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Trace metal levels in mushroom samples from Ordu, Turkey

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Abstract

The concentrations of Fe, Mn, Zn, Cu, Pb, Cd, Cr, Ni in mushroom species of Turkish origin were determined by atomic absorption spectrometry after microwave digestion. The mushrooms were collected from Ordu, Turkey. The highest Fe level was 628 mg/kg in *Mycena inclinata*. The highest Mn levels was 103 mg/kg in *Coprinus comatus*. Zn level was 162 mg/kg in *Panellus stipticus*. Cu level was 86.2 mg/kg in *M. inclinata*. Pb level was 11.4 mg/kg in *P. stipticus*. Cd level was 1.6 mg/kg in *Panaeolus campanulatus*. Cr level was 4.4 mg/kg in *C. comatus* and Ni level was 21.6 mg/kg in *M. inclinata*.

Keywords: Trace metals; Mushrooms; Ordu-Turkey

1. Introduction

Wild-growing mushrooms have been a popular delicacy in many countries, mainly in central and eastern Europe. For instance, collecting mushrooms has become a national hobby in the Czech Republic. By a survey, 72% of families collect mushrooms with a mean yearly level of 7 kg per household (Kalac & Svoboda, 2000; Sisak, 1996). Mushrooms are valuable health foods, low in calories, high in vegetable proteins, iron, zinc, chitin, fibre, vitamins and minerals. Mushrooms also have a long history of use in traditional Chinese medicine (Demirbaş, 2001; Mendil, Uluözlü, Hasdemir, & Çağlar, 2004). In general, their fruiting bodies, on a dry weight basis, contain about 39.9% carbohydrate, 17.5% protein and 2.9% fats, with the rest constituted of minerals (Demirbaş, 2001; Latiff, Daran, & Mohamed, 1996; Mendil et al., 2004).

According to international data (Işıloğlu, Yılmaz, & Merdivan, 2001; Kalac, Niznamska, Bevilaqua, & Staskova, 1996; Kalac & Svoboda, 2000; Kuusi, Laaksovirta, Liukonen-Lilja, Lodenius, & Piepponen, 1981; Malinowska, Szefer, & Falandaysz, 2004; Svoboda, Zimmermannova, & Kalac, 2000), many species of wild-growing mushrooms possess the ability to take up and accumulate (in their fruiting bodies) several metals, such as cadmium, lead, arsenic, copper, nickel, silver, chromium and mercury (Malinowska et al., 2004; Mejstrik & Lepsova, 1993; Schmitt & Sticher, 1991; Wondratschek & Röder, 1993;). The essential metals can also produce toxic effects when the metal intake is excessively elevated. Recently, both international and Turkish studies have drawn attention to the metal pollution of soil and plant samples (Tüzen, 2003).

The concentrations of four heavy metals in 149 samples of mushroom fruiting bodies, representing 11 species, most edible, have been determined by atomic

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absorption spectroscopy (Sesli & Tüzen, 1999). The reported metal concentrations vary widely and studies of their accumulation rates are very limited (Svoboda et al., 2000).

Turkey has a large edible mushroom potential and is becoming an important exporter of wild mushrooms. However, qualified studies have not been carried out on this subject in Turkey (Demirbaş, 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 (Ordu) widely consume wild edible mushrooms because of their delicacy and abundance.

In this study, the levels of trace metals in mushroom samples collected from Ordu, Turkey were determined by flame and graphite furnace AAS after microwave digestion methods.

2. Materials and methods

Mushroom samples were collected in Ordu, Turkey in 2003 (Fig. 1). Samples of mushrooms, *Omphalotus olearius*, *Panaeolus campanulatus*, *Panellus stipticus* from Akkuş forestries, *Clitocybe houghtonii*, *Agaricus porphyrocephalus* from Fatsa forestries and *Mycena inclinata*, *Coprinus comatus* from Mesudiye forestries, were collected. The collected samples were dried at 105 °C for 24 h. Dried samples were homogenized using an agate homogenizer and stored in polyethylene bottles prior to analysis. All the plastic ware and glassware were cleaned by soaking overnight in a 10% nitric acid solution and then rinsed with deionized water.

One gramme of sample was digested with 6 ml of HNO_3 (Suprapure, Merck), 2 ml of H_2O_2 (Suprapure, Merck) in a microwave digestion system for 31 min and diluted to 10 ml with double-deionized water

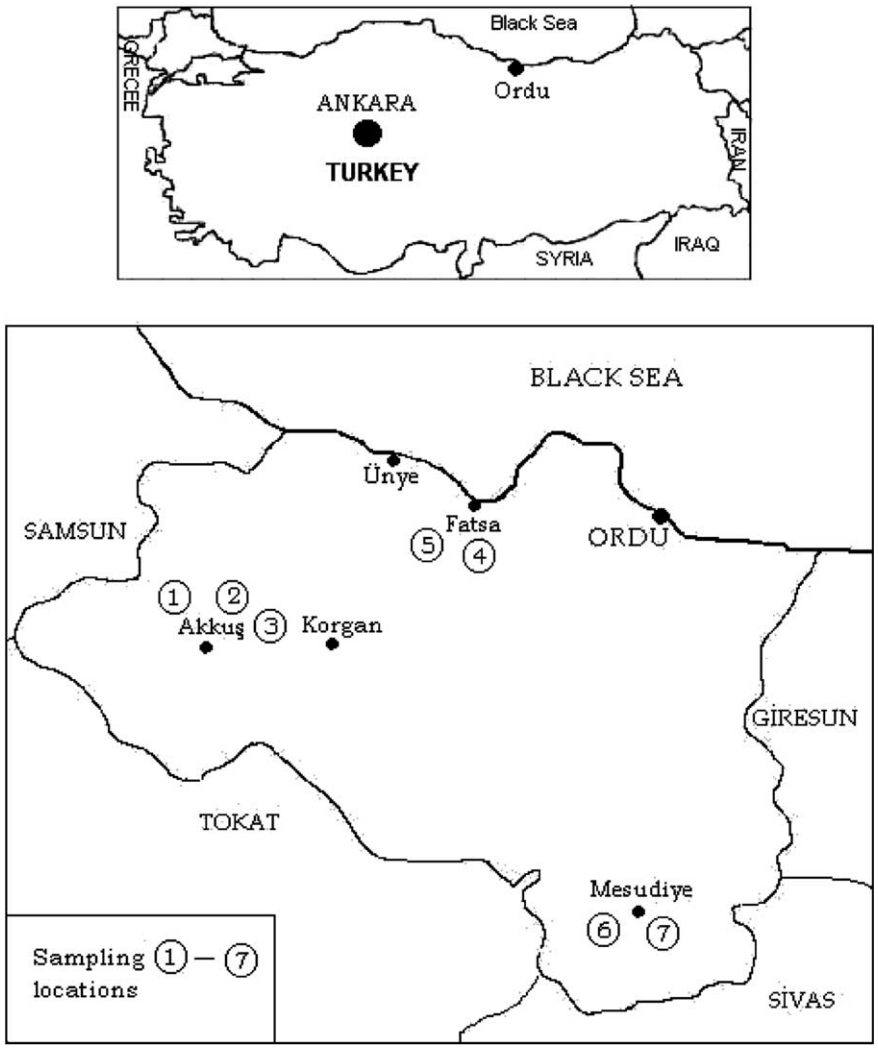

Fig. 1. Location of mushroom species collected in Ordu.

Table 1
Families, habitat and edibility of mushroom species

No	Class, family and species of mushrooms	Habitat	Edibility
1.	*O. olearius* (Dc.ex.Fr.) Sign.	On the roots or certain trees	Not edible
2.	*C. houghtonii* (Bk. & Br.) Dennis	In beech litter	Unknown
3.	*P. Campanulatus* (Fr.) Quel.	In pastureland, or on horse dung	Not edible
4.	*P. stipticus* (Bull.: Fr.) P. Karst	On dead branches or stumps	Not edible
5.	*A. porphyrocephalus* (Moller)	Lawns or pastures	Edible
6.	*M. inclinata* (Fr.) Quel.	In dense tufts on oak stumps	Not edible
7.	*C. comatus* (Müll.: Fr.) Pers.	In grass by roadsides or lawns	Edible

Table 2
Trace metal levels (as mg/kg) in mushroom species

Mushroom Species	Fe	Mn	Zn	Cu	Pb	Cd	Cr	Ni
O. olearius	401 ± 38.4	21.2 ± 1.8	118 ± 10.2	24.1 ± 2.2	5.6 ± 0.6	1.3 ± 0.1	2.4 ± 0.2	11.5 ± 1.1
C. houghtonii	211 ± 20.1	23.7 ± 2.3	62.4 ± 5.8	63.3 ± 5.9	8.1 ± 0.8	0.64 ± 0.05	1.8 ± 0.1	8.2 ± 0.7
P. campanulatus	274 ± 22.3	50.3 ± 4.1	88.1 ± 7.4	42.6 ± 3.6	5.8 ± 0.5	1.6 ± 0.1	3.6 ± 0.3	13.5 ± 1.2
P. stipticus	476 ± 45.6	76.6 ± 5.6	162 ± 14.2	52.1 ± 4.9	11.4 ± 1.0	0.32 ± 0.03	1.1 ± 0.1	20.3 ± 2.0
A. porphyrocephalus	291 ± 20.9	18.1 ± 1.5	74.9 ± 6.8	65.7 ± 6.5	9.7 ± 0.8	1.3 ± 0.1	2.4 ± 0.2	9.3 ± 0.8
M. inclinata	628 ± 57.4	94.5 ± 6.9	103 ± 10.1	86.2 ± 7.7	8.7 ± 0.8	0.96 ± 0.01	3.1 ± 0.3	21.6 ± 2.0
C. comatus	414 ± 39.7	103 ± 9.8	51.5 ± 4.9	31.9 ± 2.3	6.9 ± 0.6	0.28 ± 0.02	4.4 ± 0.4	18.7 ± 2.0

(Milli-Q Millipore, 18.2 MΩ cm resistivity). A blank digest was carried out in the same way (digestion conditions for microwave system were applied as 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min, respectively). This procedure was preferred because it was more accurate with respect to both time and recovery values. The recovery values were nearly quantitative (>95%) for the above digestion method.

The concentrations of elements were determined in an air-acetylene flame by the AAS method (A Perkin–Elmer Aanalyst 700 model atomic absorption spectrometer) using a deuterium background correction. Lead and cadmium levels in the mushroom samples were determined using an HGA graphite furnace, with argon as inert gas.

3. Results and discussion

The habitat, edibility and families of mushroom species are listed in Table 1. Trace metal levels in the analysed samples are shown in Table 2. All trace element concentrations were determined on a dry weight basis. The relative standard deviations were less than 10% for all elements.

The trace metal concentrations in mushrooms are hardly affected by pH or organic matter contents of their ecosystem and soil.

Metal concentrations in mushrooms were 211–628, 18.1–103, 51.5–162, 24.1–86.2, 5.6–11.4, 0.28–1.6, 1.1–4.4 mg/kg and 8.2–21.6 mg/kg for iron, manganese, zinc, copper, lead, cadmium, chromium and nickel, respectively.

Fig. 2. Distribution of Fe Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

The levels of iron in the samples ranged from 211 to 628 mg/kg, and the highest iron levels were obtained in *Mycena inclinate* and *P. stipticus* (Fig. 2). Fe concentration has been reported to be 180–407, 56.1–7162 and 146–835 mg/kg in the literature (Işıloğlu et al., 2001; Mendil et al., 2004; Tüzen, 2003). Minimum and maximum concentrations of manganese were 18.1 and 103 mg/kg. The highest and lowest levels of Mn were found in *C. comatus* and *A. porphyrocephalus* (Fig. 3). Mn contents of mushrooms were lower than our results in other studies (Isıldak, Turkekul, Elmastas, & Tuzen, 2004; Işıloğlu et al., 2001; Tüzen, 2003). The highest Zn

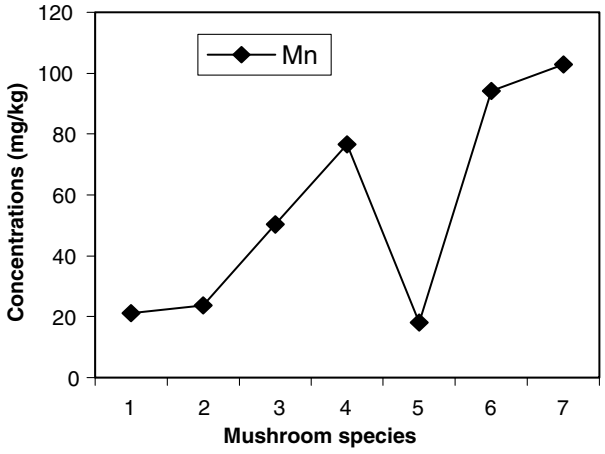

Fig. 3. Distribution of Mn Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

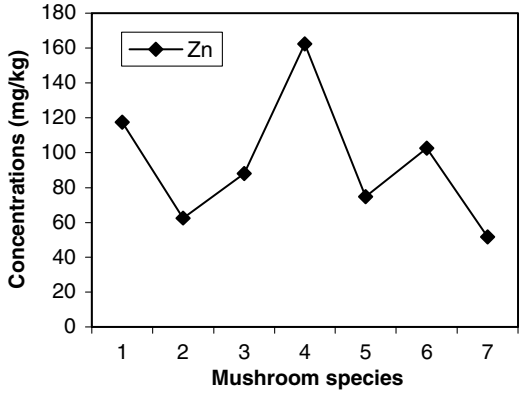

Fig. 4. Distribution of Zn Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

content was 163 mg/kg in *P. stipticus*. However, the Zn levels of other mushrooms were 117.6, 62.4, 88.1, 74.9, 102.7, and 51.5 mg/kg (Fig. 4). Zinc is widespread among living organisms due to its biological significance. Mushrooms are known as zinc accumulators and sporophores: Substrate ratio for Zn changed from 1 to 10 mg/kg (Bano, Nagaraja, Vibhakar, & Kapur, 1981; Işıloğlu et al., 2001). Zinc levels are in agreement with literature values (Işıloğlu et al., 2001; Marzano, Bracchi, & Pizzetti, 2001; Tüzen, 2003). Copper concentrations were between 86.2 and 24.1 mg/kg in the samples (Fig. 5). Copper concentrations have been reported to be 71.1 mg/kg, 96.2 μg/g and 95.9 mg/kg (Demirbaş, 2000; Işıloğlu et al., 2001; Tüzen, 2003). In this study, lead contents in mushrooms were below 12.0 mg/kg. Pb concentrations were high in *P. stipticus* (Fig. 6). Mean Cd was 0.28–1.6 mg/kg in the samples (Fig. 7). These results conform with FAO/WHO (1976) standards for Pb and Cd (toxic

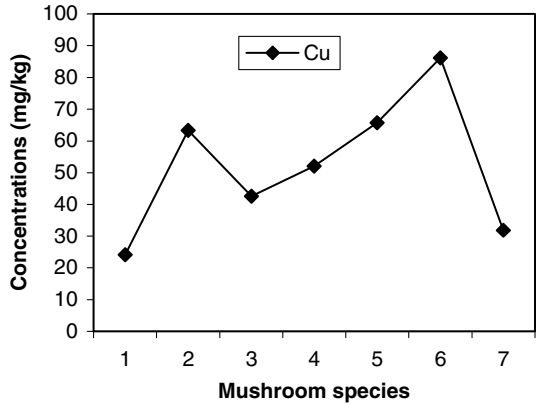

Fig. 5. Distribution of Cu Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

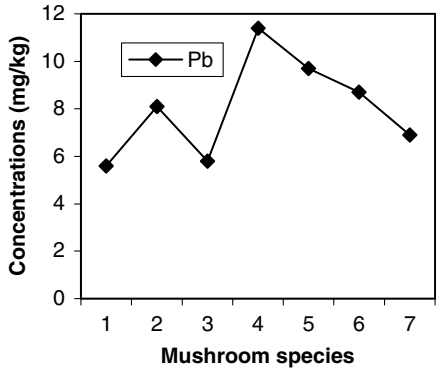

Fig. 6. Distribution of Pb Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

metals). The Pb and Cd concentrations in previous studies were 2.86–6.88 mg/kg and 2.71–7.5 mg/kg, respectively (Işıloğlu et al., 2001; Sesli & Tüzen, 1999; Tüzen, 2003). Minimum and maximum concentrations of chromium were obtained in *P. stipticus* (1.1

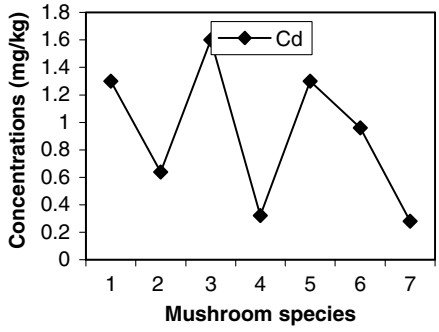

Fig. 7. Distribution of Cd Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

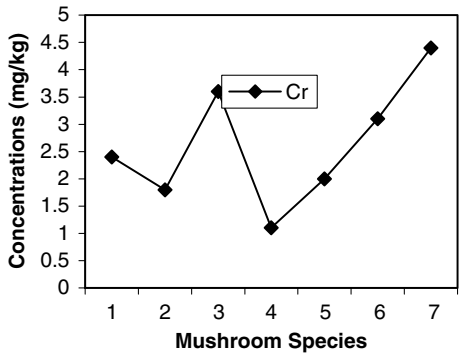

Fig. 8. Distribution of Cr Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) . *C. houghtonii*; (3) *P. campanulatus*; (4) . *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

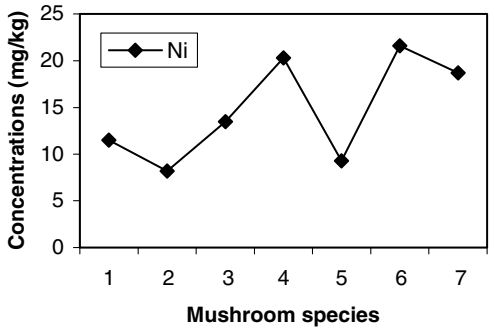

Fig. 9. Distribution of Ni Concentrations (as mg/kg) in mushroom species: (1) *O. olearius*; (2) *C. houghtonii*; (3) *P. campanulatus*; (4) *P. stipticus*; (5) *A. porphyrocephalus*; (6) *M. inclinata*; (7) *C. comatus*.

mg/kg) and *C. comatus* (4.4 mg/kg) (Fig. 8). The highest and lowest nickel levels were found in *M. inclinate* (21.6 mg/kg) and in *C. houghtonii* (8.2 mg/kg) (Fig. 9). Cr values in mushrooms were below reported values (Isıldak et al., 2004; Marzano et al., 2001). Nickel levels in mushrooms are agreement with previous studies (Işıloğlu et al., 2001).

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