extraction with dichloromethane in place of petroleum ether [18]. Mineral contents including Na, K, Fe, Zn, Cu, Cd and Pb were determined by atomic absorption spectrophotometer [10]. All the plastic and glassware were cleaned by soaking, with contact, over night in a %10 nitric acid solution and then rinsed with distilled water prior to use. The element standard solutions and HNO_3 used for digestion were supplied by Merck. A Perkin–Elmer Analyst 800 atomic absorption spectrometer with deuterium background corrector was used in this study. The operating parameters for working elements were set as recommended by the manufacturer. Lead and cadmium were determined by HGA graphite furnace using argon as inert gas. The other elements, iron, copper, zinc, potassium and sodium were determined by flame technique. After determining the ash content of the samples by oven method, ashes of the samples were dissolved in 100 ml nitric acid and kept in refrigerator until being analyzed. The element standard solutions were prepared by diluting stock solutions of 1000 ppm of sodium, cadmium, iron, zinc, copper, lead, potassium. The ratio of standard solutions prepared for each element, were different.

2.3. Statistical analysis

The data presented are the averages of the results of three replicates with a standard error of less than 5 %.

3. RESULTS AND DISCUSSION

Proximate analysis was carried out on four wild edible mushroom species: *Armillaria mellea*, *Infundibulicybe geotropa*, *Meripilus giganteus* and *Sparassis crispa*. Results of proximate composition are presented in

Table 2. *Sparassis crispa* had the highest concentration of protein (83.40% d.w.) followed by *Armillaria mellea* and *Meripilus giganteus*, while *Infundibulicybe geotropa* had the least (75.28 % d.w.). Fat levels of these wild mushrooms were between 0.68% and 1.20% d.w. The ash content of *Meripilus giganteus* was high (11.62% d.w.) while the other species ranged from 5.68% to 9.76%. Also, *Meripilus giganteus* had the total dry matter level (92.42% d.w.) and *Infundibulicybe geotropa* had the least (89.92% d.w.) (Table 2).

Table 2. Proximate composition (% dry weight) of four wild edible mushrooms

Species	**Ash**	**Total Dry Matter**	**Protein**	**Fat**
Armillaria mellea (AM)	9.76 ± 0.14	91.00 ± 0.60	76.94 ± 0.66	1.20 ± 0.05
Infundibulicybe geotropa (IG)	8.23 ± 1.11	89.92 ± 0.34	75.28 ± 1.75	1.05 ± 0.04
Meripilus giganteus (MG)	11.62 ± 0.41	92.42 ± 1.41	75.56 ± 0.46	0.68 ± 0.08
Sparassis crispa (SC)	5.68 ± 0.17	92.36 ± 0.44	83.40 ± 0.94	0.95 ± 0.04

Although lead and cadmium which were highly important for human healthy were analyzed in collected fruiting bodies at the beginning of this study, both of them were not detected in tested samples (Table 3). This result clearly shows that collection areas are not polluted by heavy metals in respect to Pb and Cd. Some mushroom species reported as a highly lead and cadmium accumulating organisms in the literature. The reported Pb values for edible macrofungi were 0.5 – 20 mg/kg [19]. A higher content of cadmium was reported for saprotrophic species compared to mycorrhizal ones; however, exceptions occurred [20]. It was reported that cadmium is accumulated mainly in kidneys, spleen and liver and its blood serum level increases considerably following mushroom consumption [11]. Thus, cadmium seems to be the most deleterious among heavy metals in mushrooms. Its acceptable daily or weekly intake may be easily reached by consumption of an accumulating mushroom species [21].

The range of iron concentrations were between 54.00 and 112.33 µg/g in mushroom species. The highest Fe content was 112.33 µg/g in *Infundibulicybe geotropa* and the lowest Fe content was 54.00 µg/g in *Sparassis crispa* (Table 3). Iron contents of four wild mushroom species used in this study were lower than literature values [1, 10, 12].

Among wild-grown edible mushroom species, the greatest concentration of Na was obtained in *Infundibulicybe geotropa* (117.33 µg/g). For the other mushroom species in this study, Na concentrations were between 66.50 and 93.00 µg/g (Table 3). Na value has been reported to be 28.0 – 120.8 µg/g [1, 22], but Sesli [12] reported that Na value of some mushroom species between 401 – 1388 µg/g.

Table 3. Mineral concentration of four wild edible mushrooms (µg / g dry weight)

Species	**Fe**	**Na**	**K**	**Cu**	**Zn**	**Pb**	**Cd**
AM*	63.50 ± 6.36	66.50 ±2.12	72.00 ± 4.24	62.47 ± 3.18	60.85 ± 0.78	ND	ND
IG*	112.33 ± 2.08	117.33 ± 5.51	117.00 ± 4.36	74.67 ± 1.27	87.40 ± 4.78	ND	ND
MG*	84.33 ± 8.50	93.00 ± 8.54	69.33 ± 8.14	70.17 ± 0.86	75.63 ± 3.88	ND	ND
SC*	54.00 ± 7.00	83.00 ± 4.00	32.33 ± 3.06	54.30 ± 2.15	47.40 ± 1.54	ND	ND

ND: Not detected, *See Table 2 for abbreviations of mushrooms

Minimum and maximum values of K were obtained for *Sparassis crispa* (32.33 µg/g) and *Infundibulicybe geotropa* (117.00 µg/g) (Table 3). Moreno-Rojas et al. [22] reported that K content of *Amanita ponderosa* was 7.7 µg/g. Also, Sanmee et al. [18] reported that K values of some wild edible mushrooms between 12.8 and 45.2 µg/g.

The greatest concentration of Cu was obtained in the *Infundibulicybe geotropa* (74.67 µg/g) in tested fruiting bodies. For the other mushroom species in this study, Cu concentrations were between 54.30 and 70.17 µg/g (Table 3). Isildak et al. [10] reported that Cu value of some wild edible mushrooms between 8.5 – 107.00 µg/g. Also, Cu value has been reported to be 10 – 70 µg/g in Vetter [23].

The highest Zn concentration found in *Infundibulicybe geotropa* (87.40 µg/g), whereas the lowest Zn concentration was in *Sparassis crispa* (47.40 µg/g) (Table 3). Zinc is widespread among living organisms due to its biological significance. Content of zinc in mushrooms ranged from 30 – 150 µg/g. Hence, zinc content in mushrooms of the present study is in agreement with previous studies [10, 13].

The amounts of mineral contents in these organisms are related to species of mushroom, taxonomic position, collected site of samples, age of fruiting bodies and distance from the source of pollution or industrial site [10]. The mineral concentrations in the mushroom are hardly affected by pH or organic matter content of the soil [19, 24]. The trace element contents of the species depend on the ability of the species to extract elements from the substrate, on the selective uptake and deposition of elements in tissues [1]. The uptake of metal ions in macrofungi is higher than in plants. For this reason, the concentration variations of minerals could be considered due to mushrooms species and their ecosystems [10]. The lower concentration of tested minerals in *A. mellea* can be explained by the very low mineral content of wood. Therefore, it should be analyzed the substrates and nutritional strategies of collected mushrooms, such as litter decomposing saprotrophic, wood destroying saprotrophic etc. for further discussion.

In conclusion, mineral (Fe, Na, K, Cu, Zn, Cd, Pb) contents of analyzed wild-growing mushrooms collected from southwest regions of Anatolia at the field researches were generally similar to those reported from Turkey and other countries. The highest mineral concentrations were measured in *Infundibulicybe geotropa* for Fe, Na, K, Cu and Zn as 112.33, 117.33, 117.00, 74.67 and 87.40 μg/g (dry weight basis) respectively (Table 3). *Infundibulicybe geotropa*, synonym: *Clitocybe geotropa* is collected and consumed as a food by the villagers living in this region. Cadmium and lead were not determined in all mushroom samples.

Using this proximate analysis, the mineral and analytical food value as approximate indices of nutritional quality, it would appear that some of these mushrooms fall between most legumes and meat. Adejumo and Awosanya [25] and Gençcelep et al. [26] indicated that wild edible mushrooms were highly nutritional and compared favorably with meat, egg and milk. Further study should be undertaken on of chemical composition, which shows the food quality of the wild-grown edible mushroom.

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