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Concentrations of Trace Elements in Fruiting Bodies of Wild Growing Fungi in Rize Province of Turkey

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Fruiting bodies of *Fomitopsis pinicola, Ganoderma applanatum, Gloeophyllum odoratum, Hypholoma fasciculare, Paxillus atrotomentosus, Inonotus dryadeus, Phellinus igniarius, Hydnellum peckii, Phellodon tomentosus, Sarcodon imbricatus, Hydnum repandum, Clavulina rugosa, Laetiporus sulphureus, Polyporus badius, Trametes versicolor, Ramaria botrytis, R. flava, R. formosa, Tulostoma brumale, Scleroderma areolatum, Clavariadelphus truncatus, Geastrum fimbriatum, Phallus impudicus, Lactarius deliciosus, L. flavidus, L. piperatus, L. rufus, L. vellereus* var. *vellereus, L. volemus* and *Russula delica* were collected from Oriental Spruce stands of Rize province in Turkey. Concentrations of trace element contents in fruiting bodies of wild growing fungi were determined by atomic absorption spectrometry after microwave digestion. The results were (mg/kg) 61.1–190 zinc, 10.5–81 manganese, 140–1400 iron, 10.1–180 copper, 1.0–7.5 cadmium and 1.1–95.6 nickel.

Key Words: Macro and micro elements, Fungi, Rize.

INTRODUCTION

Although not common in all cultures, the gathering of fungi for eating is an ancient practice and today several species are widely cultivated, while huge quantities of morels, chanterelles, and boletes are collected and sold worldwide[1].

On the other hand, fruiting bodies of many wild growing edible fungi contain trace elements such as silver, aluminium, cadmium, lead, copper, iron, manganese, zinc, sodium, potassium, calcium or magnesium[2–18].

Wild mushrooms are a popular food source among the people living in Rize province of Turkey. The region is a high rainfall area and covered with oriental spruce forests. The high humidity level during autumn provides ideal atmospheric conditions for fungal growth. There are many wild mushrooms that grow in the forests of Rize province of Turkey and are collected by local people to eat[19]. In spite of the immense popularity of this perfect food in the region, there is no data regarding the levels of trace elements of fungi species collected from Rize province of Turkey. The present study is the first, which determines the levels of trace elements of fungi growing in Rize province of Turkey.

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EXPERIMENTAL

The specimens of macrofungi were collected during field studies in the Province of Rize in Turkey (Fig. 1). The colour, odour and other apparent properties of macrofungi were noted at the field. Fungal specimens were examined in the laboratory after collection. All the spore measurements were calculated from at least 20 individual measurements using Nikon microscopes[20]. The fungi (Table-1) were identified according to Breitenbach and Kränzlin's method[21]. Specimens were deposited at the fungarium of Faculty of Fatih Education at Karadeniz Technical University, Trabzon, Turkey.

Fig. 1. Location of the sampling area

TABLE-1
SAMPLE NUMBER, FUNGARIUM NUMBER, BOTANICAL NAME, HABITAT, EDIBILITY AND FAMILY OF THE FUNGI

S.No.	F.No	Botanical name	Habitat	Edibility	Family
1.	SES 2093	*Fomitopsis pinicola* (Sw.) P. Karst.	On dead *Picea orientalis*	Inedible	Fomitopsidaceae
2.	SES 2086	*Ganoderma applanatum* (Pers.) Pat.	On dead *Fagus orientalis*	Inedible	Ganodermataceae
3.	SES 2207	*Gloeophyllum odoratum* (Wu.) Im.	On dead *Picea orientalis*	Inedible	Gloeophyllaceae
4.	SES 2108	*Hypholoma fasciculare* (Huds.) Quel.	On dead *Picea orientalis*	Inedible	Strophariaceae
5.	SES 2120	*Paxillus atrotomentosus* (Batsch) Fr.	Under *Picea orientalis*	Inedible	Paxillaceae

S.No.	F.No	Botanical name	Habitat	Edibility	Family
6.	SES 2018	*Inonotus dryadeus* (Pers.) Murrill	On *Quercus sp.*	Inedible	Hymenochaetaceae
7.	SES 2044	*Phellinus igniarius* (L.) Quel.	On *Alnus glutinosus*	Inedible	Hymenochaetaceae
8.	SES 2318	*Hydnellum peckii* Banker	On soil among mosses	Inedible	Bankeraceae
9.	SES 2070	*Phellodon tomentosus* (L.) Banker	On soil	Inedible	Bankeraceae
10.	SES 2316	*Sarcodon imbricatus* (L.) P. Karst.	On soil	Edible	Bankeraceae
11.	SES 2126	*Hydnum repandum* L.	On soil	Excellent	Hydnaceae
12.	SES 2157	*Clavulina rugosa* (Bull.) J. Schrot.	On soil	Edible	Clavulinaceae
13.	SES 2220	*Laetiporus sulphureus* (Bull.) Murr.	On broadleaved trees	Edible	Polyporaceae
14.	SES 2024	*Polyporus badius* Jungh.	On dead broadleaved trees	Inedible	Polyporaceae
15.	SES 2033	*Trametes versicolor* (L.) Lloyd.	On dead broadleaved trees	Inedible	Polyporaceae
16.	SES 2329	*Ramaria botrytis* (Pers.) Ricken	On soil	Edible	Ramariaceae
17.	SES 2331	*R. flava* (Toum.) Quel.	On soil	Edible	Ramariaceae
18.	SES 2330	*R. formosa* (Pers.) Quel.	On soil	Poisonous	Ramariaceae
19.	SES 2185	*Tulostoma brumale* Pers.	On chalky, sandy soil	Inedible	Tulostomataceae
20.	SES 2077	*Scleroderma areolatum* Ehrenb.	On soil	Inedible	Sclerodermataceae
21.	SES 2308	*Clavariadelphus truncatus* (Quel.) Donk.	On chalky soil	Inedible	Gomphaceae
22.	SES 2055	*Geastrum fimbriatum* Fr., (1829)	On soil	Inedible	Geastraceae
23.	SES 2023	*Phallus impudicus* L.	On soil	Edible	Phallaceae
24.	SES 2300	*Lactarius deliciosus* (E.) Gray	Under *Pinus pinea*	Edible	Russulaceae
25.	SES 2083	*L. flavidus* Boud.	On soil	Inedible	Russulaceae
26.	SES 2027	*L. piperatus* (E.) Pers.	Under *Fagus orientalis*	Edible	Russulaceae
27.	SES 2315	*L. rufus* (Scop.) Fr.	Under *Picea orientali*	Inedible	Russulaceae
28.	SES 2026	*L. vellereus* var. *vellereus* (Fr.) Fr.	*Picea orientalis*	Inedible	Russulaceae
29.	SES 2046	*L. volemus* (Fr.) Fr.	*Picea orientalis*	Good	Russulaceae
30.	SES 2005	*Russula delica* Fr.	*Picea orientalis*	Edible	Russulaceae

Fresh specimens, after removal of plant and substrate debris with a plastic knife, were dried in an oven at 105°C for 24 h, then air-dried for several days. Dried samples were homogenized and stored in pre-cleaned polyethylene bottles until analysis.

1 g of sample was placed in a porcelain crucible and ashed at 450°C for 20 h; then the ash was dissolved in 1 mL concentrated HNO_3, evaporated to dryness, heated again at 450°C for 4 h, treated with 1 mL concentrated H_2SO_4, 1 mL HNO_3 and 1 mL H_2O_2, and then diluted with double deionized water up to a volume of 10 mL. The blank samples were treated in the same way.

For the determination of metal contents, an ATI Unicam 929 model atomic absorption spectrometer (AAS) was used. The determination of all metal contents was carried out in an air/acetylene flame. The wavelength and slit values in nm used for the determination of Zn, Mn, Fe, Cu, Cd and Ni were: 213.9 and 0.5; 279.5 and 0.2; 248.3 and 0.2; 324.8 and 0.5; 228.8 and 0.5; 232 and 0.2, respectively. All the experimental results were mean SD of three parallel measurements.

RESULTS AND DISCUSSION

Some mushroom species analyzed (*Sarcodon imbricatus, Hydnum repandum, Clavulina rugosa, Laetiporus sulphureus, Ramaria botrytis, R.. flava, Phallus impudicus, Lactarius deliciosus, L. piperatus, L. volemus* and *Russula delica*) are edible and collected for domestic use in the study area.

All metal concentrations were determined on a dry weight basis. Table-2 presents the results of the analyses of micro- and macro-element levels in fungi samples collected from Rize, Turkey.

The zinc content was the least (61.1 mg/kg) in *Gloeophyllum odoratum*, whereas in *Geastrum fimbriatum* it was the highest (190 mg/kg). The average zinc content for the fungi was 137 mg/kg. Zinc concentrations of fungus samples in literature have been reported in the range of 33.5–89.5, 29.3–158 and 45–188 μg/g[16, 7, 22]. Zinc is known to be involved in most metabolic pathways in humans and zinc deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities.

The manganese content of the fungi studied ranged from 10.5 mg/kg in *Sarcodon imbricatus* to 81.1 mg/kg in *Phellinus igniarius*. The average manganese content for the fungi was 49.1 mg/kg. The reported manganese values in the literature for fungi were 14.2–69.7, 21.7–74.3 and 7.1–81.3 μg/g respectively[10, 16, 22]. Our manganese values are in agreement with those reported in literature.

The iron content of the fungi ranged from 140 mg/kg in *Scleroderma areolatum*, to 1400 mg/kg in *Ganoderma applanatum*. The average iron content for the fungi was 653.63 mg/kg. Iron values in fungi samples have been reported in the range of 31.3–1190, 568–3904, 56.1–7162 and 102–1580 μg/g respectively[2, 7, 12, 16]. Our iron values are in agreement with those reported in literature. It is known that adequate iron in the diet is very important for decreasing the incidence of anemia.

The copper levels had ranges of 10.1–180 mg/kg for *Phallus impudicus* and *Inonotus dryadeus* respectively. The average copper content for the fungi was 67.1 mg/kg. Copper contents of mushroom samples in literature have been reported in the range of 4.71–51.0, 12–181, 10.3–145, 34.5–83.0, 10.0–14.0 and

13.4–50.6 μg/g respectively[2, 7, 16, 23–25]. Copper contents found in this study are in agreement with those reported in literature. Copper concentrations in the accumulating mushroom species are usually 100–300 mg/kg dry matter which is not considered a health risk[3].

TABLE-2
CONCENTRATIONS OF Zn, Mn, Fe, Cu, Cd, AND Ni IN THE FUNGI SAMPLES (mg/kg DRY WEIGHT)

Sample No.	Fungi No.	Zn	Mn	Fe	Cu	Cd	Ni
1.	SES 2093	138 ± 6	29.4 ± 1.5	900 ± 10	121 ± 5	—	10.4 ± 0.6
2.	SES 2086	101 ± 5	57.2 ± 1.8	1400 ± 17	52.1 ± 4.1	—	5.6 ± 0.8
3.	SES 2207	61.1 ± 1.9	73.3 ± 1.9	850 ± 8	34.5 ± 1.3	2.1 ± 0.2	31.7 ± 2.1
4.	SES 2108	150 ± 5	46.3 ± 1.9	800 ± 7	25.9 ± 1.4	2.4 ± 0.3	16.5 ± 0.9
5.	SES 2120	130 ± 4	30.1 ± 1.6	300 ± 5	50.9 ± 3.9	3.1 ± 0.6	10.3 ± 0.6
6.	SES 2018	182 ± 6	75.2 ± 2.3	1100 ± 7	180 ± 5	4.4 ± 0.6	32.8 ± 1.4
7.	SES 2044	145 ± 5	81.1 ± 3.6	900 ± 7	66.1 ± 3.5	—	17.2 ± 1.1
8.	SES 2318	115 ± 4	70.2 ± 2.2	1060 ± 9	16.2 ± 1.0	6.4 ± 0.5	15.4 ± 1.0
9.	SES 2070	119 ± 5	20.1 ± 1.5	1050 ± 8	75.0 ± 4.5	6.0 ± 0.5	58.6 ± 3.6
10.	SES 2316	172 ± 4	10.5 ± 1.4	950 ± 7	16.2 ± 1.2	3.8 ± 0.2	33.5 ± 2.8
11.	SES 2126	103 ± 3	14.8 ± 1.2	700 ± 10	24.2 ± 1.0	7.5 ± 0.9	45.5 ± 4.0
12.	SES 2157	120 ± 4	75.1 ± 2.5	600 ± 9	16.4 ± 1.7	6.4 ± 0.8	95.6 ± 5.5
13.	SES 2220	130 ± 4	30.5 ± 0.8	362 ± 5	35.2 ± 2.1	1.1 ± 0.1	20.1 ± 1.8
14.	SES 2024	130 ± 4	51.1 ± 1.6	178 ± 4	81.5 ± 4.7	1.1 ± 0.2	—
15.	SES 2033	100 ± 3	30.2 ± 0.9	500 ± 5	109 ± 5	3.2 ± 0.3	1.1 ± 0.2
16.	SES 2329	139 ± 4	21.1 ± 0.5	700 ± 7	93.4 ± 4.9	7.2 ± 0.9	11.4 ± 0.9
17.	SES 2331	154 ± 4	75.1 ± 3.1	700 ± 6	60.9 ± 4.0	7.3 ± 0.7	22.7 ± 1.1
18.	SES 2330	188 ± 7	65.1 ± 2.0	607 ± 5	90.1 ± 3.9	3.3 ± 0.5	11.8 ± 0.8
19.	SES 2185	120 ± 4	26.4 ± 0.8	145 ± 5	160 ± 6	—	15.8 ± 1.0
20.	SES 2077	122 ± 5	75.1 ± 3.1	140 ± 10	80.1 ± 4.5	1.2 ± 0.2	14.3 ± 0.8
21.	SES 2308	125 ± 5	60.9 ± 2.9	655 ± 8	90.2 ± 5.0	2.2 ± 0.2	7.8 ± 0.4
22.	SES 2055	190 ± 8	71.2 ± 3.0	320 ± 5	75.9 ± 5	4.1 ± 0.4	19.0 ± 1.3
23.	SES 2023	155 ± 5	80.1 ± 3.2	270 ± 7	10.1 ± 0.3	4.7 ± 0.5	27.4 ± 1.2
24.	SES 2300	123 ± 5	46.6 ± 1.8	900 ± 13	75.6 ± 5.5	—	11.4 ± 0.5
25.	SES 2083	175 ± 7	14.7 ± 0.9	600 ± 10	64.1 ± 4.0	—	18.1 ± 0.9
26.	SES 2027	135 ± 4	62.6 ± 2.1	500 ± 10	39.1 ± 2.3	1.0 ± 0.1	11.8 ± 0.8
27.	SES 2315	164 ± 5	62.8 ± 2.8	600 ± 12	49.3 ± 3.5	1.4 ± 0.2	1.9 ± 0.1
28.	SES 2026	125 ± 4	45.1 ± 1.7	452 ± 10	75.5 ± 5.1	—	3.5 ± 0.4
29.	SES 2046	186 ± 9	66.1 ± 3.1	750 ± 5	65.2 ± 4.1	—	4.9 ± 0.3
30.	SES 2005	121 ± 4	14.5 ± 0.8	620 ± 7	85.1 ± 4.6	4.1 ± 0.6	11.4 ± 0.5

The higher and lower cadmium concentrations were found 7.5 mg/kg in *Hydnum repandum* and 1.0 mg/kg in *Lactarius piperatus*, respectively. The average cadmium content for the fungi was 2.8 mg/kg. Cadmium contents of fungi samples in the literature have been reported in the range of 0.81–7.50, 0.14–0.95, 0.28–1.6 and 0.12–2.60 μg/g[5, 16, 17, 26]. Our cadmium values are in agreement with those reported in literature.

The lower and higher nickel contents were found 1.1 mg/kg in *Trametes versicolor* and 95.6 mg/kg in *Clavulina rugosa*, respectively. The average nickel content for the fungi was 19.5 mg/kg. Nickel contents of fungi samples have been reported in the range of 0.15–127 mg/kg[6, 7, 10, 11, 16, 17]. Our nickel values are in agreement with those reported in literature.

The order of the levels of trace elements in the fungi species was found to be as: Fe > Zn > Mn > Ni > Cd.

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