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Assessment of heavy metals in some wild edible mushrooms collected from Yunnan Province, China

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Abstract Eight heavy metals (Cu, Zn, Fe, Mn, Cd, Cr, Ni, and Pb) in 14 different wild-growing edible mushroom species (*Coprinus comatus, Voluariella volvacea, Pleurotus nebrodensis, Hypsizigus marmoreus, Hericium erinaceus, Agrocybe aegerita, Lenfinus edodes, Collybia velutipes, Agaricus bisporus, Russula albida, Clitocybe conglobata, Pleurotus eryngii, Lepista sordida,* and *Pleurotus ostreatus*) collected from Yunnan province, China, were determined by inductively coupled plasma-atomic emission spectrometry after microwave digestion. All element concentrations were determined on a dry weight basis. The ranges of element concentrations for copper, zinc, iron, manganese, cadmium, chromium, nickel, and lead were 6.8–31.9, 42.9–94.3, 67.5–843, 13.5–113, 0.06–0.58, 10.7–42.7, 0.76–5.1, and 0.67–12.9 mg/kg, respectively. In general, iron content was higher than other metals in all mushroom species. The levels of zinc, cadmium, and lead in some edible mushroom samples were found to be higher than legal limits. The relative standard deviations were found below 10%. The accuracy of procedure was confirmed by certified reference material.

Keywords Wild edible mushrooms · Heavy metals · Microwave digestion · China

Introduction

The consumption of wild edible mushrooms is increasing, even in the developed world, due to a good content of proteins as well as a higher content of trace minerals (Agrahar-Murugkar and Subbulakshmi 2005). Wild mushrooms are considered as a popular and favorite delicacy in many countries, mainly in Europe and Asia. Wild mushrooms have a long history of use in traditional Chinese medicine. 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 et al. 2001).

Lead, cadmium, iron, copper, manganese, zinc, cobalt, chromium, nickel, magnesium, aluminum, tin, and arsenic were chosen as representative trace metals whose levels in the environment represent a reliable index of environmental pollution. Metals such as iron, copper, zinc, and manganese

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are essential metals since they play an important role in biological systems, whereas aluminum and lead are non-essential metals as they are toxic even in traces (Unak et al. 2007). The essential metals can also produce toxic effects when the metal intake is excessively elevated (Al-Khlaifat and Al-Khashman 2007; Gopalani et al. 2007).

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. Many wild edible Mushroom species have been known to accumulate great concentrations of heavy metals such as lead, cadmium, iron, copper, manganese, zinc, chromium, nickel, aluminum, and mercury (Kalač et al. 1991; Demirbaş 2000, 2001a; Svoboda et al. 2000; Kalač and Svoboda 2001; Falandysz et al. 2003; Dursun et al. 2006; Cocchia et al. 2006; Chen et al. 2009). The accumulation of heavy metals in macrofungi has been found to be affected by environmental and fungal factors. Environmental factors, such as organic matter amount, pH, and metal concentrations in soil, and fungal factors, such as species of mushroom, morphological part of fruiting body, development stages, age of mycelium, and biochemical composition, affect metal accumulation in macrofungi (Garcia et al. 1998; Kalač and Svoboda 2001).

China has a high production of wild mushrooms for commercialization and consumption. In the province of Yunnan, the climate is mild and rainy in summer and autumn, the climate providing ideal conditions for fungal growth. People who live in this region of China widely consume wild edible mushrooms because of their delicacy and abundance.

Since heavy metals may enter the food chain as a result of their uptake by edible mushrooms, it is necessary to assess the levels of heavy metal and to report possible contamination that would represent a health hazard. However, there has been no report, to our knowledge, on the heavy metal levels in wild mushroom samples in Yunnan province. In the light of above, the contents of eight heavy metals (Cu, Zn, Fe, Mn, Cd, Cr, Ni, and Pb) in 14 different wild-growing edible mushroom species collected from Yunnan province were determined by inductively coupled plasma-atomic emission spectrometry after microwave digestion.

Materials and methods

Samples

The mushroom samples were collected from Yunnan Province during 2008. The habitat, edibility, and the families of mushrooms used in this study are given in Table 1. The collected samples were washed with deionized water and dried at 105°C for 24 h. Dried samples were homogenized using an agate homogenizer and stored in pre-cleaned polyethylene bottles until the analysis started.

Table 1 Families, habitat, and edibility of mushroom species

Sample number	Class, family, and species of mushrooms	Habitat	Edibility
1	*Coprinus comatus* (Mull.: Fr.) Gray	In forests	Edible
2	*Voluariella volvacea* (Bull.ex Fr.)Sing.	In forests	Edible
3	*Pleurotus nebrodensis* (Inzengae) Quel	In forests	Edible
4	*Hypsizigus marmoreus* (PK.) Bigelw	In forests	Edible
5	*Hericium erinaceus* (Bull.)Pers.	In mixed woods	Edible
6	*Agrocybe aegerita* (Brig.) Sing.	On trees	Edible
7	*Lenfinus edodes* (Berk.)Sing.	On dead wood	Edible
8	*Collybia velutipes* (Fr.)Quel.	On dead wood	Edible
9	*Agaricus bisporus* (Lange)Sing.	In forests	Edible
10	*Russula albida* Peck.	In forests	Edible
11	*Clitocybe conglobata* Bres.	On soil in forests	Edible
12	*Pleurotus eryngii* (DC.ex.Fr.) Quel.	On dead wood	Edible
13	*Lepista sordida* (Schum.:Fr.)Sing.	On trees	Edible
14	*Pleurotus ostreatus* (Jacq. ex Fr.)Kummer	In mixed woods	Edible

Reagents

All reagents were of analytical reagent grade, 69–72% HNO_3, 30% H_2O_2, and 70% $HClO_4$ were used for digestion of samples. Double deionized water was used for all dilutions. During the experiments, all glasswares and equipment were carefully cleaned starting with 2% HNO_3 and ending with repeated rinsing distilled deionized water to prevent contamination. All standard solutions used (0.1, 1, 10, or 100 μg/ml) were prepared by diluting 1 mg/ml stock multi-element standard solutions.

Apparatus

For the elemental analysis, A ICP-AES (Optima 2100 DV, PE, USA) was used in this study. For digestion, a high-performance microwave system (XT-9912, Corp. Xintuo, China) equipped with advanced composite PTFE vessels was used.

Digestion procedure

Samples (0.3 g) were digested with 5 ml of HNO_3 (65%), 1 ml of H_2O_2 (30%), and 1 ml of $HClO_4$ (70%) in microwave digestion system for 32 min and finally diluted to 25 ml with 2% nitric acid. All sample solutions were clear. A blank digest was carried out in the same way. Digestion conditions for microwave system were applied as 3 min for 500 W, 4 min for 800 W, 5 min for 1,000 W, 5 min for 1,300 W, 8 min for 550 W, vent 8 min.

Statistical analysis

The whole data were subjected to a statistical analysis, and correlation matrices were produced to examine the interrelationships between the investigated trace element concentrations of the samples. Student's *t* test was employed to estimate the significance of values.

Results and discussion

The recovery values were nearly quantitative (≥95%) for microwave digestion method. The relative standard deviations were less than 10% for all investigated elements. *t* test was used to determine significant differences between mean values ($p < 0.05$). In order to validate the method for accuracy and precision, certified reference material (CRM), namely poplar leaves (GBW07605), was analyzed for corresponding elements. The CRM was approved by State Bureau of Technical Supervision, Langfang, China. A control sample was digested and analyzed with each analytical batch of samples to check the effectiveness of our digestion procedure. As shown in Table 2, the result of the analysis of the CRM showed good agreement with the certified levels.

The mean and comparison of heavy metal concentrations for the analyzed mushroom species were summarized in Table 3 and Fig. 1. The contents of copper, zinc, iron, manganese, cadmium, chromium, nickel, and lead in mushroom species were found to be 6.8–31.9, 43.5–205, 67.5–843, 13.5–113, 0.06–0.58, 10.7–42.7, 0.76–5.1, and 0.67–12.9 mg/kg, respectively. The order of the levels of heavy metals in the mushroom samples was found to be as Fe > Zn > Mn > Cu > Cr > Pb > Ni > Cd.

The FAO/WHO has set a limit for heavy metals intakes based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intake for copper, zinc, iron, and lead are 3 mg, 60 mg, 48 mg, and 214 μg/g, respectively (FAO/WHO 1999).

Copper is the third-most abundant trace element in human body, with vitamin-like impact on living systems. Small amount of copper is found in the human body (50–120 mg), but it plays a critical role in a variety of biochemical processes (Yaman and Akdeniz 2004). Copper forms part of at least 13 different enzymes, and its presence is

Table 2 Observed and certified values of trace metals in GBW07605 Poplar leaves, $n = 3$

Element	Certified value (μg/g)	Microwave (μg/g)	Recovery (%)
Cu	17.3 ± 1.0	16.8 ± 0.8	97
Zn	26.3 ± 0.9	26.8 ± 0.5	102
Fe	264 ± 10	262 ± 9	99
Mn	1240 ± 40	1265 ± 55	102
Cd	0.057 ± 0.008	0.055 ± 0.005	96
Cr	0.80 ± 0.02	0.78 ± 0.03	98
Ni	4.60 ± 0.50	4.45 ± 0.24	97
Pb	4.40 ± 0.30	4.32 ± 0.22	98

Table 3 Concentrations of Cu, Zn, Fe, Mn, Cd, Cr, Ni, and Pb of the mushroom samples analyzed (mg/kg, dry weight), $n = 3$

Sample number	Cu	Zn	Fe	Mn	Cd	Cr	Ni	Pb
1	31.9 ± 2.4	52.1 ± 4.2	94.0 ± 6.8	35.2 ± 2.6	0.58 ± 0.03	10.7 ± 0.8	1.12 ± 0.07	1.61 ± 0.09
2	25.9 ± 2.2	66.2 ± 4.8	86.0 ± 6.5	14.2 ± 1.1	0.27 ± 0.02	21.4 ± 1.6	1.93 ± 0.12	1.70 ± 0.10
3	8.23 ± 0.71	62.7 ± 4.6	138 ± 8.0	38.5 ± 2.8	0.24 ± 0.01	21.5 ± 1.6	0.76 ± 0.04	2.49 ± 0.15
4	7.81 ± 0.62	75.3 ± 5.8	94.2 ± 6.8	75.7 ± 5.2	0.11 ± 0.00	14.9 ± 1.1	1.69 ± 0.10	2.62 ± 0.17
5	8.75 ± 0.74	47.4 ± 4.1	182 ± 12	15.2 ± 1.2	0.29 ± 0.01	22.6 ± 1.8	2.62 ± 0.15	3.04 ± 0.19
6	17.9 ± 1.5	67.3 ± 4.8	140 ± 9	20.4 ± 1.3	0.11 ± 0.00	25.3 ± 2.0	2.08 ± 0.12	4.43 ± 0.21
7	7.47 ± 0.55	61.3 ± 4.5	67.5 ± 5.4	39.6 ± 2.8	0.21 ± 0.01	17.4 ± 1.5	1.82 ± 0.11	0.92 ± 0.05
8	9.62 ± 0.76	42.9 ± 3.6	142 ± 9	31.3 ± 2.4	0.07 ± 0.00	15.7 ± 1.2	1.24 ± 0.08	0.99 ± 0.06
9	14.8 ± 1.1	81.4 ± 6.4	190 ± 13	28.8 ± 2.1	0.35 ± 0.02	22.6 ± 1.8	0.92 ± 0.06	2.21 ± 0.13
10	10.9 ± 0.9	94.3 ± 7.1	168 ± 11	113 ± 8	0.12 ± 0.00	42.7 ± 3.5	5.08 ± 0.28	3.28 ± 0.20
11	7.10 ± 0.51	56.2 ± 4.6	153 ± 10	64.9 ± 4.4	0.14 ± 0.01	19.1 ± 1.5	0.86 ± 0.05	2.42 ± 0.14
12	6.83 ± 0.52	57.9 ± 4.6	242 ± 16	13.5 ± 0.9	0.06 ± 0.00	22.3 ± 1.8	0.83 ± 0.05	12.9 ± 1.0
13	7.44 ± 0.53	68.8 ± 4.8	843 ± 43	68.2 ± 4.5	0.18 ± 0.01	31.8 ± 2.5	4.21 ± 0.23	3.08 ± 0.19
14	26.7 ± 2.1	48.4 ± 3.8	95.7 ± 7.2	31.4 ± 2.4	0.28 ± 0.01	16.3 ± 1.3	1.50 ± 0.09	0.67 ± 0.05

needed for each if they are to function properly. It is known that copper may be toxic to both humans and animals when its concentration exceeds the safe limits (Gast et al. 1988). The copper content of the samples ranged from 6.83 to 31.9 mg/g, *Pleurotus eryngii* had the lowest copper concentration whereas *Coprinus comatus* had the highest. The average copper content of the samples was 13.7 mg/kg. Copper concentrations, accumulated in mushroom species, are usually 100–300 mg/kg, which is not considered a health risk (Soylak et al. 2005). These levels are below the WHO permissible limits in foods, which is 40 mg/kg (Bahemuka and Mubofu 1999). Copper contents of mushroom samples in the literature have been reported to be in the ranges: 4.71–51.0 mg/kg (Tüzen et al. 1998), 10.3–145 mg/kg (Sesli and Tüzen 1999), 12–181 mg/kg (Tüzen et al. 2003), 12–181 mg/kg (Tüzen 2003), 13.4–50.6 mg/kg (Soylak et al. 2005), 10.6–144.2 mg/kg (Yamaç et al. 2007), and 15–73 mg/kg (Sesli et al. 2008), respectively. Our copper levels were found to be lower than those reported in the literature.

Zinc is an integral component of a wide variety of different enzymes in which it plays catalytic, structural, and regulatory roles. Zinc deficiency which can result from inadequate dietary intake, impaired absorption, excessive excretion or inherited defects in zinc metabolism. The deficiency of zinc particularly in children can lead to loss of appetite, growth retardation, weakness, low spirited, stagnation in sexual growth. Mushrooms are known as zinc accumulators and the sporophore: substrate ratio for Zn ranges from 1 to 10 mg/kg (Isıloğlu et al. 2001). Minimum and maximum values of zinc in our samples were 42.9 and 94.3 mg/kg in *Collybia velutipes* and *Agaricus bisporus.* The mean zinc content of the samples was 63.0 mg/kg. The WHO permissible limit of zinc in foods is 60 mg/kg (WHO 1982). The values for zinc in some investigated mushroom samples were above the WHO's values. Zinc concentrations of mushroom samples in the literature have been reported to be in the ranges: 29.3–158 mg/kg (Isıloğlu et al. 2001), 33.5–89.5 mg/kg (Tüzen 2003), 40.3–64.4 mg/kg (Mendil et al. 2004), 45.2–173.8 mg/kg (Soylak et al. 2005), and 43.5–205 mg/kg (Sesli et al. 2008), respectively. Our zinc values are in agreement with literature values.

Iron was found to be the dominant elemental ion as compared with other heavy metals in mushrooms followed by zinc and manganese ions. Iron is vital for almost all living organisms, participating in a wide variety of metabolic processes, including oxygen transport, DNA synthesis, and electron transport. It is known that adequate iron in a diet is very important for decreasing the incidence of anemia. Iron deficiency occurs when the demand for iron is high, e.g., in growth, high menstrual loss, and pregnancy, and the intake is quantitatively inadequate or contains elements that render the iron unavailable for absorption (Lynch and Baynes 1996). High concentrations

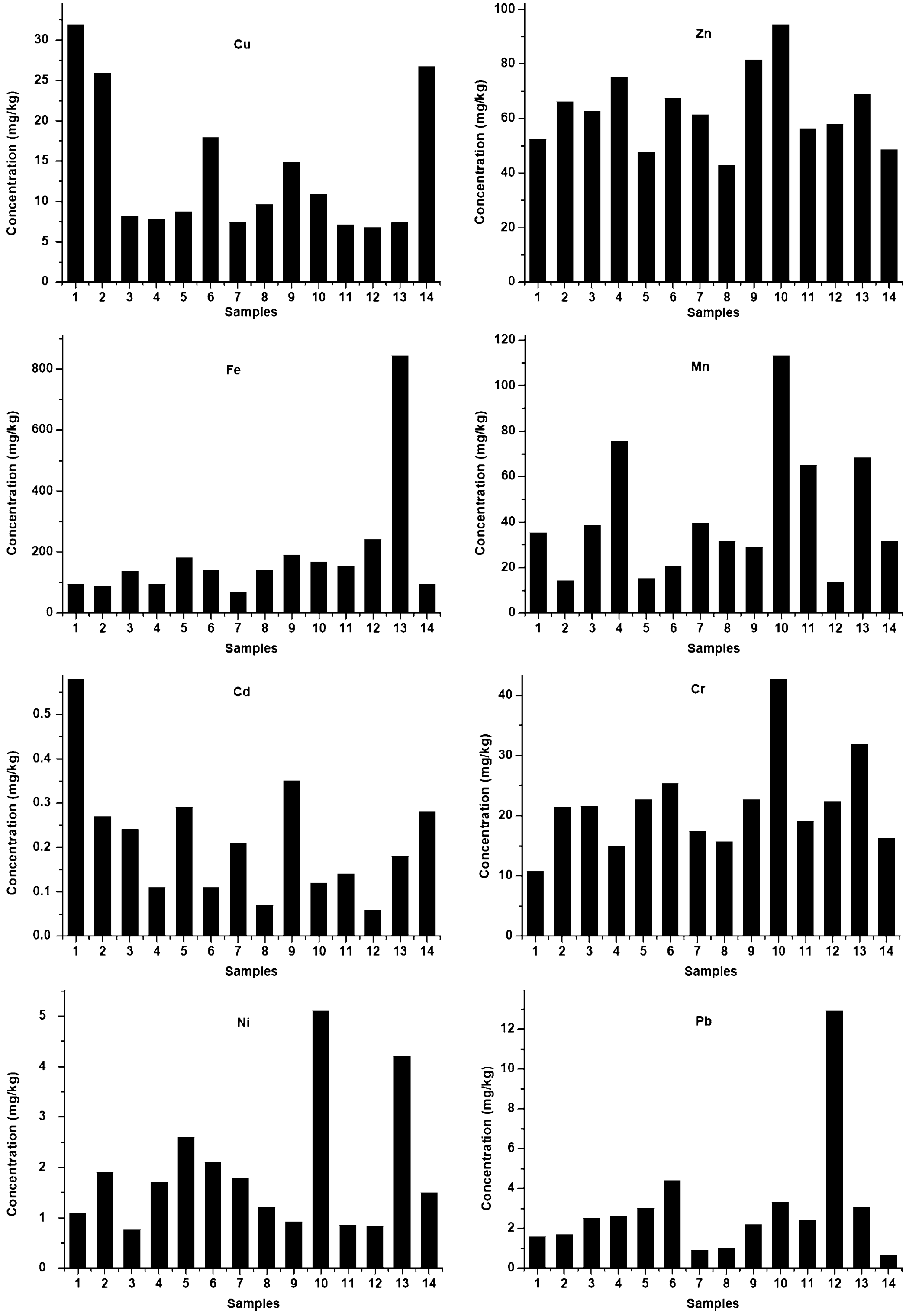

Fig. 1 Levels of analyte ions in analyzed samples: *1 C. comatus*; *2 V. volvacea*; *3 P. nebrodensis*; *4 H. marmoreus*; *5 H. erinaceus*; *6 A. aegerita*; *7 L. edodes*; *8 C. velutipes*; *9 A. bisporus*; *10 R. albida*; *11 C. conglobata*; *12 P. eryngii*; *13 L. sordida*; *14 P. ostreatus*

of iron may lead to tissue damage, as a result of the formation of free radicals. The highest iron content in our mushroom samples was 843 mg/kg in *Lepista sordida*, whereas the lowest iron content was 67.5 mg/kg in *Lenfinus edodes*, most samples having concentrations between 90 and 200 mg/kg. The average concentration of iron was 188.2 mg/kg. The maximum iron level permitted for food is 15 mg/kg according to Turkish Food Codex Anonymous Regulation (2002). Iron levels in all analyzed mushroom samples were found to be higher than legal limits. The reported iron values for mushroom samples were 31.3–1,190 mg/kg (Sesli and Tüzen 1999), 30–150 mg/kg (Kalač and Svoboda 2001), 180–407 mg/kg (Isıloğlu et al. 2001), 146–835 mg/kg (Tüzen 2003), 56.1–7,162 mg/kg (Mendil et al. 2004), 568–3,904 mg/kg (Türkekul et al. 2004), 102–1,580 mg/kg (Soylak et al. 2005), 211–628 mg/kg (Mendil et al. 2005), 110–11,460 mg/kg (Yamaç et al. 2007), and 150–1,741 mg/kg (Sesli et al. 2008), respectively. Our iron values are similar to those of previous studies.

Manganese is one of the vitally important elements. Manganese is present in metalloproteins, such as pyruvate carboxylase, and in the cytoplasmic glial enzyme, glutamine synthetase. The deficiency of manganese can produce severe skeletal and reproductive abnormalities in mammals. High doses of manganese produce adverse effects primarily on the lungs and on the brain. Manganese contents of mushroom samples were found in 13.5–113 mg/kg. The lowest and highest manganese values were observed in *P. eryngii* and *Russula albida*, most samples having concentrations between 20 and 70 mg/kg. The average manganese content of the samples was 42.1 mg/kg. Toxicity limits of manganese for plants are high (400–1,000 mg/kg). Our values are under toxicity limits. Manganese concentrations of mushroom samples, in the literature, have been reported in the ranges of 7.6–56.2 mg/kg (Demirbaş 2001b), 14.5–63.6 mg/kg (Isıloğlu et al. 2001), 5.0–60.0 mg/kg (Kalač and Svoboda 2001), 12.9–93.3 mg/kg (Tüzen 2003), 7.1–81.3 mg/kg (Isildak et al. 2004), 21.7–74.3 mg/kg (Mendil et al. 2004), 14.2–69.7 mg/kg (Soylak et al. 2005), respectively. Our values for these species are in agreement with those reported earlier.

Trivalent chromium is a trace metal necessary for the normal metabolism of cholesterol, fat, and glucose. Chromium deficiencies in the diet produce elevated circulating insulin concentrations, hyperglycemia, elevated body fat, decreased sperm counts, reduced fertility, and shortened life span. In this study, the lowest chromium content was 10.7 mg/kg, for the species *C. comatus*, whereas the highest manganese content was 42.7 mg/kg, for the species *R. albida*, most samples having concentrations between 20 and 70 mg/kg. The mean manganese content of the samples was 21.7 mg/kg. These values were well below the FDA recommended daily intake of chromium for foods and feeds, which is 120 mg/kg (Haider et al. 2004). Chromium values in mushroom samples have been reported to be in the ranges: 7.0–11.0 mg/kg (Sivrikaya et al. 2002), 0.87–2.66 mg/kg (Tüzen 2003), 0.16–4.86 mg/kg (Malinowska et al. 2004), 1.2–4.2 mg/kg (Mendil et al. 2004), 0.34–1.10 mg/kg (Soylak et al. 2005), and 1.95–73.8 mg/kg (Yamaç et al. 2007), respectively. Our chromium contents were found to be higher than those reported earlier.

Cadmium is a highly toxic metal with a natural occurrence in soil, but it is also spread in the environment due to human activities. Cadmium is known as a principal toxic metal, since excessive cadmium exposure may give rise to renal, pulmonary, hepatic, skeletal, reproductive effects, and cancer. It was reported that cadmium is accumulated mainly in kidneys, spleen, and liver, and its blood serum level increases considerably following mushroom consumption (Kalač and Svoboda 2001). Thus, cadmium seems to be the most deleterious among heavy metals in mushrooms. The WHO mentions maximum permissible levels in raw plant materials for cadmium and lead which amount to 0.30 and 10.0 mg/kg, respectively. The cadmium content ranged from 0.06 mg/kg in *P. eryngii* to 0.58 mg/kg in *C. comatus*. The average cadmium content of the samples was 0.208 mg/kg. The levels of cadmium in *C. comatus* and *A. bisporus* were higher than the WHO permissible limit. Cadmium contents of mushroom samples in the literature have been reported to be in the ranges: 0.81–7.50 mg/kg (Svoboda et al. 2000), 0.10–0.71 mg/kg (Mendil

Table 4 Correlations between heavy metal concentrations of mushroom samples

	Cu	Zn	Fe	Mn	Cd	Cr	Ni	Pb
Cu	1							
Zn	−0.033	1						
Fe	−0.290	0.116	1					
Mn	−0.349	0.616	0.226	1				
Cd	0.463	−0.100	−0.072	−0.314	1			
Cr	−0.097	0.664	0.442	0.546	−0.117	1		
Ni	−0.054	0.505	0.487	0.618	−0.043	0.836	1	
Pb	−0.297	0.042	0.172	−0.196	−0.495	0.192	−0.093	1

et al. 2004), 0.12–2.60 mg/kg (Malinowska et al. 2004), 0.28–1.6 mg/kg (Mendil et al. 2005), and 0.26–3.24 mg/kg (Yamaç et al. 2007), respectively. Our cadmium levels are in agreement with those reported in the literature.

Trace amounts of nickel may be beneficial as an activator of some enzyme systems, but its toxicity at higher levels is more prominent. It accumulates in the lungs and may cause bronchial hemorrhage or collapse (Demirbaş 2001b). Maximum nickel level was 5.08 mg/kg in *R. albida* and minimum nickel level was 0.76 mg/kg in *Pleurotus nebrodensis*. The average nickel content of the samples was 1.90 mg/kg. The WHO recommended daily intake of nickel was between 100 and 300 mg/kg (WHO 1994). Nickel values have been reported in the ranges: 2.73–19.4 mg/kg (Isıloğlu et al. 2001), 1.18–5.14 mg/kg (Tüzen 2003), 8.2–21.6 mg/kg (Mendil et al. 2004), 0.4–15.9 mg/kg (Isildak et al. 2004), and 1.22–58.60 mg/kg (Yamaç et al. 2007), respectively. Our nickel values are in agreement with those reported in the literature.

Lead is similar to Cd that has no beneficial role in human metabolism, producing progressive toxicity. Lead can reach humans through air, water, and food. Lead accumulates in bones, and it can take in place of calcium. Lead creates health disorders such as sleeplessness, tiredness, hearing, and weight loss. The lead level ranged from 0.67 to 12.9 mg/kg for *Pleurotus ostreatus* and *P. eryngii*. The average lead content of the samples was 3.03 mg/kg. These values were below the WHO permissible limit except *P. eryngii* (12.9 mg/kg). Lead contents of mushroom samples in the literature have been reported to be in the ranges: 0.75–7.77 mg/kg (Tüzen et al. 1998), 0.40–2.80 mg/kg (Svoboda et al. 2000), 1.43–4.17 mg/kg (Tüzen 2003), 0.800–2.700 mg/kg (Türkekul et al. 2004), 0.82–1.99 mg/kg (Soylak et al. 2005), and 0.9–2.6 mg/kg (Sesli et al. 2008), respectively. The lead results of all mushroom species were in agreement with those found in the literature.

Statistically significant correlation coefficients ($r > \pm 0.532$ at 0.05 probability level) were established between metal concentrations. The values of correlation coefficients between metal concentrations are given in Table 4. There are good correlations between chromium and nickel ($r = 0.836$), chromium and manganese ($r = 0.546$), chromium and zinc ($r = 0.664$), nickel and manganese ($r = 0.618$), and manganese and zinc ($r = 0.616$). The other correlations between metals were not significant. There are positive correlations of zinc and iron, zinc and lead, iron and manganese, iron and chromium, iron and nickel, iron and lead, cadmium and copper, chromium and iron, lead and zinc, and chromium and lead. Negative correlations were found between copper and zinc, copper and iron, copper and manganese, copper and chromium, copper and nickel, copper and lead, zinc and cadmium, iron and cadmium, manganese and cadmium, chromium and cadmium, nickel and cadmium, lead and cadmium, lead and manganese, and lead and nickel.

Conclusion

Eight heavy metals (Cu, Zn, Fe, Mn, Cd, Cr, Ni, and Pb) in 14 wild-growing edible mushroom species collected from Yunnan province, China, were determined by inductively coupled plasma-atomic emission spectrometry after microwave digestion. In the present study, the detected levels of zinc, iron, manganese, cadmium, nickel, and lead were generally in agreement with previously reported. But the chromium contents were higher than those reported earlier and the copper levels were lower than literature values. The trace metal contents in the mushrooms are mainly affected by acidic and organic matter content of their ecosystem and soil (Gast et al. 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 (Chojnacka and Falandysz 2007; Kowalewska et al. 2007; Shin et al. 2007). In general, the levels of zinc, cadmium, and lead in some mushroom samples were found to be higher than legal limits. The heavy metal levels of wild edible mushrooms should be analyzed more often in this region in order to evaluate the possible danger to human health from them.

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