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Nutritional value of some wild edible mushrooms from Black Sea Region (Turkey)

[Karadeniz Bölgesi'nden (Türkiye) bazı yabani yenilebilir mantarların besin bileşenleri]

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ABSTRACT

Objectives: The aim of this study is to profile the nutritional content of eight edible mushrooms collected from East Black Sea region in Turkey.

Methods: The eight different wild edible mushrooms (*Boletopsis leucomelaena, Hydnum repandum, Laetiporus sulphureus, Boletus edulis, Armillaria mellea, Macrolepiota procera* var. *procera, Lactarius piperatus* and *L. quietus*) were analyzed in terms of macro- and micronutrient, organic acids and minerals contents.

Results: The average ash, moisture, carbohydrate, fat, nitrogen and protein contents of mushrooms were 6.72, 11.7, 56.86, 3.64, 3.07 and 19.19 g/100g dry weight, respectively. An average of 8.57, 0.99 and 15.20 g/kg dry weight of malic, ascorbic and citric acids were determined. As for the energy value, it was averaged 377 kcal/100 g dry weight. The ratio minimum and maximum levels of each macro- and micronutrient contents (K, Ca, Mg, Fe, Mn, Zn, Cu, Co, Ni, Pb and Cd) of the investigated mushrooms varied up 2 to 58 fold.

Conclusion: The examined mushrooms species were rich in protein and carbohydrate, and had low amounts of fat and convenient amounts of major and trace minerals (K, Ca, Na, Fe, Mn, etc). The major variations between the nutritional values of these mushroomo can be attributed to different species ane seasonal differences in maturatios of these mushrooms as well nd the difference in their tastes that is related with the species, therefod provides variety in organoleptic characteristics for consumpties. The present resulte suggest these wild edible mushrooms studied in that study popular to consume as good food sources.

Key Words: Chemical composition, ash, moisture, carbohydrate, fat, nitrogen, protein, wild mushroom, major and trace elements

ÖZET

Amaç: Bu çalışmanın amacı Türkiye'de, Karadeniz Bölgesi'nden toplanan sekiz yenilebilir mantarın besinsel içeriğini ortaya koymaktır.

Yöntem: Sekiz adet farklı yabani yenilebilir mantar (*Boletopsis leucomelaena, Hydnum repandum, Laetiporus sulphureus, Boletus edulis, Armillaria mellea, Macrolepiota procera* var. *procera, Lactarius piperatus* ve *L. quietus*) makro- ve mikro mikrobesin değeri, organik asitleri ve mineral içeriği açısından analiz edilmiştir.

Bulgular: Mantarların ortalama kül, nem, karbohidrat, yağ, azot ve protein miktarları sırasıyla 6.72, 11.7, 56.86, 3.64, 3.07 ve 19.19 g/100g kuru ağırlıktır. Malik, askorbik ve sitrik asit ortalama, 8.57, 0.99 ve 15.20 g/kg kuru ağırlık tespit edildi. İncelenen mantarların her birinin makro- ve mikro (K, Ca, Mg, Fe, Mn, Zn, Cu, Co, Ni, Pb ve Cd) besin içeriklerinin en büyük ve en küçük değerlerinin oranı 2 ile 58 arasında değişmiştir.

Sonuçlar: İncelenen mantar türleri, protein ve karbonhidrat bakımından zengindir; ve düşük miktarlarda yağ ve uygun miktarlarda major ve eser minerallere (K, Ca, Na, Fe, Mn, vs.) sahiptir. Besin değerlerinin bu oranda farklılık göstermesi, değişik mantar tiplerinin değişik zamanlardakr besin değerlerine bağlı lezzet (organoleptik karakterler) farklılığına ve tüketim çeşitliliğiin nedni olmaktadır. Mevcut sonuçlar, bu çalışmadaki yabani yenilebilir mantarları tüketim için iyi bir kaynak yapar.

Anahtar Kelimeler: Kimyasal kompozisyon, kül, nem, karbohidrat, yağ, azot, protein, yabani mantar, major ve eser elementler

Introduction

Being a partake of the human diet, interest in nutritional analysis in wild edible mushrooms are growing (1,2). Consumption of wild edible mushrooms both fresh and dried is increasing, even in the developed world, due to a good content of protein as well as a higher content of trace minerals (1-4). In this respect, some of wild edible mushrooms have been cultivated (*Agaricus bisporus*, *Pleurotus* spp., *Lentinus edodes*, *Volvariella volvacea*, *Auricularia* spp. etc.) and however, in most countries, a well-established consumer acceptance for cultivated mushrooms also occurred (5).

From a nutritional point of view, wild mushrooms are becoming more and more important for their health in our diet for their nutritional characteristics (1-5). A large number of studies worldwide have been done on the chemical composition and nutritional quality of both wild edible and cultivated mushroom species which have been cited in a restricted number here. *Boletus* (2,5,6), *Tricholoma* (1,7), *Agaricus* (1,2), *Cantharellus* (3,5), *Pleurotus* (5), *Armillaria* (4, 8-10), *Hydnum* (5, 11-13), *Lactarius* (1,3,5) spp., etc. are the mushrooms recently have often been studied for their chemical composition and nutritional qualities by the several authors.

Black Sea region of Turkey (due to climatic conditions and flora diversity) is one of the geographical regions of Turkey with higher wild edible mushroom diversity, some of them with great gastronomic relevance. Despite the immense popularity of this food in the region and its increasing consumption by local people, enthusiast and gourmets, data regarding the nutritive value of the wild edible mushrooms available in the region are very meager. Therefore, we have been driven to necessity to profile a nutritional database of these mushrooms in ongoing project to retain the information on these unique species and for a better management and conservation of these natural resources and the habitats related to them.

Herein, we report the chemical compositions of eight wild edible mushrooms collected from northeast Anatolia (Turkey), with reference to the content (as d.w. basis) of ash, moisture, carbohydrate, fat, nitrogen, protein and energy. To our knowledge, no data have previously been reported on the nutritional content of *Boletopsis leucomelaena, Boletus edulis*, *Lactarius quietus*, *Laetiporus sulphureus, Macrolepiota procera* var. *procera* and *Lactarius piperatus*, except *Hydnum repandum* and *Armillaria mellea* which are examined from a different habitat in the same Region. We hope that these results may be useful for mushroom consumption and chemotaxonomy.

Materials and Methods

Identification of mushroom species

The materials for this study were collected during field trips to the provinces of Trabzon, Giresun and Ordu in the period of August–September between 2002 and 2005 in the Black Sea Region of Turkey. At each collecting site, both ecological and morphological properties of the specimens were noted (Figure 1, Table 1). The colour, odour and other necessary properties of the mushrooms and vegetation were noted in the field. The mushroom samples were cleaned from forest debris (without washing and division into pileus and stipe) with a plastic knife, transported to the laboratory within 3-4 hrs of collection and placed temporarily in cool boxes at 0-4 °C until arrival to the laboratory. The microscopic examinations of the mushrooms were made according to method of Breitenbach and Kränzlin (14). The mushrooms were examined microscopically in the laboratory in a week after collection. Spore prints were made to determine the colour of the spores and measurements. To do this, the pileus of the mushroom was separated from the stipe and laid on a piece of glass. Microscopic examinations were performed using research microscopes with magnifications of 10x, 40x, and 100x. Lamellae were moistened by adding a few drops of potassium hydroxide solution and were sectioned. The sections were subsequently stained with cotton blue and examined. The length and breadth of the spore, hyphae, basidia and cystidia were measured. The identifications of the mushrooms were made according to method of Moser (15). After the examinations, several of the species were stored as herbal materials in plastic boxes and the rest was stored at -80°C and freeze-dried for further analyses.

Sample preparation

The freeze-dried (-80°C) mushroom samples were lyophilizated (Christ, Alpha 1-2 LD Plus, Germany) at -60 °C one week, until a constant dry weight, then the hard, dried samples were broken up with a steel hammer and then ground to a fine powder using a stainless steel mill (125 μm particle size, Cole-Parmer Analytical Mill, USA) analysed for their basic and nutrient composition and their metal content profile. At first, the samples were reduced to a fine powder (20 mesh) and submitted to chemical analysis. Samples of each species were analysed individually. All extractions and determinations were done in triplicate and the results were expressed as dry weight basis (d.w.).

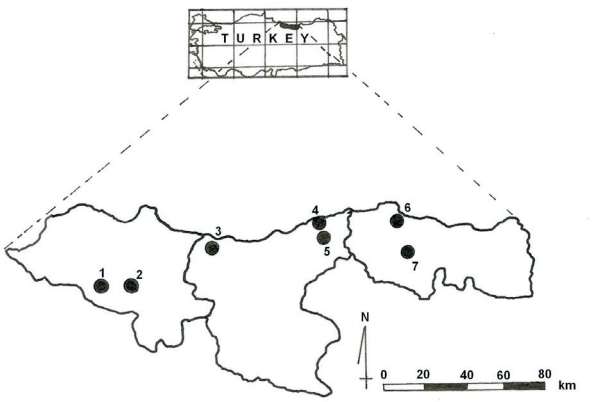


Figure 1. Location of the sampling area: 1. Aybastı, 2. Gölköy, 3. Bulancak, 4. Görele, 5. Çanakçı, 6. Akçaabat, 7. Sevinç.

Table 1. Mushroom samples collected from Black Sea region of Turkey.

No	Fungarium	Family	Species and their edibility	Habitat	Geographical location and collection date
1	SES 2292	Bankeraceae	Boletopsis leucomelaena (Pers.) Fayod, edible,	Under Picea orientalis	Ordu-Gölköy 26.08.2004
2	SES 2021	Hydnaceae	Hydnum repandum L, edible and excellent	Under Picea orientalis	Ordu-Aybastı 26.10.2005
3	SES 2220	Polyporaceae	Laetiporus sulphureus (Bull.) Murrill, edible and excellent,	On Alnus	Giresun-Bulancak 20.07.2002
4	SES 2065	Boletaceae	Boletus edulis Bull., edible and excellent	Under Abies nordmanniana	Trabzon-Akçaabat 16.07.2004
5	SES 2090	Marasmia-ceae	Armillaria mellea (Vahl) P. Kumm., edible	On Corylus	Giresun-Canakcı 18.09.2004
6	SES 2161	Agaricaceae	Macrolepiota procera (Scop.) Singer var. procera,, edible and excellent	In mixed hard-wood forest	Giresun-Görele 30.08.2002
7	SES 2050	Russulaceae	Lactarius piperatus (L.) Pers., edible and good,	In hardwood forest	Trabzon-Akçaabat-10.09.2002
8	SES 2416	Russulaceae	Lactarius quietus (Fr.) Fr., edible,	Under oaks	Maçka-Sevinç 15.09.2003

Analysis of macronutrients

Moisture content was determined according to AOAC Official Method 925.40 (16) by drying in a moisture determination apparatus (Precisa HA60) at 110 ºC until circulation was completed. Ash content was determined according to previously published method (16) from the incinerated residue obtained at 550 °C after 3 h. Total nitrogen was measured by the Kjeldahl method and then crude protein was calculated over total nitrogen with a conversion factor of 6.25 (16,17). Crude fat was gravimetrically determined after Soxhlet extraction with petroleum ether (16,18). The total carbohydrate was calculated as 100% - (% moisture + % ash + % crude protein + % fat) (16). 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 (19). All analyses were done in triplicate and the results were expressed on dry weight basis (d.w.).

Analysis of micronutrients

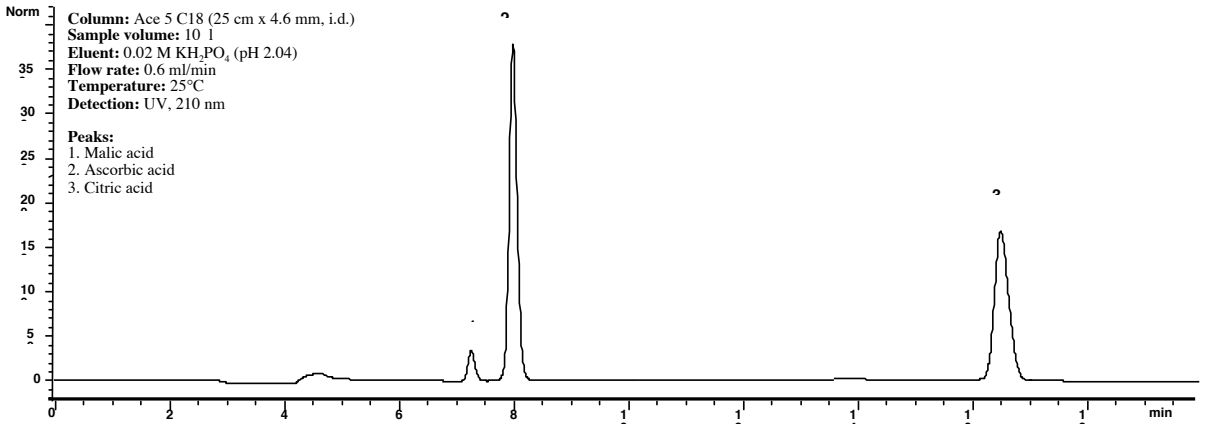
HPLC determination of organic acids

Organic acid extraction of the mushrooms specimens was carried out according to Ayaz et al. (20) and quantitative analysis of the acids were performed as described below. The HPLC system consisted of an Agilent 1100 Series instrument (Palo Alto, CA) equipped with a quaternary HPLC pump, microvacuum degasser (MVD), thermostated column compartment (TCC), UV/VIS detector, standard micro and preparative autosampler. The liquid chromatographic method used to seperate and quantify malic acid, citric acid and ascorbic acid was an isocratic procedure with UV-F visible detection at 210 nm. Separations were carried out on Ace 5 C18 (Advanced Chromatography Technologies, Aberdeen, Scotland) column (25cm x 4.6 mm i.d., 10 µm particle size). The mobile phase employed was 0.02 M potassium phosphate solution (pH 2.04). The flow rate of the mobile phase was 2 mL/min and the injection volume was 20 µL. The temperature of the column was held constant at 25 °C. The automatic injection system used was a 10 µL sample loop and organic acids were detected using a HP 1100 Series multivariable wavelength detector set at 210 nm. Standard solutions and extracts were filtered through a prefilter and finally a 0.45 µm milipore membrane before they were injected onto the column. To prevent the loss of ascorbic acid, standard solutions and extracted samples were protected from light using amber flasks. Quantitation was performed by comparing the peak areas with those of the respective external standards (Figure 2A, B). The calibration curve was plotted in the concentration range of 0.05-0.5 mg/L and based on a five-point calibration. With those three standard solutions, calibration curves for each one of the acids (malic acid; R^2= 1.00000, y=94405.59501.x + 45.24800, ascorbic acid; R^2= 0.99993, y=94405.59501.x + 45.24800, R^2=1.00000, y=9685.98240.x + 0.907071) were made, which were later used for assessing the concentrations corresponding to the different peaks in the chromatograms. The areas of peaks of compounds were quantified by the HP ChemStations software. Mean values of three replicates of three different extractions of the samples and standards were run.

FAAS determination of metal contents

Acid digestion and quantification of trace and major minerals as well as running conditions of FAAS (Flame Atomic Absorption Spectrometry) were followed ac-

(A)



(B)

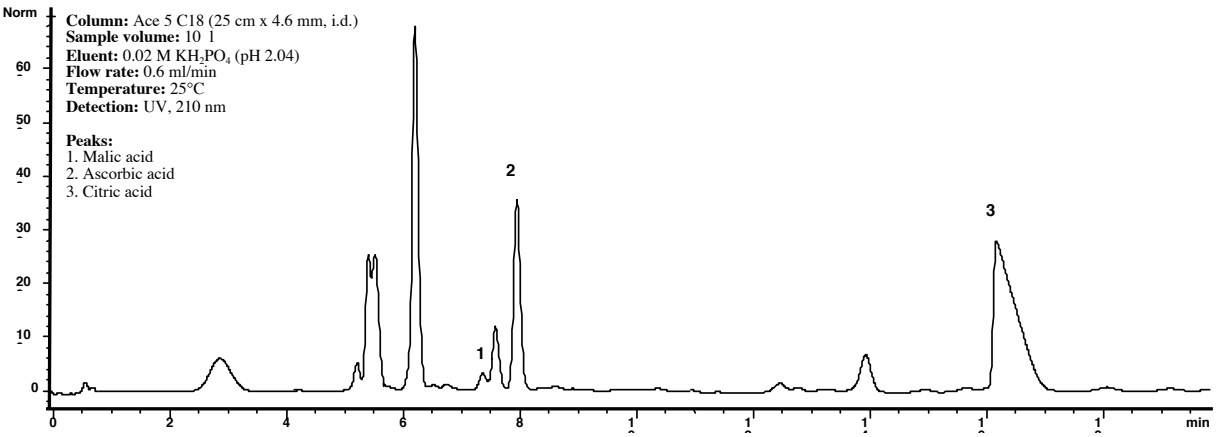


Figure 2. HPLC-UV chromatograms of standard (A) and identified organic acid compounds in Armillaria mellea (B).

cording to Colak et al. (8). In brief, dried and powdered mushroom samples were weighed in a teflon beaker between 0.5-1.0 g range and 0.1 mg sensitivity and 6 mL of HNO_3 (65%, w/w), 1 mL of H_2O_2 (30%, w/w) and 0.5 mL HF (40%, w/w) were added into the beakers. The content of the vessel was digested by microwave irradiation. The residue filtered and diluted to 25.0 mL final volume with deionized water. A blank digest was carried out in the same way. The final sample solution was analyzed by FAAS.

Results

Macronutrient profile of eight species of mushrooms

The results of the basic compositions and estimated energy values obtained for the eight muhroom species are given in Table 2. The ash ranged from 4.00 g/100 g d.w. in *L. sulphureus* and 9.20 g/100 g d.w. in *H. repandum*. The lowest (9.80 g/100 g d.w.) and the highest (13.30 g/100 g d.w.) moisture contents were recorded at *M. procera* and *L. sulphureus,* respectively. Carbohydrates, calculated by difference, were also an abundant macronutrient and ranged from 42.50 g/100 d.w. in *L. piperatus* to 67.65 g/100 g d.w. in *L. quietus*. The fat varied between 2.20 g/100 g d.w. (*B. leucomelaena*) and 5.80 g/100 g d.w. in (*L. sulphureus*). The nitrogen content was the highest in *B. edulis* (5.20 g/100 d.w.) and lowest in *A. mellea* (1.73 g/100 d.w.). Protein was found in high levels and varied between 10.80 g/100 g d.w. in *A. mellea* and 32.50 g/100 g d.w. in *B. edulis*. On the basis of the proximate analysis, it can be calculated that an edible portion of 100 g of these mushrooms provides, on average, 377 kcal/100g d.w. The highest and lowest energy values were 360 kcal/100g d.w. (*L. sulphureus*) and 289.65 kcal/100g d.w. (*L. piperatus*) (Table 2).

Organic acid composition of eight species of mushrooms

The HPLC-UV analysis showed that all of the eight mushroom samples presented a profile of at least three organic acids, which were malic, ascorbic and citric acids (see Table 2, Figure 2A, B). The highest malic acid content was found in *M. procera* var. *procera* (19.40 g/

Table 2. Proximate chemical composition, energetic value, organic acid composition and mineral content of mushrooms collected from Black Sea Region of Turkey[a].

Composition	*Boletopsis leucomelaena*	*Hydnum repandum*	*Laetiporus sulphureus*	*Boletus edulis*	*Armillaria mellea*	*Macrolepiota procera*	*Lactarius piperatus*	*Lactarius quietus*
				macronutrient profile (g/100 g dry weight)				
Ash	6.30 ± 0.40	9.20 ± 0.50	4.00±0.10	5.00±0.70	9.00±0.50	6.80±0.10	6.55±0.05	6.96±0.06
Moisture	10.25 ± 0.50	10.65 ± 0.60	13.30±0.80	12.75±0.60	13.05±0.50	9.80±0.30	13.25±0.80	10.55±0.60
Carbohydrate	58.35 ± 4.30	56.10 ± 3.00	64.90±6.20	46.95±2.80	46.95±2.80	54.70±2.80	42.50±1.60	67.65±6.50
Crude fat	2.20 ± 0.20	4.30 ± 0.10	5.85±0.15	2.85±0.20	3.40±0.30	2.40±0.20	5.80±0.20	2.30±0.10
Nitrogen	3.65 ± 0.19	3.15 ± 0.25	1.91±0.25	5.20±0.12	1.73±0.21	4.22±0.24	2.70±0.30	2.00±0.20
Protein	22.90 ± 1.20	19.70 ± 1.50	11.90±1.60	32.50±1.20	10.80±1.30	26.35±1.50	16.85±1.80	12.55±1.20
Energy[b]	344.90 ± 12.20	342.10 ± 11.60	360.00±12.80	343.50±11.90	328.70±10.60	345.70±12.30	289.65±9.60	341.50±11.40
				Organic acid (g/kg dry weight)				
Malic acid	5.91 ± 0.83	3.09 ± 0.45	3.68 ± 0.26	4.93 ± 1.12	16.85 ± 2.33	19.40 ± 0.62	9.93 ± 12.6	4.74 ± 0.73
Ascorbic acid	0.80 ± 0.11	0.11 ± 0.02	0.06 ± 0.01	4.11 ± 0.77	1.57 ± 0.08	0.77 ± 0.09	0.18 ± 0.02	0.28 ± 0.09
Citric acid	6.70 ± 0.80	6.53 ± 0.22	3.13 ± 0.51	21.48 ± 1.55	17.93 ± 0.22	40.86 ± 4.36	8.85 ± 1.19	16.14 ± 3.78
				Major minerals (mg/kg dry weight)[c,d]				
K	18.800±700	28.900±160	18.500±600	10.700±800	33.700±210	18.200±110	20.900±0.13	16.800±140
Ca	4200±300	6000±400	4200±300	3300±200	5200±300	4100±200	4100±200	4200±200
Mg	2000±100	2300±120	2100±110	2200±100	3700±200	3300±115	4800±300	5300±280
Na	425.13±21.20	318.73±16.41	285.00±13.42	322.98±15.22	363.57±13.40	173.05±10.2	145.13±9.15	346.10±20.14
				Trace minerals (mg/kg dry weight)[c,d]				
Fe	370.8±15.0	380±10	28.6 ± 1.0	440±21	200 ±12	300 ±22	940 ±32	720± 43
Mn	50.1±2.5	232.4±10.1	5.0±0.3	233.1±11.1	188.8±8.2	432.0±21.0	328.6±16.3	291.2±13.1
Zn	94.7±5.0	57.2±2.4	38.6±1.7	77.2±3.8	59.4±2.8	74.5±3.3	88.7±4.4	51.6±2.5
Cu	22.2±1.3	38.9±1.5	2.8 ±0.1	21.5±1.0	16.6±0.7	91.9±4.1	53.5±2.7	35.6±1.2
Co	n.d[e]	2.0±0.1	n.d	4.4±0.17	n.d	3.5±0.2	6.4±0.3	4.1±0.2
Ni	n.d	12.92±0.51	n.d	2.93±0.13	n.d	1.73±0.09	2.20 ±0.12	2.37±0.11
Pb	n.d	n.d	n.d	4.20±0.3	n.d	2.58±0.19	3.94±0.22	6.94±0.41
Cd	0.90±0.04	1.41±0.05	0.33±0.01	0.88±0.03	2.26±0.11	0.37±0.01	1.93±0.12	0.26±0.02

[a]Values are the averages of triplicate extractions and determinations (n=6) expressed on dry weight basis.
[b]kcal/100 g dry weight
[c]Wavelenght (nm): Fe; 248.3, Cu; 324.8, Mn; 279.5, Zn; 213.9, Co; 240.7, Ni; 232.0, Cd; 228.8, Pb; 217.0, Na; 589.0, Mg; 285.2, K; 766.5, Ca; 422.7.
[d]Detection limit (mg/L): Fe: 0.08, Cu and Mn: 0.04, Zn, Cd and Mg: 0.01, Co, Ni and Na: 0.05, K:0.25, Ca:4.00
[e] n.d: not detected

kg d.w.), whereas the lowest malic acid content was found in *H. repandum* (3.09 g/kg d.w.), respectively. The mushrooms studied showed wide variation in organic acid contents; 3.09-19.40 g/kg d.w. for malic acid, 0.06-4.11 g/kg d.w. for ascorbic acid and 3.13-40.86 g/kg d.w. for citric acid, respectively (see Table 2). Except for *B. edulis* (4.11 g/kg d.w.), the concentration of ascorbic acid in the samples was very low (see Table 2).

Micronutrient profile of eight species of mushrooms

Table 2 shows the profiles and concentrations of the major and trace mineral contents of the eight wild edible mushrooms. All metal concentrations were determined on d.w. basis (Table 2). Of the eight wild edible mushrooms analysed, the potassium content, with relatively high concentration, ranged from 10,700 mg/kg d.w. in *B. edulis* to 33,700 mg/kg d.w. in *A. mellea*. There were close differences in the content of Ca in the mushroom species. The contents of this mineral ranged from 3300 to 6000 mg/kg d.w., in *B. edulis* and *H. repandum*, respectively. The highest Mg content (5300 mg/kg d.w.) was found in *L. quietus* whereas the lowest (2000 mg/kg d.w.) was found in *B. leucomelaena*. Besides the three minerals, the Na contents were relatively low in the studied mushrooms in the present study. Minimum and maximum levels of the element were measured 145.13 and 425.13 mg/kg d.w. in *L. piperatus* and *B. leucomelaena*, respectively.

The iron content of the mushrooms studied was between 28.6 mg/kg d.w. (*L. sulphureus*) and 940 mg/kg d.w. (*L. piperatus*). Manganese (mg/kg d.w.) levels varied between 5.0 in *L. sulphureus* and 432.0 in *M. procera* var. *procera* (Table 2). Mn also accumulated at high concentrations in the majority of the present mushrooms. The highest zinc content was found in *B. leucomelaena* (94.7 mg/kg d.w.) whereas the lowest zinc content was found in *L. sulphureus* (38.6 mg/kg d.w.). The range of Cu concentrations (mg/kg d.w.) in the species were between 2.8 mg/kg d.w. in *L. sulphureus* and 91.9 mg/kg d.w. in *M. procera* var. *procera* (Table 2).

Concerning to other heavy metals (Co, Ni, Pb and Cd), no any detectable levels of Co, Ni, Pb were determined in *B. leucomelaena*, *L. sulphureus*, and *A. mellea*, with the exception of Co and Ni concentration in *H. repandum*. We found the lowest Co content in the range of 2 mg/kg d.w. in *H. repandum* and the highest in the range of 6.4 mg/kg d.w. in *L. piperatus*. The highest Ni content was observed in *H. repandum* in the present study. For the other mushroom species, its levels were between 1.73 and 2.93 mg/kg d.w. Lead levels were determined in only four mushrooms of all eight, ranging between 2.58 mg/kg d.w. in *M. procera* var. *procera* and 6.94 mg/kg d.w. in *L. quietus*. Cadmium was found in all studied mushrooms and the levels varied between 0.26 mg/kg d.w. in *L. quietus* and 2.26 mg/kg d.w. in *A. mellea* (Table 2).

Discussion

It has been stressed that nutritional profiles of mushrooms are directly affected with their moisture content depending on their harvesting time, maturation period and environmental conditions (humity, temperature, growing period, storage conditions, etc.,) (4, 7-9, 21). Recently, Colak et al. (8) have reported relatively high and low ash contents for *H. repandum* (11.38 g/100 g d.w.) and *A. mellea* (3.16 g/100 g d.w) from a different habitat of the present study. Whereas in the present study a similar content of ash for both two species were found (9.20 and 9 g/100 g d.w., Table 2). Total carbohydrate content of the same species also concurs with the literature (8) that have recently been reported. A remarkable variation in total carbohydrate content was also reported for different mushrooms species in the range between 29.70 to 65.30 mg/100 g d.w. Barros et al. (1) have attracted an attention that the wild mushrooms are rich sources of protein and had low amounts of fat making it an ideal snack material. Low fat characteristics of the edible wild mushrooms have been previously been reported by some authors in the range from 1.0 to 5.3 (3), 2.7 to 9.5 (18) and 2.70 to 27.50 (22) g/100 d.w. In the present study, the crude fat content of the mushrooms was 3.64 g/100 g d.w., on average. In his rewiev, Kalač (4) reported that nutritional value of wild growing mushrooms lipids is limited, due to a low total lipid content and low proportion of desirable *n*-3 fatty acids.The crude fat content of *H. repandum* and *A. mellea* reported from a different habitat by Colak et al. (8) were 8.80 and 6.08 g/100 d.w., respectively, being relatively low in that of the present study (4.30 and 3.40 g/100 d.w., respectively, Table 2). When compared with the present results, nitrogen content of *H. repandum* reported in the literature (8) was relatively high (5.70 g/100 d.w.), while a similar range of nitrogen content was found in the present study for *A. mellea* (3.400 g/100 d.w.). The protein values for *H. repandum* and *A. mellea* are not in well agreement with the reported data (8) because of different habitat. In addition, the protein content of all eight studied species in the present study well agreed with data reported in the literature (3, 18, 19, 23). It has been emphasized that protein content of mushrooms are affected by a number of factors, namely the type of mushrooms, the stage of development, the part sampled, level of nitrogen available and the location (24). The limits of energy value of current results (289-360 kcal/100 g d.w.) were relatively low compared to earlier report (397-493 kcal/100 g d.w.) (22). Our values for *H. repandum* and *A. mellea* studied in the present study were found lower than those reported in the literature for the same two species (434.2 and 417.6 kcal/100g d.w., respectively) (8). In his rewiev, Kalač (4) has compared values some wild-growing European mushrooms in terms of their macronutrient profiles and he concluded that there is a great variability in macronutrient profiles (% d.w.) in ash (3.5-32.5), carbohydrate (16.4-68.4), crude protein (17.2-59.4) and fat

(1.4-6.6). The data obtained in the present study are in most within these ranges with some exce Several studies reported a wide variation in the content of main organic acid composition in diverse of macrofungi species (25,26). In frozen samples of *Cantharellus cibarus* contained malic and citric acid as the main organic acids, ranged from 5 to 8 g/kg, respectively, corresponding to 85 and 15% of total organic acids (25). Valentão et al. (26) reported that *Lactarius deliciosus*, contained malic and quinic acids as the main acids which ranged from 405 to 3885.92 mg/kg d.w., 1393.17-4126.68 mg/kg d.w. in *B. edulis*, 465.67-2654.77 mg/kg d.w. in *Suillus collinitus*, while the content was 3040.97 mg/kg d.w. in *Xerocomus chrysenteron*, 3333.03 mg/kg d.w. in *Amanita caesarea*, and 3812.78 mg/kg d.w. in *Gyroporus castaneus.* They concluded that no differences were found among the three geographical origins (26). The abundance of malic acid and quinic acid with low levels of ascorbic, ketoglutaric, shikimic, e.g., were present in twenty-eight and twenty-five mushroom populations, belonging to different six and nine taxa (26,27). They concluded that different taxa contained the major organic acids in different levels. For instance they showed that *L. deliciosus* contained 65-72% malic acid, wheras *B. edulis* contained malic plus quinic acids around 66-91% and *A. caesarea* contained 56% malic acid (26). Our analyses for *Cantharellus cibarus* have revealed that malic and citric acid were the main organic acids.

K levels of studied mushrooms were sufficient for nutrition and the contents were generally in accordance with the previous studies (4,18). Reported Ca levels (mg/kg d.w.) of some species of willd growing mushrooms ranged between 4.2-19.1 (3), 100-500 (4) and 100-2400 (18) which were not in accordance with the present study. Our Ca levels were found between 3300 and 600 mg/kg d.w. The high Ca accumulation of the investigated mushroom species can be attributed to soil characteristics of the habitat.

Recently, in his rewiev, Kalač (4) have reported Mg levels in the range of 800-1800 mg/kg d.w. in a number of European wild growing mushrooms. High amounts (100-500 mg/kg) of magnesium are found in green leafy vegetables, legumes and wholegrain cereals while meat and dairy products contain lower levels of Mg (100-300 mg/kg) (28). Reported Mg values were in the range of 739-1165 and 300-1200 mg/kg d.w. (13, 29), 500-1600 mg/kg d.w. (18) and 253.1-3270 mg/kg d.w. (3). Therefore, our Mg concentrations can be regarded as high concentrations especially for the last four mushrooms listed in Table 2. In his rewiev, Kalač (4) has pointed out the low levels of this metal in a number of European mushroom species.

With regard to trace elements, their levels in mushrooms are considerably higher than vegetables, fruits and agricultural crop plants because of their effective take up mechanisms (30). In the present study, Fe and Mn were the most predominant minerals in the analysed mushrooms. The level of iron reported in this study (28.6-940 mg/kg d.w.) was relatively low (11,12,31-34) and high compared to earlier published reports (13,30,35).

Earlier, large variations in Mn levels have been reported in the range of 53.5-130 mg/kg (32), 6.20-480 mg/kg (11), 1.2-46.0 mg/kg (35) and 11.3-100 mg/kg (13). Additionally, Mn values (mg/kg d.w.) for *H. repandum* reported previously were 26.3 (13), 3.12 (12) and 24.2 (36), while in the present study the content was determined 232.4 mg/kg d.w. in the same species collected from Black Sea Region of Turkey which was relatively high.

Low, high and similar ranges for Zn content (mg/kg d.w.) from different mushroom sources have been reported in the ranges of 44.7-198, (31), 45.0-173.8 (11), 5.5-12.2 (36), 35.9-96.9 (13) and 34.4-47 (22). The limits of Zn contents evaluated from these data ranged between 5.5 and 370 mg/kg d.w. and ours were in accordance with the earlier reports. Zinc content for *H. repandum* in the literature has been reported to be in the range between 14.1 to 21.3 mg/kg d.w. (12), and 35.9 mg/kg d.w. (13) which are lower than that found in the present study fo the same species (~39-95 mg/kg d.w.). Zinc is widespread among living organisms due to its biological significance. Mushrooms are a known zinc accumulator and sporophore (32). The latter species was also reported as metal accumulator of copper (34).

Relatively low and high Cu contents (mg/kg d.w.) in previous studies for wild-growing mushrooms reported were 10-70 (4), 18.9-64.8 (31), 10.3-145 (12,32), 10.60-144.20 (11), 11.6-41.9 (36), 3.80-32.6 (13) and 8.2-19.3 (22). Recently, Ouzouni et al. (13) have reported the content of Cu in *H. repandum* in the range of 24.3 mg/kg d.w., while in the present study we have reported relatively high content of Cu in *H. repandum* (38.9 mg/kg d.w.). In the present study, the highest concentrations of Cu were found in *M. procera* var. *procera* (91.9 mg/kg d.w.) whereas the lowest copper content was found in *L. sulphureus* (2.8 mg/kg d.w.) and the rest fell the concentrations, except the lowest one, in the range of 16.6-53.55 mg/kg d.w. Our data for Cu concentrations are in agreement with some of these literatures (18.9-64.8) (19,13,31,35). The recommended dietary allowance (RDA) for adults is 0.90 mg copper/day (37). In general, Cu contents in mushrooms are higher than those in green plant and vegetables and should be considered as a nutritional source of this element (32).

In the literature, levels of Co for *H. repandum* was reported in the range from 0.10-0.33 mg/kg d.w. (12,36). However, Ouzouni et al. (13) were not determined any cobalt in *H. repandum*, while we found the metal in the range of 2.0-6.4 mg/kg d.w. in five mushrooms. Also, relatively low Co content was found in *Agaricus arvensis* in the range from <0.1-3 mg/kg d.w. (4). Nickel has been linked to lung cancer (38). The Ni contents obtained in this study are in agreement with previous studies reviewed by Yamaç et al. (11). Previously, a low and high

concentrations of Ni for *H. repandum* were reported in the range of 0.28 (13) and 58.3 (36) mg/kg d.w. that the latter is much higher than that found in the present study. Reported Ni values (mg/kg d.w.) in the literature for wild growing edible mushrooms were 44.6-127 (36), 0.4-15.9 (39), 2.73-19.4 (32), 0.4-2 (4), 1.72-24.1 (40), 44.6-127 (33).

When the present Pb concentrations are compared, the reported Pb values for mushrooms were in the range of 1-5 (4), 0.8 to 2.7 (34), 0.3-11.72 (11) and 0.05-1.37 (13) mg/kg d.w., respectively. The reported Cd values in mushrooms in the literatures were 0.9-2.5 mg/kg d.w. (31) and 0.08-0.4 mg/kg d.w. (13) and 1.2-1.5 mg/kg d.w. (22). Cadmium is known as a principal toxic metal, since inhibits many life processes (24). It can be taken up directly from water and via food and it has a tendency to accumulate in plants and animals. Mushrooms can be very rich in cadmium (36).

It has been known that 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 *(i)* and their ecosystems *(ii)* (41). It can be considered that the effect of the parameters on the accumulation of metals can easily be seen for the two species, *H. repandum* and *A. mellea*, by comparing the present and previously reported data (8). Iron and Mn values obtained for *H. repandum* and *A. mellea* in the present study are not agree with those reported by Colak et al. (8). The present values were relatively lower than those reported by the authors, 50 and 23.5 and 47 and 96.1 mg/kg d.w., respectively (8). With regard to Mn content, a ~9.9 and 2 fold increase in Mn contents for *H. repandum* and *A. mellea* were found in the present study when compared to the recent literature (8) that used to the same species from the same region but from different habitat (8). Our Zn and Cu contents did not concur with literature reported for the two same species collected from a different habitat in the same region (8). When the present results compared with the reported data, a similar range of Zn content (55 ± 8 mg/kg d.w.) for *H. repandum* and relatively high content of Zn for *A. mellea* (96.5 mg/kg d.w.) were also reported (8). For the two species, Cu content, was found moderately low for *H. repandum* (20 mg/kg d.w.) and relatively high with ~20 fold increase for the latter species, *A. mellea*, as 300 mg/kg d.w. (8).

It has been emphasized that not only the differences of species, mycelium, frutification organs but also habitat characteristics (climate, growing condition, region, distance from source of pollution and soil content, etc.,) can affect the water content, accumulation of metals and nutritional composition (23,29). Furthermore, knowledge on roles of trace elements in physiology of mushrooms is still remained lack. The levels of trace/heavy metals (such as Cd, Pb, Co, Al, etc.) in all studied species from the regions were sufficiently low and therefore pose no health risk. Toxic heavy metal concentrations of the investigated eight mushrooms in that study were found at relatively low levels compared to those of the essential elements. Some mushrooms accumulated trace elements at high ratios. The trace metal content in mushrooms is affected acidic and organic matter content of their ecosystem and soil (9,41). The results presented here show that obtained for trace elements in analyzed mushroom species were acceptable to human consumption at nutritional and toxic levels.

In conclusion, these wild edible mushroom species can be regarded as healthy foods in well-balanced diets due to their contents of functional minerals and nutrient. Mushrooms are a good source of protein and carbohydrates and their nutritional contents are nearly similar to most legumes and meat (42). They can also be used in low caloric diets for their low contents of fat. When compared to literature, it can be easily deduced from the present results that the investigated mushroom species are able to be consume as a good food source. In addition, *B. edulis* and *M. procera* were found favourable among the investigated mushrooms in terms of their protein contents. It is imperative that a nutritional database of these mushrooms is set up to retain the information on these unique species. This will assist the better management and conservation policies of this important natural resource.

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Conflict of Interest

There is no conflict of interest among the authors who contributed tho the present study.

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