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Micro- and Macroelement Contents of Edible Wild Growing Mushrooms in Artvin Province of Turkey

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Fruiting bodies of *Armillaria mellea, Boletus edulis, Bovista plumbea, Cantharellus cibarius* var. *cibarius, Cantharellus tubaeformis, Hydnum repandum, Laccaria laccata, Lactarius piperatus, Lactarius volemus, Lactarius circellatus, Lentinellus cochleatus, Lepista nuda, Lycoperdon pyriforme, Ramaria flava, Russula delica, Tricholoma imbricatum* and *Tricholomopsis rutilans* were collected from oriental spruce stands of Artvin province in Turkey. Micro- and macroelement contents in the fruiting bodies were determined by atomic absorption spectrometry after microwave digestion. The results were (as mg/kg) 0.23–1.59 silver, 20.6–79.5 aluminium, 0.23–2.74 cadmium, 0.55–2.72 lead, 23.9–87.8 copper, 139–895 iron, 9.1–93.2 manganese, 38.8–194 zinc, 415–1503 sodium, 22270–51455 potassium, 508–3267 calcium and 674–1819 magnesium.

Key Words: Micro and macro elements, Edible mushrooms, Atomic absorption spectrometry, Artvin.

INTRODUCTION

Mushrooms are valuable health foods, low in calories, high in proteins, iron, zinc, chitin, vitamins and minerals. In general, their fruiting bodies, on a dry weight basis, contain about 39.9% carbohydrate, 17.5% protein and 2.9% lipids with the rest constituting the minerals[1]. 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[2].

There are numerous species of wild edible mushrooms and their consumption continues to increase in many countries. Wild growing mushrooms have been a popular delicacy in many countries. Turkey has a large mushroom potential and

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is becoming an important exporter of the species of wild growing mushrooms in the world.

The specimens of macrofungi were collected during field trips in the Province of Artvin in Turkey. Artvin is in northeastern Turkey on the Çoruh River near the Georgian border. A local market for agricultural and animal products, it is linked by road with its port of Hopa to the northwest, which is on the Black Sea, and with Erzurum to the south. Collecting area has a high rainfall and the high humidity level during the autumn provides ideal atmospheric conditions for the growth of many mushrooms. The mushrooms are picked from the forest and they form an integral part of the diet during the growing months when these are abundantly available.

In a previous work the levels of trace elements in the fruiting bodies of macrofungi growing in the East Black Sea region of Turkey[3] have been studied. Four metals were determined in 56 samples of 23 wild mushroom species by Svoboda, Zimmermannova and Kalač[4]. The concentrations of Pb, Cd, Ag, Cu, Mn, Cr, Co, Ni, Fe, Zn, Na, K, Ca, Mg in fruiting bodies of *Xerocomus badius* and the underlying soil substratum were determined by Malinowska, Szefer and Falandaysz[5]. Nutritional value of edible wild mushrooms collected from the Khasi hills of Meghalaya were studied by Agrahar-Murugkar and Subbulakshmi[6]. Lithium content of some common edible wild-growing mushrooms were determined by Vetter[7]. Micro- and macroelement contents in fruiting bodies of wild mushrooms from the Notecka forest in West-Central Poland were studied by Rudawska and Leski[8].

On the other hand, some species, mainly from the genera *Agaricus, Macrolepiota, Lepista* and *Calocybe* accumulate high levels of cadmium and mercury even in unpolluted and mildly polluted areas. The concentrations of both metals and also of lead increase considerably in the heavily polluted sites, such as in the vicinity of metal smelters[9].

In this study, micro- and macroelement contents of the commonly consumed wild mushrooms collected from Artvin, Turkey were determined by AAS.

EXPERIMENTAL

The specimens of macrofungi were collected during field trips in the province of Artvin in Turkey. The colour, odour and other apparent properties of macrofungi were noted at the field. The specimens were examined in the laboratory at the earliest convenient time after collection. All the spore measurements were calculated from at least 20 individual measurements using Nikon microscopes. Excised pieces of fungus pileus were moistened by addition of a few drops of Clemencon's solution [20 mL concentrated ammonia + 1 g glycerine + 80 mL 96% ethanol] and then sectioned under a binocular loupe[10]. The mushrooms (Table-1) were identified according to Breitenbach and Kränzlin[11]. Some specimens were deposited at the fungarium of Faculty of Fatih Education at Karadeniz Technical University in Trabzon Province of Turkey.

TABLE-1
HABITAT, EDIBILITY AND NAMES OF MUSHROOMS

Sample	Fungarium	Name of mushroom	Habitat	Edibility	Family
1.	SES 2090	*Armillaria mellea* (Vahl) P. Kumm.	on or around trunks or stumps of trees	edible	*Marasmiaceae*
2.	SES 2141	*Boletus edulis* Bull.,	in forests and along forest edges	excellent	*Boletaceae*
3.	SES 2081	*Bovista plumbea* Pers,	in meadows and pastures	edible	*Lycoperdaceae*
4.	SES 2020	*Cantharellus cibarius* var. *cibarius* (Fr.) Quél.	in hardwood and conifer forest	excellent	*Cantharellaceae*
5.	SES 2110	*Cantharellus tubaeformis* (Bull.) Fr.	on soil in forests	edible	*Cantharellaceae*
6.	SES 2021	*Hydnum repandum* L.,	on soil in foreste	excellent	*Hydnaceae*
7.	SES 2192	*Laccaria laccata* (Scop.) Fr.,	in troops in woods or heaths	edible	*Hydnangiaceae*
8.	SES 2088	*Lactarius circellatus* (Battarra) Fr.,	under hornbeams	edible	*Russulaceae*
9.	SES 2050	*Lactarius piperatus* (L.) Pers.,	deciduous woods	edible	*Russulaceae*
10.	SES 2029	*Lactarius volemus* (Fr.) Fr.,	under trees	good	*Russulaceae*
11.	SES 2206	*Lentinellus cochleatus* Hoffm.	on hardwoode	edible	*Auriscalpiaceae*
12.	SES 2145	*Lepista nuda* (Bull.) Cooke,	inside and outside forest	excellent	*Tricholomataceae*
13.	SES 2094	*Lycoperdon pyriforme* Schaeff.,	on dead wood of trees	edible	*Lycoperdaceae*
14.	SES 2100	*Ramaria flava* (Tourn.) Quél.,	on soil in forests	edible	*Ramariaceae*
15.	SES 2153	*Russula delica* Fr.,	under trees	edible	*Russulaceae*
16.	SES 2205	*Tricholoma imbricatum* (Fr.)P.Kumm	in coniferous forests	edible	*Tricholomataceae*
17.	SES 2204	*Tricholomopsis rutilans* (Sch.)Sin	on stumps of conifers	edible	*Tricholomataceae*

The samples were dried at 105°C for 24 h for chemical investigations. Dried samples were homogenized using an agate homogenizer and stored in polyethylene bottles until analysis. All the plastic and glassware were cleaned by soaking with the contact overnight in a 10% nitric acid solution and then rinsed with deionized water. One gram of sample was digested with 6 mL of concentrated HNO_3 (Suprapure, Merck) and 2 mL of concentrated H_2O_2 (Suprapure, Merck) in Milestone Ethos D model microwave digestion system (maximum pressure 1450 psi and maximum temperature 300°C) and diluted to 10 mL with double deionized water (Milli-Q Millipore 18.2 MΩ cm^{-1} 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). The accuracy of the method was verified by standard reference materials (SRM 1515 apple leaves). A Perkin-Elmer Analyst 700 model atomic absorption spectrometer with deuterium background corrector was used in this study. Silver, aluminium, lead and cadmium levels in the mushroom samples were determined by HGA graphite furnace using argon as inert gas. The other elements were determined in air-acetylene flame.

RESULTS AND DISCUSSION

All mushroom species analyzed in this paper are edible. Some species in our study (*Boletus edulis, Cantharellus cibarius* var. *cibarius, Hydnum repandum, Lactarius piperatus, Lactarius volemus* and *Lepista nuda* are popular and are exported to European destinations. Some other edible species (*Armillaria mellea, Bovista plumbea, Cantharellus tubaeformis, Laccaria laccata, Lactarius circellatus, Lentinellus cochleatus Lycoperdon pyriforme, Ramaria flava, Russula delica, Tricholoma imbricatum* and *Tricholomopsis rutilans*) are collected only for domestic use in the study area. We have observed that harvesting of mushrooms in forests, either commercially or recreationally, is increasing 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 macroelement levels (as mg/kg) in some edible mushroom samples collected from Artvin, Turkey. The lower and higher silver content was found 0.23 mg/kg in *Cantharellus cibarius* var. *cibarius* and 1.59 mg/kg in *Lycoperdon pyriforme*, respectively. Silver contents of mushroom samples have been reported in the range of 0.24–38 mg/kg[12]; 4.0–5.5 mg/kg[13]. Our silver levels were found to be lower than those reported in literature.

Aluminium content ranged from 20.6 mg/kg in *Armillaria mellea* to 79.5 mg/kg in *Bovista plumbea*. Aluminium contents of mushroom samples have been reported in the range of 95–175 mg/kg[13]; 8.5–365 mg/kg[8]; 7.9–943 mg/kg[14]. Aluminium is not considered to be an essential element in humans. Exposure of aluminium has been implicated in a number of human pathologies including encephalopathy/dialysis dementia, Parkinson disease and Alzheimer's disease[15]. The permissible aluminium dose for an adult is quite high (60 mg per day)[16].

TABLE-2
MICRO AND MACRO ELEMENT LEVELS (AS mg/kg) IN MUSHROOM SAMPLES COLLECTED FROM ARTVİN, TURKEY

Sample	Ag	Al	Cd	Pb	Cu	Fe	Mn	Zn	Na	K	Ca	Mg
1.	1.12 ± 0.10	19.4 ± 1.2	1.98 ± 0.17	0.99 ± 0.10	33.8 ± 3.2	579 ± 55	85.6 ± 7.6	95.6 ± 8.8	961 ± 89	27847 ± 688	2564 ± 200	1357 ± 106
2.	0.39 ± 0.03	17.8 ± 1.9	1.56 ± 0.13	1.21 ± 0.11	63.3 ± 5.4	642 ± 56	54.6 ± 5.1	55.2 ± 4.3	803 ± 70	26543 ± 878	876 ± 76	1258 ± 95
3.	0.66 ± 0.04	75.9 ± 3.6	0.56 ± 0.05	2.52 ± 0.20	80.2 ± 7.6	820 ± 75	76.7 ± 6.4	64.5 ± 5.4	754 ± 63	39800 ± 670	3000 ± 267	865 ± 54
4.	0.25 ± 0.02	30.2 ± 0.8	0.37 ± 0.03	1.24 ± 0.10	25.2 ± 1.3	302 ± 16	32.1 ± 1.9	41.5 ± 2.7	450 ± 35	28000 ± 560	589 ± 37	732 ± 58
5.	0.72 ± 0.08	38.5 ± 2.7	2.55 ± 0.19	0.87 ± 0.09	42.8 ± 3.6	550 ± 49	34.8 ± 3.3	78.6 ± 6.8	640 ± 52	38960 ± 780	508 ± 47	1430 ± 88
6.	0.76 ± 0.06	46.1 ± 3.3	0.25 ± 0.02	0.67 ± 0.05	46.4 ± 3.7	265 ± 22	15.3 ± 1.4	74.2 ± 6.3	589 ± 53	25670 ± 757	768 ± 66	1247 ± 79
7.	1.35 ± 0.09	63.2 ± 4.9	0.43 ± 0.05	0.78 ± 0.07	43.7 ± 5.3	152 ± 13	27.8 ± 2.5	42.4 ± 3.7	860 ± 74	22875 ± 605	2587 ± 174	1008 ± 77
8.	0.42 ± 0.03	56.9 ± 3.8	0.92 ± 0.08	1.57 ± 0.13	64.2 ± 5.3	389 ± 35	46.5 ± 3.7	154 ± 14	1105 ± 96	26480 ± 687	1995 ± 146	1580 ± 123
9.	0.47 ± 0.05	68.6 ± 5.3	1.52 ± 0.14	1.73 ± 0.15	76.7 ± 5.3	670 ± 60	45.8 ± 4.6	86.5 ± 6.5	978 ± 86	50475 ± 980	2540 ± 138	976 ± 68
10.	0.90 ± 0.05	27.8 ± 2.1	0.77 ± 0.06	0.89 ± 0.08	65.2 ± 6.2	504 ± 44	10.2 ± 1.1	135 ± 12	1250 ± 105	46753 ± 870	1589 ± 75	1687 ± 132
11.	1.12 ± 0.10	65.5 ± 5.6	1.90 ± 0.16	0.86 ± 0.07	54.1 ± 4.8	487 ± 43	31.2 ± 2.9	92.7 ± 8.3	706 ± 65	42965 ± 806	2476 ± 211	1109 ± 105
12.	0.82 ± 0.07	53.7 ± 5.1	1.13 ± 0.11	1.52 ± 0.14	55.8 ± 5.9	759 ± 74	73.2 ± 4.7	87.6 ± 7.4	500 ± 45	35760 ± 470	997 ± 65	965 ± 79
13.	1.46 ± 0.13	65.8 ± 4.3	2.34 ± 0.20	1.33 ± 0.12	39.6 ± 3.5	623 ± 57	19.9 ± 1.5	150 ± 14	1400 ± 103	37420 ± 934	2005 ± 124	1150 ± 86
14.	0.36 ± 0.04	59.1 ± 4.1	1.75 ± 0.15	1.96 ± 0.18	51.9 ± 4.7	754 ± 66	54.3 ± 5.2	178 ± 16	874 ± 75	47540 ± 569	1478 ± 102	879 ± 75
15.	0.94 ± 0.06	42.4 ± 4.4	0.77 ± 0.08	2.33 ± 0.20	47.2 ± 3.8	238 ± 21	55.8 ± 4.9	102 ± 10	854 ± 80	31250 ± 700	1780 ± 98	1326 ± 97
16.	0.62 ± 0.07	48.5 ± 3.8	1.46 ± 0.13	1.25 ± 0.10	39.5 ± 3.3	642 ± 57	42.8 ± 3.7	75.3 ± 6.2	478 ± 43	47689 ± 860	2745 ± 150	745 ± 60
17.	0.77 ± 0.05	41.6 ± 3.2	0.86 ± 0.07	0.60 ± 0.05	64.6 ± 5.9	276 ± 22	54.6 ± 4.5	25.8 ± 2.6	657 ± 60	37645 ± 658	1326 ± 89	867 ± 73

The higher and lower cadmium concentration was found 2.74 mg/kg in *Cantharellus tubaeformis* and 0.23 mg/kg in *Hydnum repandum*, respectively. Cadmium contents of mushroom samples in literature have been reported in the range of 0.81–7.50 μg/g[4], 0.14–0.95 μg/g[17], 0.28–1.6 μg/g[18], 0.12–2.60 μg/g[5]. Our cadmium values are in agreement with those reported in literature. Cadmium is accumulated mainly in kidneys, spleen and liver and its level in blood serum increases considerably following mushroom consumption[9]. The lead (Pb) content ranged from a high of 2.72 mg/kg in *Bovista plumbea* to a low of 0.55 mg/kg in *Tricholomopsis rutilans*. Lead contents of mushroom samples in literature have been reported in the range of 0.40–2.80 μg/g[4], 0.75–7.77 μg/g[19], 1.43–4.17 μg/g[20], 0.75–1.99 μg/g[17]. These results conform to the FAO/WHO[21] standards for Pb and Cd toxic metals. The maximum permissible dose for an adult is 3 mg lead and 0.5 mg cadmium per week.

The copper levels had ranges of 23.9–87.8 mg/kg for *Cantharellus cibarius* var. *cibarius* and *Bovista plumbea*, respectively. Copper contents of mushroom samples in literature have been reported in the range of 4.71–51.0 μg/g[22], 12–181 μg/g[19], 10.3–145 μg/g[3], 34.5–83.0 μg/g[23], 10.0–14.0 μg/g[23], 13.4–50.6 μg/g[17], respectively. 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[9].

The iron (Fe) content of the mushrooms ranged from 139 mg/kg in *Laccaria laccata* to 895 mg/kg in *Bovista plumbea*. The average iron contents for the mushrooms were 509 mg/kg. Iron values in mushroom samples have been reported in the range of 31.3–1190 μg/g[3], 568–3904 μg/g[24], 56.1–7162 μg/g[23], 102–1580 μg/g[17], respectively. Our iron values are in agreement with those reported in literature. It is known that adequate iron in a diet is very important for decreasing the incidence of anemia.

The manganese (Mn) content of the mushrooms studied ranged from 9.1 mg/kg in *Lactarius volemus* to 93.2 mg/kg in *Armillaria mellea*. The reported manganese values in literature for mushrooms were 14.2–69.7 μg/g, 21.7–74.3 μg/g, 7.1–81.3 μg/g[17, 20, 25], respectively. Our manganese values are in agreement with those reported in literature.

The zinc (Zn) content was the least (38.8 mg/kg) in *Cantharellus cibarius* var. *cibarius*, whereas in *Ramaria flava*, it was the highest (194 mg/kg). Zinc concentrations of mushroom samples in the literature have been reported in the range of 33.5–89.5 μg/g[17]; 29.3–158 μg/g[23], 45–188 μg/g[20]. 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 order of the levels of macro elements in the mushroom species was found to be as K > Ca > Mg > Na. The sodium content ranged from a low of 415 mg/kg in *Cantharellus cibarius* var. *cibarius* to a high of 1503 mg/kg in *Lycoperdon pyriforme* whereas the potassium ranged from a low of 22270 mg/kg in *Laccaria laccata* to a high of 51455 mg/kg in *Lactarius piperatus*. The calcium content was the highest (3267 mg/kg) in *Bovista plumbea*, whereas it was the lowest (508

mg/kg) in *Cantharellus tubaeformis*. In human body, calcium has a vital role in bone structure and dietary calcium plays an integral role in the maintenance of normal blood pressure. Magnesium levels ranged from 674 mg/kg in *Cantharellus cibarius* var. *cibarius* to 1819 mg/kg in *Lactarius volemus*, with an average of 1128 mg/kg. Magnesium has an important role in all biosynthetic processes and is also essential in the activation of more than 300 enzymes in human body. K, Ca and Mg levels in mushroom samples have been reported in the range of 10.3–55.1, 0.2–3.6, 0.3–1.2 g/kg, respectively[8].

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