ELSEVIER

Food Chemistry 84 (2004) 389–392

Food Chemistry

www.elsevier.com/locate/foodchem

Determination of iron, copper, manganese, zinc, lead, and cadmium in mushroom samples from Tokat, Turkey

Ibrahim Turkekul[a,*], Mahfuz Elmastas[b], Mustafa Tüzen[b]

[a]Gaziosmanpasa University, Faculty of Science and Arts, Biology Department, 60250 Tokat, Turkey
[b]Gaziosmanpasa University, Faculty of Science and Arts, Chemistry Department, 60250 Tokat, Turkey

Received 7 March 2003; accepted 6 May 2003

Abstract

Contents of Fe, Cu, Mn, Zn, Pb, and Cd in 10 mushrooms species from Tokat, Turkey were determined by atomic absorption spectrometry. The results indicate that Fe, Cu, Mn, and Pb levels in the species *Fomes fementarius* were the highest with means of 3904±307 mg/kg, 54±4 mg/kg, 64±5 mg/kg, 2.7±2.0 mg/kg, respectively. The highest level of Zn was 122±11 mg/kg in the species *Polyporus frondosus*. Content of Cd in *Boletus appendiculatus* and *Fomes fomentarius* were the highest with a mean of 1.8±0.2 mg/kg.

Keywords: Metal; Mushroom; Atomic absorption spectrometry; Tokat, Turkey

1. Introduction

Mushrooms are important in the ecosystem because they are able to biodegrade the substrate and therefore use the wastes of agricultural production. Fruit body of mushrooms are appreciated, not only for texture and flavour but also for their chemical and nutritional properties (Manzi, Aguzzi, Vivanti, Paci, & Pizzoferrato, 1999). Mushrooms have also been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia, and cancer. These functional characteristics are mainly due to their chemical composition (Manzi, Aguzzi, & Pizzoferrato, 2001).

Heavy metal concentrations in mushroom are considerably higher than those in agricultural crop plants, vegetables and fruit. This suggests that mushrooms possess a very effective mechanism that enables them readily to take up some heavy metals from the ecosystem. The concentrations of trace elements in the fruiting bodies of fungi are primarily species-dependent. The concentrations were found to depend on the physiology of the species and particularly on its ecosystem pattern. It has proven rather difficult to determine the effects of environmental factors on the heavy metals (Lepsova & Mejstrik, 1988).

In most countries, there is a well-established consumer acceptance of cultivated mushrooms (*Agaricus bisporus, Pleurotus* spp., *Lentinus edodes, Volveriella volvacea, Auricularia* spp., etc). However, wild edible mushrooms have been traditionally eaten only by specific groups of people and seasonally (Diez and Alvarez, 2001). Nevertheless, wild edible mushrooms are becoming increasingly important in our diet for their nutritional and pharmacological characteristics (Bobek et al., 1991; Breene, 1990; Crisan & Sands, 1978; Manzi et al., 2001). Therefore, it is necessary to investigate the levels of essential elements in wild mushrooms, because many wild edible mushroom species are known to accumulate high levels of several heavy metals, and mainly cadmium, mercury, copper and lead. Results from over one hundred original papers, dealing with heavy metals in edible mushrooms, show that cadmium, mercury and to a lesser extent lead are the metals of toxicological importance (Kalac and Svoboda, 2000).

In the Middle Black Sea region of Turkey, the climate is mild and rainy. Therefore, the seasons are normally wet with mild temperatures, especially; spring and autumn are suitable for fungal growth. People who live in this region of Turkey (Tokat) widely consume wild edible mushrooms because of their delicacy and abundance.

* Corresponding author. Fax: +90-356-252-1585.
E-mail address: turkoibrahim@yahoo.com (I. Turkekul).

0308-8146/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0308-8146(03)00245-0

Table 1
Operating conditions for mushroom samples in the microwave digestion system[a]

Steps	Time (min)	Power (W)
1	2	250
2	2	0
3	6	250
4	5	400
5	8	550

[a] Vent: 8 min.

Many studies have been carried out on the trace element contents of macrofungus in Turkey (Demirbaş, 2000; Tüzen, Özdemir, & Demirbaş, 1998; Yildiz, Karakaplan, & Aydin, 1998; Sesli and Tüzen, 1999; Sivrikaya, Bacak, Saracbaşi, Toroğlu, & Eroğlu, 2002). However, qualified studies have not been carried out in this area of Turkey.

The aim of this study is to determine Pb, Cd, Mn, Zn, Cu and Fe contents in the fruiting bodies of 10 wild mushroom species collected from Tokat, Turkey.

2. Materials and methods

The mushroom samples were collected from uncontaminated agricultural lands in Tokat, Turkey. The samples were dried at 105 °C for 24 h. Dried samples were homogenized using an agate homogenizer and stored in pre-cleaned polyethylene bottles until analysis.

All reagents were of analytical reagent grade unless otherwise stated. Double deionised water was used for all dilutions. HNO_3 and H_2O_2 were of suprapure quality (Merck).

For the elemental analysis, a Perkin-Elmer Analyst 700 atomic absorption spectrometer with deuterium background corrector was used in this study. Pb and Cd in samples were determined by a HGA graphite furnace using Argon as inert gas. Other measurements were carried out in an air/acetylene flame.

For digestion, Milestone Ethos D microwave closed system was used in this study. Sample (0.25 g)was digested with 6 ml of HNO_3 (65%) and 1 ml of H_2O_2 (30%) in microwave digestion system for 23 min and final diluted to 25 ml with deionised water. A blank digest was carried out in the same way. Digestion conditions are given in Table 1.

3. Results and discussion

The habitat, edibility and the families of mushrooms used in this study are given in Table 2. The results of heavy metal concentrations in the mushroom species are shown in Table 3.

The heavy metal concentration in the mushrooms are mainly affected by acidic and organic matter content of their ecosystem and soil (Gast, Jensen, Bierling, & Haanstra, 1988). 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 (Seeger, 1982).

The highest iron content was 3904 mg/kg in *Fomes fomentarius* whereas the lowest iron content was 568 mg/kg in *Lepista nuda* (Fig. 1). Reported iron contents in mushrooms are much lower than ours except in three recent studies (Işıloğlu, Yılmaz, & Merdivan, 2001; Latiff, Daran, & Mohamed, 1996; Tüzen et al., 1998).

Copper content ranged from 18 to 54 mg/kg in the present study. The highest copper content was seen in *F. fomentarius* and the lowest in *Boletus appendiculatus* (Fig. 2). Copper contents in mushrooms higher than those in vegetables should be considered as a nutritional source of the element. Nevertheless, for people, bioavailability from mushrooms was reported to be low, due

Table 2
Families, habitat and edibility of mushroom species

No	Class, family and species of mushrooms	Habitat	Edibilty
01	*Nectriaceae*		Not edible
	Nectria cinnabarina (Tode.: Fr.) Fr.	On dead wood	
02	*Lycoperdaceae*	In pastures or on heaths, usually on	Edible
	Calvatia utriformis (Bull.: Pers) Jaap.	sandy soil	
03	*Bovista plumbea* Pers.: Per Pers.	Amongst short grass, on lawns	Edible
04	*Lycogola epidendron* Fr.	On trunks of coniferous	Poisonous
05	*Polyporaceae*		Not edible
	Coriolus versicolor (L.: Fr.) Pilat.	On deciduous wood	
06	*Fomes fomentarius* (L.: Fr.) Fr.	On beech	Not edible
07	*Funallia trogii* (Berk.) Bend. et., Sing.	On dead twigs	Not edible
08	*Polyporus frondosus* (Mich.: Fr.)	On trunks of *Salix* spp.	Edible
09	*Boletaceae*		Edible
	Boletus appendiculatus Shaef.: Fr.	With broad-leaved trees	
10	*Tricholomataceae*		Edible
	Lepista nuda (Bull.: Fr.) Cook.	In woodland hedgerows and garden	

Table 3
Concentrations of Fe, Cu, Mn, Zn, Pb, and Cd of the mushroom samples analyzed (mg/kg, dry wt.) (mean±standard deviation), $n=5$

Mushroom samples	Fe	Cu	Mn	Zn	Pb	Cd
Nectria cinnabarina	1420±75	30±3	44±5	105±10	0.8±0.2	0.3±0.04
Calvatia utriformis	924±48	25±4	28±3	58±4	1.5±0.3	1.1±0.1
Bovista plumbea	2340±175	42±3	36±2	42±5	2.3±0.2	0.7±0.1
Lycogola epidendron	3562±282	21±2	41±3	71±6	1.2±0.1	1.4±0.1
Coriolus lersicolor	1905±108	47±3	28±2	39±3	0.9±0.1	0.5±0.07
Fomes fomentarius	3904±307	54±4	64±5	40±4	2.7±2.0	1.8±0.2
Funalli trogii	1665±190	32±4	33±2	25±2	1.6±0.2	1.4±0.1
Polyporus frondosus	2003±345	41±3	28±3	122±11	1.2±0.1	0.7±0.1
Boletus appendiculatus	1040±202	18±2	35±4	63±4	2.2±0.3	1.8±0.2
Lepista nuda	568±46	20±3	16±2	45±3	1.4±0.1	1.1±0.1

to limited absorption from the small intestine (Schellman, Hilz, & Opitz, 1980). Copper levels in mushrooms are in agreement with those reported earlier (Demirbaş, 2000; Işıloğlu et al., 2001; Sesli & Tüzen, 1999; Tüzen et al., 1998).

In this study, the highest manganese content was 64 mg/kg, for the species *Fomes fomentarius*, whereas the lowest manganese content was 16 mg/kg, for the species *Lepista nuda* (Fig. 3). Manganese content is in good agreement with other studies (Demirbaş, 2001; Işıloğlu et al., 2001; Jorhen & Sundström, 1995; Latiff & Daran, 1996; Sesli & Tüzen, 1999). In the previous works, the concentrations of manganese in mushrooms were large. But there are no great differences among the species.

Minimum and maximum values of zinc in the present study were 25 and 122 mg/kg. The highest and lowest levels were found in *Polyporus frondosus* and *Funalli trogii*, respectively (Fig. 4). Zinc is widespread among living organisms due to its biological significance.

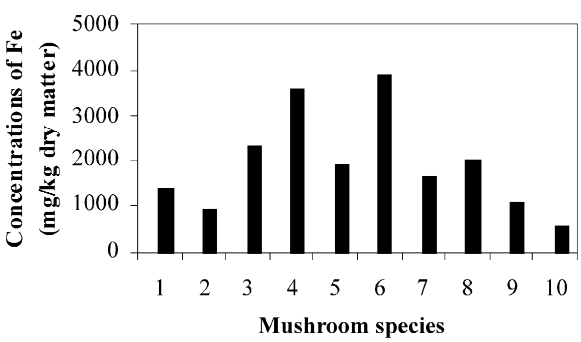

Fig. 1. Distribution of iron in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

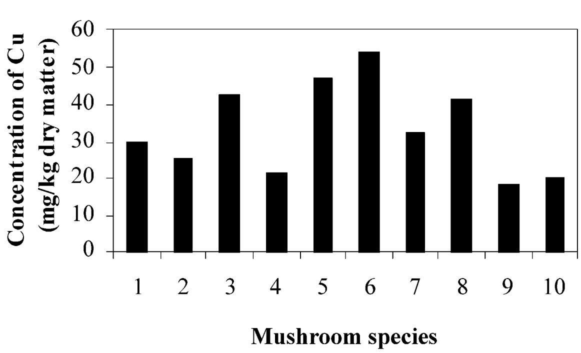

Fig. 2. Distribution of copper in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

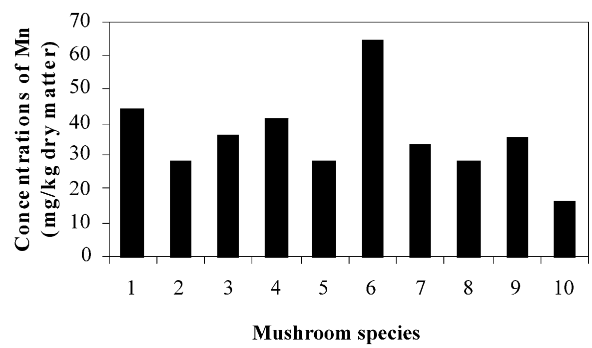

Fig. 3. Distribution of manganese in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

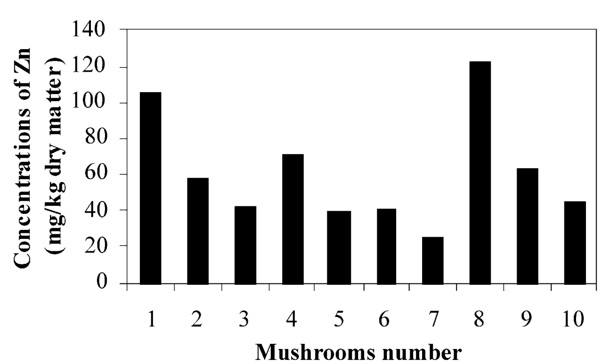

Fig. 4. Distribution of zinc in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

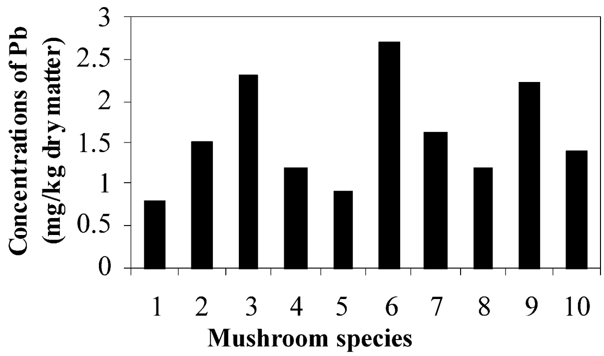

Fig. 5. Distribution of lead in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

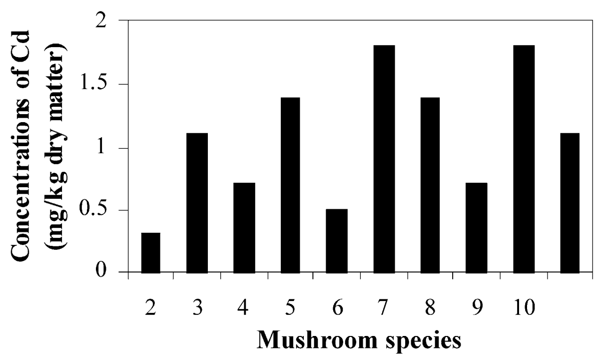

Fig. 6. Distribution of cadmium in mushroom species: 1, *Nectria cinnabarina*; 2, *Calvatia utriformis*; 3, *Bovista plumbea*; 4, *Lycogola epidendron*; 5, *Coriolus ersicolor*; 6, *Fomes fomentarius*; 7, *Funalli trogii*; 8, *Polyporus rondosus*; 9, *Boletus appendiculatus*; 10, *Lepista nuda*.

Content of zinc related in mushrooms ranges from 30 to 150 mg/kg (Kalac & Svoboda, 2000). Hence, zinc content in mushrooms of the present study is in agreement with the previous studies (Anderson, Lykke, Lange, & Bech, 1982; Kalac & Svoboda, 2000).

Lead concentrations in mushrooms of this study ranged from 0.8 to 2.7 mg/kg. The lowest mean levels were found in *Nectria cinnabarina* and the highest in *F. fomentarius* (Fig. 5). In the prior studies, data on lead concentrations in mushrooms are given in *Lycoperdon perlatum, Macrolpiota rhacodes,* and *L. nuda*, which are highly accumulating species. However, lead content in *L. noda* was 1.4 mg/kg in this study.

The lowest cadmium content was 0.3 mg/kg in *N. cinnabarina* and the highest was 1.8 mg/kg in two species of *Boletus appendiculatus* and *F. fomentarius* (Fig. 6). Our data are in agreement with values given in the literature. Cadmium is accumulated mainly in kidneys and liver and its level in blood serum increases considerably following mushroom consumption.

References

Anderson, A., Lykke, S. E., Lange, M., & Bech, K. (1982). Trace elements in edible mushrooms. *Publ, 68, Stat, Levenedmiddelinst, Denmark*. (p. 29).

Bobek, P., Ginter, E., Jurcovicova, M., & Kunia, K. (1991). Cholesterol-lowering effect of the mushroom *Pleurotus ostreatus* in hereditary hipercholesterolemic rats. *Annals of Nutrition and Metabolism*, *35*, 191–195.

Breene, W. M. (1990). Nutritional and medicinal value of specially mushrooms. *Journal of Food Protection*, *53*(10), 883–894.

Crisan, E. V., & Sands, A. (1978). Nutritional value. In S. T. Chang, & W. A. Hayes (Eds.), *The biology and cultivation of edible fungi* (pp. 727–793). New York: Academic Press.

Demirbaş, A. (2000). Accumulation of heavy metals in some edible mushrooms from Turkey. *Food Chemistry*, *68*, 415–419.

Demirbaş, A. (2001). Heavy metal bioaccumulation by mushrooms from artificially fortified soil. *Food Chemistry*, *74*, 293–301.

Diez, V. A., & Alvarez, A. (2001). Compositional and nutritional studies on two wild edible mushrooms from northwest Spain. *Food Chemistry*, *75*, 417–422.

Gast, C. H., Jensen, E., Bierling, J., & Haanstran, L. (1988). Heavy metals in mushrooms and their relationship with soil characterictics. *Chemosphere*, *17*, 789–799.

Işıloğlu, M., Yılmaz, F., & Merdivan, M. (2001). Concentrations of trace elements in wild edible mushrooms. *Food Chemistry*, *73*, 169–175.

Jorhen, L., & Sundström, B. (1995). Levels of some trace elements in edible fungi. *Zeitschrift für Lebensmittel-Untersuchung und -Forschung*, *201*, 311–316.

Kalac, P., & Svoboda, L. (2000). A review of trace element concentrations in edible mushrooms. *Food Chemistry*, *62*, 273–281.

Latiff, L. A., Daran, A. B. M., & Mohamed, A. (1996). *B Food Chemistry*, *56*(2), 115–121.

Lepsova, A., & Mejstrik, V. (1998). *The Science of the Total Environment*, *76*, 117–128.

Manzi, P., Aguzzi, A., Vivanti, V., Paci, M., & Pizzoferrato, L. (1999). Mushrooms as a source of functional ingredients. In *Euro. Food Chem X European conference on: functional foods. A new challange for the food chemist*. (Vol. 1, pp. 86–93), 22–24 September, Budapest, Hungary.

Manzi, P., Aguzzi, A., & Pizzoferrato, L. (2001). Nutritional value of mushrooms widely consumed in Italy. *Food Chemistry*, *73*, 321–325.

Seeger, R. (1982). Toxische schwermetalle in Pilzen. *Deutsche Apotheke Zeitschrift*, *122*, 1835–1844.

Schellmann, B., Hilz, M. J., & Opitz, O. (1980). Cadmium an kopfer ausscheidung nach aufnahme von champignon-mahlzeiten. *Zeitschrift für Lebensmittel-Untersuchung und Forschung*, *171*, 189–192.

Sesli, E., & Tüzen, M. (1999). Levels of trace elements in the fruiting bodies of macro.ingi growing in the East Black Sea region of Turkey. *Food Chemistry*, *65*, 453–460.

Sivrikaya, H., Bacak, L., Saracbaşı, A., Toroğlu, I., & Eroğlu, H. (2002). Trace elements in *Pleurouts Sajor-caju* cultivated on chemithermomechanical pulp for bio-bleaching. *Food Chemistry*, *79*(2), 173–176.

Tüzen, M., Özdemir, M., & Demirbaş, A. (1998). Study of heavy metals in some cultivated and uncultivated mushrooms of Turkish origin. *Food Chemistry*, *63*, 247–251.

Yıldız, A., Karakaplan, M., & Aydın, F. (1998). Studies on *Pleurotus ostreatus* (Jacq.ex Fr.) Kum. Var. *Salignus* (Pers. Ex Fr.) Konr. Et Maubl.: cultivation, proximate composition, organic and mineral composition of carpophores. *Food Chemistry*, *61*, 127–130.