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Biochemical Composition of Some Turkish Fungi

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The fructification organs of *Macrolepiota mastoidea, Lepista nuda, Handkea excipuliformis, Amanita rubescens* and *Boletus queletii* were analyzed in terms of moisture, nitrogen, protein, crude fat, carbohydrate, vitamin C, ash, energy values and trace element contents (Zn, Mn, Fe, Cu, Cd, Pb, Co and Ni). The chemical composition of the specimens in dried matter g/100 g, moisture 74.03-92.5 %, nitrogen 4.36-7.08 %, protein 27.30-44.20 %, crude fat 2.70-27.50 %, total carbohydrate 29.70-65.30 %, vitamin C 0.01-0.05 %, ash 2.00-10.00 % and energy 397.66-493.90 kcal/100 g. The trace element contents of specimens were determined by atomic absorption spectrometry after microwave digestion. The results were (as mg/kg) 34.4-47.0 zinc, 22.8-100.0 manganese, 13.7-44.9 iron, 3.9-19.3 copper, 0.2-0.7 lead, 0.4-0.5 cobalt and 1.2-2.2 cadmium. These results make these edible wild mushrooms popular as a food source and it can be thought that these mushrooms may be cultivated.

Key Words: Mushroom, Biochemical composition, Trace elements.

INTRODUCTION

Mushrooms have been used for centuries in most places for different purposes and today are gaining more acceptances in the world. The nutritive and medicinal values of many wild species have long been known in the world. Some wild-growing mushrooms also possess pharmacological properties. There are various types of medicinal mushroom showing different effects on immune system related disorders. Cancer, AIDS and liver disorders seem to be well helped by wild mushrooms. Medicinal mushrooms also support cardiovascular health in terms of cholesterol lowering, hypertension and diabetes.

The present study determines the nutritional contents of the commonly consumed wild mushrooms collected from Macka district of Trabzon

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province in Turkey. The nutritional and medicinal properties, trace element composition and biochemical structure of the most of the wildly occurring mushroom species in the collecting area have not been investigated before that would be a reliable indicator of the nutritional value and potential economic importance. Despite of the potential economic importance of these wild growing mushrooms in the collecting area, this is the first work has been carried out on their biochemical composition. In this investigation, we have examined the proximate biochemical composition, of moisture, protein, crude fat, carbohydrate, vitamin C, ash and trace elements. The results may be valuable for food industry, chemotaxonomy and cultivation purposes of mushrooms.

EXPERIMENTAL

In the period of August-September 2004, some fungi specimens were collected from Lisar High Plateau of Macka district of Trabzon, Turkey. The specimens were carried into the laboratory in an ice bath and stored deep-frozen at -34°C until used. The colour, odour and other apparent properties of the fungi and vegetation were noted in the field. The fungi collected from the study area were photographed and examined in the laboratory as soon as possible after collection. Microscopic examinations were performed using Nikon research microscopes. The specimens were identified by Moser[1], Breitenbach & Kränzlin[2] and Bessette *et al.*[3]. At the end of examinations, five edible wild mushroom species were identified (Table-1). All biochemical studies were completed in 10 d. The reagents were of analytical grade and used as obtained. The specimens were deposited at the Herbarium of Fatih Faculty of Education.

TABLE-1
IDENTIFIED MUSHROOM SPECIES

Scientific names of analysed mushroom species	Habitat	Edibility	Family
Macrolepiota mastoidea (Fr. : Fr.) Singer	In open woodland	Good	*Agaricaceae*
Lepista nuda (Bull. : Fr.) Cooke	Under Spruce	Excellent	*Tricholomataceae*
Handkea excipuliformis (Scop. : Pers.) Perdeck	On pastures	When young	*Lycoperdaceae*
Amanita rubescens (Pers.: Fr.) Gray s. lat.	Under Spruce	When cooked	*Pluteaceae*
Boletus queletii Schulzer	Under beech	When cooked	*Boletaceae*

Sample preparation: The mushroom specimens were washed thoroughly with demineralized water to free them from external material such as mud, bush, soil *etc.* and then dried between filter papers on air. The material (5 g) were taken immediately for determination of moisture. Remaining mushrooms were stored in deep-frozen until used.

Chemical analysis: Samples for moisture determination were dried in a moisture determination apparatus (Precisa HA60) at 110ºC until its circulation was completed. Ash content for each mushroom was determined by heating them in a furnace at 550ºC for 3 h to constant weight according to the AOAC manual[4]. Crude protein was determined on the fruit bodies of mushrooms from Kjeldahl nitrogen using a 6.25 conversion factor[4,5]. Crude fat was extracted from each mushroom species with petroleum ether by Soxhlet apparatus and was gravimetrically determined[6,7]. Total carbohydrate contents of mushrooms were calculated as difference between 100 and total percentage of moisture, protein, crude fat and ash[5,8]. Total energy values were calculated by multiplying the amounts of protein and carbohydrate by the factor of 4 kcal/g and lipid by the factor of 9 kcal/g. The ascorbic acid amount was determined by a reduction method in which IO_3^- reduces to I_2 in acidic solution, using starch as an indicator[9]. In all tables, data points represent mean of three determinations.

Microelement analysis: Fresh mushrooms, after removal of plant and substrate debris with a plastic knife, were dried in an oven at 105°C for 24 h after air dried for several days. Dried samples were homogenized, using an agate homogenizer and stored in pre-cleaned polyethylene bottles until analysis. 1 g of sample was placed in a porcelain crucible and burned at 450°C for 20 h. The ash was dissolved in 1 mL concentrated HNO_3 and 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 Unicom 929 model atomic absorption spectrometer was used. The determination of all metal contents was carried out in an air/acetylene flame. The maximum absorbance was obtained by adjusting the hallow cathode lamps at the operation conditions shown in Table-2. All the experimental results were means ± SD of three parallel measurements.

RESULTS AND DISCUSSION

The chemical composition of the analysed species was shown in Table-3. It is known from the previous data that dry matter content of fresh mushrooms are generally in range 5-15 % and their nutritional profiles are directly affected with moisture content[10-12]. It is also known that the

TABLE-2
TRACE ELEMENT CONCENTRATIONS OF THE SPECIMENS
(mg/kg DRY WEIGHT)

Metal	Wavelength/ Band width (nm)	*Macrol-epiota mastoidea*	*Lepista nuda*	*Handkea excipuliformis*	*Amanita rubescens*	*Boletus queletii*
Zn	213.9/0.5	34.4±2.80	36.5±2.20	36.1±2.90	47.0±3.10	44.6±2.90
Mn	279.5/0.2	48.5±3.50	100.0±5.20	22.8±2.20	28.5±2.40	43.0±2.90
Fe	248.3/0.2	15.6±1.20	44.9±3.50	13.7±1.00	30.4±2.50	21.9±1.40
Cu	324.8/0.5	8.2±0.80	19.3±1.20	3.9±0.60	8.9±0.70	11.8±0.90
Pb	217.0/0.5	0.7±0.04	0.2±0.02	0.7±0.02	0.6±0.03	0.3±0.02
Co	240.7/0.2	0.5±0.02	*ND	*ND	0.4±0.01	*ND
Cd	228.8/0.5	2.2±0.30	1.5±0.20	1.4±0.20	2.0±0.40	1.2±0.10

*ND: could not be determined.

moisture content of mushrooms depends on their harvesting time, maturation period and environmental conditions such as humidity and temperature in growing period and storage conditions[10]. The moisture content of mushroom in the present study ranged 74.03-92.50 % (Table-3). Current results were similar to the species (*Agaricus bisporus* (J.E. Lange) Imbach, *Pleurotus ostreatus* (Jacq. : Fr.) P. Kumm., *Lentinula edodes* (Berk.) Singer, *Cantharellus cibarius* Fr.: Fr., *Cantharellus cinereus* (Pers.) Fr. *Gomphus floccosus* (Schwein.) Singer, *Ramaria brevispora* Corner and *Russula integra* Quél.), which were studied by Mattila *et al.*[8] and Agrahar-Murugkar & Subbulakshmi[13].

TABLE-3
CHEMICAL COMPOSITION OF THE SPECIMENS
IN DRIED MATTER (g/100 g)

Composition (%)	*Macrolepiota mastoidea*	*Lepista nuda*	*Handkea excipuliformis*	*Amanita rubescens*	*Boletus queletii*
Moisture	84.18±4.000	85.48±5.000	74.03±5.00	92.50±5.00	78.59±4.000
Nitrogen	5.33±0.300	7.08±0.100	5.03±0.30	5.11±0.10	4.36±0.100
Protein	33.31±3.000	44.20±3.000	31.44±3.00	31.90±2.60	27.30±2.100
Crude fat	4.58±0.300	9.04±0.100	2.70±0.20	27.50±3.00	5.20±0.200
Total Carbohydrate	55.80±6.000	41.90±5.700	62.84±6.60	29.70±3.00	65.30±7.000
Vitamin C	0.01±0.001	0.01±0.001	0.03±0.01	0.05±0.01	0.01±0.001
Ash	5.40±0.400	5.40±0.300	2.00±0.07	10.00±0.60	2.70±0.060
Energy (kcal/100 g)	397.66±14.300	425.76±15.000	401.42±15.00	493.90±17.20	417.20±14.000

Protein contents of the species were observed in range 27.30 and 44.20% (Table-3). It was *ca.* 27 % for *Boletus queletii* Schulzer and this result is inconsistent with earlier reports on *Cantharellus cinereus* (Pers.) Fr. and *Calvatia gigantea* (Batsch) Lloyd[13]. The protein contents of *Lactarius quieticolor* Romagn., *Cantharellus cibarius* Fr. : Fr. and *Gomphus floccosus* (Schwein.) Singer was studied by Agrahar-Murugkar & Subbulakshmi[13].

Pleurotus ostreatus (Jacq.: Fr.) P. Kumm. and *Lentinus edodes* (Berk.) Singer analysed by Mattila *et al.*[8]. The protein content of *Tricholoma portentosum* (Fr.) Quél. and *Tricholoma terreum* (Schaeff.) Quél. were analyzed by Diez and Alvarez[14]. The present results were higher than above studies. Protein content (44.20 %) of *Lepista nuda* (Bull. : Fr.) Cooke was quite higher than the others. It can be understood from the data that the studied mushrooms are good protein source when compared with other species and some commercially important fish species from the Black Sea[5].

All kind of lipid compounds such as free fatty acids, mono-, di- and triglycerides, phospholipids, sterols and derivatives can be extracted from mushrooms as crude fat[10]. Since mushrooms have low crude fat content, they are consumed for low-calorie diet. Various fat content in dry mushrooms varies from 0.8 to 8.0 %[10,13,15-17]. Crude fat levels of our species varied from a low of 2.70 % for *Handkea excipuliformis* (Scop. : Pers.) Perdeck to a high of 27.50 % for *Amanita rubescens* (Pers. : Fr.) Gray s. lat. (Table-3). Except for *Amanita rubescens* (Pers. : Fr.) Gray s. lat., the crude fat content of analyzed mushrooms is suitable with earlier reports[6]. *Amanita rubescens* (Pers. : Fr.) Gray s. lat. has high fat and protein content and can be considered as a good energy source.

Carbohydrates and proteins are the major components of mushrooms. Mushroom carbohydrates include glucans mono- and disaccharides, sugar alcohol, glycogen and chitin[18]. Sanmee *et al.*[6] found carbohydrate contents of some wild edible mushrooms from nitrogen free extracts between 41 and 65 %. Mattila *et al.*[8] also found carbohydrate contents of *Pleurotus ostreatus* (Jacq. : Fr.) P. Kumm. and *Lentinus edodes* (Berk.) Singer as 62.5 and 69 %, respectively. Although *Amanita rubescens* (Pers. : Fr.) Gray s. lat. had high protein and fat content, it was found that the carbohydrate content of this species (29.70 %) was lower than the others (Table-3). Protein, fat and carbohydrate profiles similar with reported data make these mushrooms ideal food sources.

The ash contents of mushrooms in this study were found in the range from 2.00 to 10.00 % (Table-3). Mattila *et al.*[19] were reported that the main constituents in the mushroom ash were K and P (total 60 %). It can be speculated that lower ash contents in *Handkea excipuliformis* (Scop. : Pers.) Perdeck and *Boletus queletii* Schulzer can be attributed to their low K and P content (not determined). Ash contents of the other mushrooms are consistent with the earlier data[6,8,13].

The calculated energy values of species varied from 397.66 kcal/100 g to 493.90 kcal/100 g in dry matter basis (Table-3). These values were found to be higher than reported data[8] obtained from other cultivated mushrooms such as *Pleurotus ostreatus* (Jacq. : Fr.) P. Kumm. and *Lentinus edodes* (Berk.).

Vitamin C contents of all mushrooms were determined as soon as possible after they were brought to the laboratories because of their short lives. *Amanita rubescens* (Pers. : Fr.) Gray s. lat. had the highest vitamin C content (0.05 %). *Macrolepiota mastoidea* (Fr. : Fr.) Singer, *Lepista nuda* (Bull. : Fr.) Cooke and *Boletus queletii* Schulzer contained ascorbic acid levels with a low of 0.01 % (Table-3). Vitamin C contents of the species are agreed with some edible wild mushrooms widely consumed in Meghalaya such as *Calvatia gigantea* (Batsch) Lloyd, *Clavaria cinerea* Bull., *Ramaria brevispora* Corner and *Gomphus floccosus* (Schwein.) Singer which were studied by Agrahar-Murugkar and Subbulakshmi[13].

Microelement analysis

The contents of trace elements in mushrooms are considerably higher than vegetables, fruits and agricultural crop plants because of their effective take up mechanisms[20].

In the present study, the species were analyzed for their micronutrient contents (Zn, Mn, Fe and Cu) and toxic heavy metal contents (Cd, Pb, Co and Ni). Ni (wavelength/band width, 232 nm/0.2 nm) could not be determined for analyzed mushrooms.

In an earlier study, the trace element contents of mushrooms collected from Trabzon were also determined by Sesli and Tuzen[21]. The observation of different results was attributed that the trace element profile of mushrooms has been affected by environmental factors such as climate, growing conditions and region and soil content.

The concentrations of investigated trace metals in mushroom samples were found to be in the range of 34.4-47.0 mg/kg for zinc, 22.8-100.0 mg/kg for manganese, 13.7-44.9 mg/kg for iron and 8.2-19.3 mg/kg for copper. The zinc contents of the mushrooms studied in the present work ranged from 34.4 mg/kg in *Macrolepiota mastoidea* (Fr. : Fr.) Singer to 47.0 mg/kg in *Amanita rubescens* (Pers. : Fr.) Gray s. lat. The highest and the lowest manganese concentration found 100 mg/kg in *Lepista nuda* (Bull. : Fr) Cooke and 22.8 mg/kg in *Handkea excipuliformis* (Scop. : Pers.) Perdeck, respectively. The average iron and copper contents of the species were found 25.3 and 10.4 mg/kg, respectively. Our micronutrient values are in agreement with reported in the literature[6,13]. The level of toxic heavy metals (Pb, Co and Cd) was found tolerable in all analyzed mushrooms and similar to published data[21] .

It can be concluded that the investigated edible wild mushrooms may be cultivated in terms of protein, carbohydrate, crude fat, vitamin C content, and energy values of when compared with *Agaricus bisporus* (J.E. Lange) Imbach as a cultivated mushroom species. In addition, it is seen that the heavy metal contents of the investigated edible wild mushrooms, relatively lower than that of analyzed *Agaricus bisporus* (J.E. Lange) Imbach

and some popular edible wild mushrooms, make them easily able to consume.

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