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DETERMINATION OF NUTRITIONAL AND BIOACTIVE PROPERTIES IN SOME SELECTED WILD GROWING AND CULTIVATED MUSHROOMS FROM TURKEY

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ABSTRACT

This study aimed determining the contents of soluble protein, free amino acid, phenolic, flavonoid, soluble carbohydrate, sugars (glucose, fructose and sucrose) and elements in selected wild growing and cultivated mushroom species collected from various locations of Turkey. Significant differences ($P < 0.05$) were found for the contents of total free amino acid, soluble protein, phenolic, flavonoid, soluble carbohydrate and sugars. The total free amino acid, soluble protein, phenolic, flavonoid and soluble carbohydrate contents of mushrooms ranged from 33.57–126.57 mg g^{-1}, 2.77–7.55 mg g^{-1}, 28.68–157.39 mg g^{-1}, 8.55–30.66 mg g^{-1} and 59.89–343.55 mg g^{-1}, respectively. Elemental analysis showed that mushrooms contained significant amounts of potassium (1345.07–9310.17 mg kg^{-1}), phosphorus (1462.44–6159.45 mg kg^{-1}), calcium (18.78–349.15 mg kg^{-1}), sulphur (952.41–12486.63 mg kg^{-1}), iron (80.62–606.26 mg kg^{-1}), manganese (22.65–147.57 mg kg^{-1}), zinc (103.26–522.81 mg kg^{-1}) and selenium (0–115.40 mg kg^{-1}). Nutritient composition varied with mushroom species. The means of total soluble protein, total phenolic, total flavonoid, potassium, phosphorus, sulphur, chlorine, sodium, iron, calcium, manganese, selenium, zinc and copper contents in wild growing mushrooms were found higher than cultivated mushrooms.

Key words: mushrooms, soluble protein, free amino acids, phenolic and flavonoid, soluble carbohydrate, minerals

INTRODUCTION

Mushrooms are traditionally used as nutritional food, medicine and cosmetics in most of countries in the world [Sanmee et al. 2003, Hyde et al. 2010]. Nowadays, both wild edible and cultivated mushrooms, having specific taste, aroma, texture and nutritional properties, are indispensable components of the diets. They have been used in the preparation of many special dishes and as an ingredient in salads, soups, sauces and meat dishes in many world cuisines. In addition to, mushrooms have recently been considered as an attractive functional food or a nutraceutical product [Chang and Miles 2004]. They are preferred as an important and valued product both in food and pharmaceutical industries due to their important role of in human nutrition and health.

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Nutritionally, mushrooms are quite rich in proteins, essential amino acids, minerals, vitamins, carbohydrates, fibers and flavours [Mattila et al. 2001, Sadler 2003, Ouzouni et al. 2009, Caglarirmak 2011, Sun et al. 2017]. Mattila et al. [2001] have informed that the amino acid compositions of mushroom protein are comparable to that of animal proteins. So, they can be used alternative food items in elimination of protein deficiency especially in developing countries. Mushrooms are important sources of several vitamins including B-group, C, D and E [Heleno et al. 2010, Kumari et al. 2012, Reis et al. 2012]. They are recommended as valuable healthy foods for low-calorie diets due to their low fat/energy and calorie value [Wang et al. 2014]. Edible mushrooms have typical taste sourced from the existence of nonvolatile compounds covering soluble carbohydrates and free amino acids [Yang et al. 2001]. The carbohydrates constitutes the major part of mushroom nutrients and they are present mostly as polysaccharides in mushrooms. However, mono- and disaccharides are present generally at low amounts in mushrooms [Wannet et al. 2000]. Kalac [2009] reported that sugars in mushrooms consist of just a small part of the total carbohydrates. The mushrooms also contain glucose, fructose, trehalose, galactose, saccharose and mannose [Wannet et al. 2000]. They are rich in essential minerals such as phosphorus, potassium, magnesium, calcium, iron, zinc and selenium which play vital role in the human health and development [Mattila et al. 2001, Kumari and Atri 2014]. It was noted that human bodies required minimum 25 mineral elements for their health [Stein 2010]. The mushrooms are important sources for most of these elements. The insufficiency in intake of essential mineral nutrients may be cause certain diseases and negative affect on growth. Unfortunately, it is anticipated that approximately two-thirds of the world's population could be faced with risk of essential mineral deficiencies [White and Broadley 2009]. However, in some cases, both wild growing and cultivated mushrooms may accumulate high amount toxic elements or heavy metals such as aluminium, mercury, cadmium, lead, arsenic, silver, nickel and chromium which are potentially harmful for human health [Kalac and Svoboda 2000, Mleczek et al. 2016]. Accumulation of the toxic metal in mushroom body is an important problem and it can be influenced by many fungal and environmental factors. Hence, determination of toxic element levels in mushrooms is extremely important.

Furthermore, numerous studies showed medicinal and therapeutic values of mushrooms such as antitumor, antioxidant, antibacterial, antiviral, antifungal, antimicrobial, antiallergic, hypoglycemic, immunomodulating, antiatherogenic, hematological properties and cholesterol lowering activities [Barros et al. 2007, Liu et al. 2012, Lin et al. 2014]. Mushrooms are beneficial in the prevention and treatment of cancer, hypertension, cardiovascular diseases and diabetes. The mentioned these medicinal properties might be due to the presence of beneficial bioactive compounds such as polyphenols, flavonoids and carotenoids in mushrooms. Phenolic acids and flavonoids are major contributors to the antioxidant activity of mushrooms. Also, the antioxidant activity of mushrooms is usually closely correlated with their total phenolics and flavonoids [Barros et al. 2007, Ferreira et al. 2009]. Phenolic compounds existed in mushrooms have attracted great interest recently because these compounds may have an important role in the human health protection owing to their significant biological and pharmacological properties. The bioactivity of phenolic compounds is probably related to their ability to scavenge free radicals, inhibit low-density lipoprotein and oxidation chelate metals [Rodrigo and Bosco 2006]. Free radicals are responsible for the oxidative damage of proteins, nucleic acids, carbohydrates and lipids and uncontrolled production of free radicals can cause many diseases [Ferreira et al. 2009]. Determining of total phenolic and flavonoids in mushrooms is important to reveal their antioxidant activity.

Turkey has a very rich wild growing mushroom diversity because of favourable climatic conditions. Numerous edible wild mushrooms are widely consumed in Turkey as well as in many countries. They are collected seasonally by local people and sold in roadsides and local markets. They are important sources of income and food for the local residents. Turkey is also one of important wild growing mushroom exporters in the world [Peksen and Akdeniz

2012]. Wild growing edible mushrooms have been generally preferred to cultivated species for their flavour in the country. Knowledge of the nutritional composition of these mushrooms has limited. The most widely cultivated mushroom species in Turkey is *Agaricus bisporus. Pleurotus* spp. and *Lentinula edodes* are the other widely grown mushrooms in recent years [Eren and Peksen 2016]. Currently, Turkish people do not aware of nutritional and medicinal importance of cultivated and edible wild mushrooms. Determining of the nutritional value, chemical composition and bioactive properties of the commonly consumed mushrooms in Turkey will increase consumer awereness and mushroom consumption.

The study subject was to determine the contents of soluble protein, free amino acid, phenolic, flavonoid, soluble carbohydrate, sugars (glucose, fructose and sucrose) and elements in selected wild growing and cultivated mushroom species collected from various locations of Turkey.

MATERIALS AND METHODS

Supplying and preparation of mushroom samples for the analyses. Some information about wild growing and cultivated mushroom species used in the study is given in Table 1. The fruiting bodies (sporocarps) of wild edible species (*Boletus edulis*, *Craterellus cornucopioides*, *Lactarius deliciosus*, *Laetiporus sulphureus*, *Marasmius oreades*, *Morchella conica*, *Ramaria botrytis*, *Tricholoma terreum*) were collected from different geographic locations of Turkey in spring and autumn of 2015. Cultivated mushrooms (*Ganoderma lucidum*, *Hericium erinaceus*, *Lentinula edodes*, *Pleurotus ostreatus*-1, 2, 3 and 4) were sampled from different mushroom production enterprises in the same year. The taxonomic identifications of the mushroom species were made according to Phillips [1994]. Whole sporocarps (pileus + stipe) were used for analysis. All of the analyses were performed on the same mushroom sample lots with three replications. Fresh mushroom samples (~500 g for each replication of each mushroom species to use in analyses) were cut into small pieces and dried in an oven at 65°C to a constant weight. Then, the dried samples were ground into a fine powder using a laboratory mill. The ground samples were put into polyethylene bags, labelled, sealed and kept at 4°C.

Total soluble protein content. The soluble protein content of dried mushroom samples was determined according to Bradford [1976]. Approximately 0.5 g of the mushroom sample was homogenized with 5 ml of 50 mM KH_2PO_4 buffer (pH 7.0). 10 µl suspension was taken from homogenates, centrifuged at 4°C at 15000 rpm for 20 min in an Eppendorf tube and then 2.5 ml of Coomassie Brilliant Blue G-250 was added into the mixture. After 10 min standing, absorbance of each mixture was measured at 595 nm. Total soluble protein content was determined by using standard graphic prepared with bovine serum albumin and it was expressed as $mg \cdot g^{-1}$ dry weight.

Total free amino acid content. The powdered mushroom sample (0.5 g) was boiled in 10 ml of 80% ethanol. The extract obtained was centrifuged at 800 g for 15 min. The supernatant was completed to 10 ml with 80% ethanol. Then, 1 ml of extract was transferred into test tube (25 ml) and 0.1 N NaOH was added using methyl red. A 1 ml of ninhydrin reagent was added and the mixture was boiled for 20 min. Afterwards, 5 ml of ninhydrin reagent was added and it was cooled. The mixture was completed to 25 ml with distilled water. The standard was prepared by glycine and the absorbance was read at 570 nm [Moore and Stein 1948]. The total free amino acid content was expressed as $mg \cdot g^{-1}$ dry weight.

Total phenolic content. The total phenolic content of mushrooms was determined spectrophotometrically using the Folin-Ciocalteu method [Singleton et al. 1999]. 1 g of the powdered mushroom sample was diluted to 1 ml with methanol and extracted. A 2.5 ml Folin-Ciocalteu reagent (10%) was added to extract (0.5 ml) and mixed. Afterwards, 2.5 ml of 7.5% saturated sodium carbonate solution was added to this mixture and mixed thoroughly. The mixture was incubated at 45°C for 45 min in the dark. At the end of incubation, formation of blue colour was observed. Finally, absorbance of blue colour in the samples was measured at 765 nm using a spectrophotometer. For total phenolic analysis, a calibration curve was obtained by using 5 different concen-

Table 1. Mushroom species used in the study

No.	Scientific name	Family	English name	Local name	Life form	Location	Growing form	The Usage of Mushrooms
1	*Boletus edulis* Bull.: Fr.	Boletaceae	Porcini mushroom, King Bolete mushroom	Ayı mantarı	Mycorrhizal	Giresun	Wild	Food
2	*Craterellus cornucopioides* (L.) Pers.	Cantharellaceae	Black trumpet mushroom	Borazan mantarı	Saprotrophic	Samsun, Ladik	Wild	Food
3	*Ganoderma lucidum* (Curt.: Fr.) P. Karst	Ganodermataceae	Reishi mushroom	Reishi	Saprotrophic/ Parasitic	Denizli, Agroma	Cultivated	Medicinal
4	*Hericium erinaceus* (Bull.: Fr.) Pers.	Hericiaceae	Lion's mane mushroom	Aslan yelesi mantarı	Parasitic	Ondokuz Mayis University	Cultivated	Food
5	*Lactarius deliciosus* (L. ex Fr.) S.F. Gray	Russulaceae	Saffron milk cap mushroom	Kanlıca mantarı	Mycorrhizal	Giresun, Bektaş plateau	Wild	Food
6	*Laetiporus sulphureus* (Bull.: Fr.) Murr.	Polyporaceae	Sulphur shelf mushroom, Chicken of the woods mushroom	Kükürt mantarı	Saprotrophic/ Parasitic	Giresun, Bulancak	Wild	Food
7	*Lentinula edodes* (Berk.) Pegler	Tricholomataceae	Shiitake mushroom	Shiitake, Meşe mantarı	Saprotrophic	Denizli, Agroma	Cultivated	Food
8	*Marasmius oreades* (Bolt. ex Fr.) Fr.	Marasmiaceae	Scotch bonnet mushroom, Fairy ring mushroom	Cincile, Mıh tepesi	Saprotrophic	Sinop	Wild	Food
9	*Morchella conica* Pers.	Morchellaceae	Black morel mushroom	Kuzu göbeği mantarı	Mycorrhizal/ Saprotrophic	Samsun, Vezirköprü	Wild	Food
10	*Pleurotus ostreatus* (Jacq. ex Fr.) P.Kumm.-1	Pleurotaceae	Oyster mushroom	Kayın mantarı, Kavak mantarı	Saprotrophic	Giresun, Eynesil	Cultivated*	Food
11	*Pleurotus ostreatus* Jacq. ex Fr.) P.Kumm.-2	Pleurotaceae	Oyster mushroom	Kayın mantarı, Kavak mantarı	Saprotrophic	Rize	Cultivated*	Food
12	*Pleurotus ostreatus* Jacq. ex Fr.) P.Kumm.-3	Pleurotaceae	Oyster mushroom	Kayın mantarı, Kavak mantarı	Saprotrophic	Bursa	Cultivated	Food
13	*Pleurotus ostreatus* Jacq. ex Fr.) P.Kumm.-4	Pleurotaceae	Oyster mushroom	Kayın mantarı, Kavak mantarı	Saprotrophic	Rize	Cultivated*	Food
14	*Ramaria botrytis* (Pers.:Fr.) Ricken	Gomphaceae	Cauliflower coral mushroom	Pürpürüm	Mycorrhizal	Samsun, Ladik	Wild	Food
15	*Tricholoma terreum* (Schaeff.: Fr.) P.Kumm.	Tricholomataceae	Grey knight mushroom	Karakız mantarı	Mycorrhizal	Samsun, Vezirköprü	Wild	Food

*Mushrooms with the number of 10, 11 and 13 were cultivated on poplar, poplar and beech log, respectively

trations of gallic acid ranged from 0.007813 to 0.125 mg ml^{-1} as standard (R2 = 0.9993). The total phenolic content were calculated using regression equation of the curve obtained and the results were expressed as mg of gallic acid equivalents per g of dry mushroom sample.

Total flavonoid content. To determine total flavonoid content by spectrophotometrically, 10 mg of the powdered mushroom sample was diluted to 1 ml by methanol and extracted. Then, 100 µl mushroom extract was mixed with 100 µl of 20% aluminium trichloride (AlCl3) and a drop of acetic acid was added to this mixture. Total volume was completed to 5 ml with methanol. After 40 min incubation at room temperature, absorbance of pink colour in the samples was measured spectrophotometrically at 415 nm and calculated using quercetin as standard. For calibration curve, quercetin was used with 5 different concentrations range of 0.03125–0.5 mg·ml^{-1} (R2 = 0.9815). The results were calculated using regression equation of the curve obtained and expressed as mg of quercetin equivalents per g of dry mushroom sample [Kumaran and Karunakaran 2006].

Total soluble carbohydrate content. Total soluble carbohydrate content was determined using Anthrone method. Carbohydrate analysis was made as follow: 1 g of the powdered mushroom sample was placed into a 50 ml volumetric flask and 50 ml of 80% ethanol was added over it. The mixture was incubated at 4°C for 24 h. After incubation, the suspensions were filtered through Whatman No. 4 filter paper and this filtrate was used for glucose determination. To determine fructose, the remaining sample residue was incubated again in 30 ml of distilled water at 4°C for 24 h. Then, the suspension was filtered through Whatman No. 4 filter paper and the filtrate obtained was used for fructose determination. The residue from the sample used for fructose determination was incubated in 30 ml of 52% perchloric acid at 4°C for 24 h. The resulting suspension was filtered through Whatman No. 4 filter paper and the filtrate obtained was used to determine sucrose (saccharose) and total soluble carbohydrate content. The contents of total soluble carbohydrate, glucose, fructose and sucrose were determined by using standard calibration curves of glucose, fructose and sucrose [Pearson et al. 1976] and were expressed as mg g^{-1} dry weight.

Mineral element contents. The elemental analysis was performed by using energy dispersive X-ray fluorescence spectrometry (Spectro, Xepos, Ametek, Germany) [Carvalho et al. 2005]. 2.0 g dried mushroom samples were digested in solution of HNO_3. The solutions obtained after digestion were used for direct spectrophotometric analysis. Calibration was done using metal/mineral standard solutions. Content of the elements was expressed as mg kg^{-1} dry weight.

Assessment of data. The means of mushroom properties and standard deviations of the means were computed in MS Excell program over three replicates and the results were given as means ± standard deviations in tables. The results related to the contents of soluble protein, free amino acid, phenolic, flavonoid, soluble carbohydrate, sugars (glucose, fructose and sucrose) were subjected to analysis of variance (ANOVA) using JMP software program. Differences among means were evaluated by Least Significant Difference (LSD) test at $P < 0.05$ significance level.

RESULTS AND DISCUSSION

The analyses of variance showed that there were significant differences ($P < 0.05$) in terms of the total soluble protein, free amino acid, phenolic and flavonoid contents of the examined mushrooms (tab. 2). The total soluble protein content of mushrooms varied from 33.57 to 126.57 mg g^{-1}. *C. cornucopioides* had the highest total soluble protein content, followed by *M. oreades*, *P. ostreatus*-4 and *L. edodes* (>100 mg g^{-1}). However, the lowest value was determined in *P. ostreatus*-3. Generally, all of the mushrooms analysed had quite high amounts of total soluble protein. The mean contents of total soluble protein in wild growing mushrooms (95.9 mg g^{-1}) were higher than cultivated mushrooms (81.7 mg g^{-1}). Total soluble protein contents in the present study were found in agreement with the results of Turfan et al. [2016]. The protein contents of mushrooms vary depending on mushroom species/strain, the growth stage of fruiting bodies, the part sampled and the level of nitrogen present in the growth substrate/soil [Bernas et al. 2006]. The protein content and quality

Table 2. Total soluble protein, total free amino acid, total phenolic and total flavonoid contents of selected wild growing and cultivated mushroom species

Mushroom species	Total soluble protein (mg g^{-1})	Total free amino acid (mg g^{-1})	Total phenolics (mg g^{-1})	Total flavonoids (mg g^{-1})
B. edulis	91.45 ±0.15 e	3.58 ±0.17 ef	157.39 ±0.18 a	25.71 ±0.14 c
C. cornucopioides	126.57 ±0.16 a	6.64 ±0.16 bc	37.47 ±0.11 l	8.83 ±0.09 l
G. lucidium	83.68 ±0.18 i	3.14 ±0.05 ef	55.47 ±0.15 j	30.66 ±0.22 a
H. erinaceus	86.27 ±0.11 g	7.25 ±0.10 abc	36.57 ±0.21 m	9.72 ±0.02 k
L. deliciosus	88.84 ±0.07 f	2.77 ±0.03 f	62.58 ±0.18 i	22.64 ±0.09 e
L. sulphureus	83.27 ±0.16 i	3.63 ±0.15 e	28.68 ±0.14 n	12.81 ±0.12 h
L. edodes	101.50 ±0.13 d	6.57 ±0.16 c	37.14 ±0.05 l	11.58 ±0.05 i
M. oreades	121.70 ±0.11 b	7.55 ±0.11 a	144.48 ±0.93 c	27.85 ±0.05 b
M. conica	84.57 ±0.17 h	6.75 ±0.03 abc	77.65 ±0.15 g	20.23 ±0.10 f
P. ostreatus-1	75.73 ±0.19 k	4.70 ±1.06 d	53.68 ±0.26 k	8.55 ±0.13 l
P. ostreatus-2	82.45 ±0.18 j	7.43 ±0.13 ab	112.29 ±0.13 f	11.21 ±0.09 j
P. ostreatus-3	33.57 ±0.24 l	2.83 ±0.05 ef	122.68 ±0.15 d	19.81 ±0.11 g
P. ostreatus-4	108.66 ±0.10 c	7.42 ±0.11 ab	119.68 ±0.10 e	9.40 ±0.12 k
R. botrytis	84.50 ±0.15 h	3.45 ±0.05 ef	152.86 ±0.17 b	23.64 ±0.14 d
T. terreum	86.41 ±0.14 g	2.87 ±0.05 ef	70.41 ±0.19 h	23.34 ±0.11 d

Means indicated with different letters within same column are significantly different ($P < 0.05$)

Table 3. Total soluble carbohydrates and sugars (glucose, fructose and sucrose) contents of selected wild growing and cultivated mushroom species

Mushroom species	Glucose (mg g^{-1})	Fructose (mg g^{-1})	Sucrose (mg g^{-1})	Total soluble carbohydrates (mg g^{-1})
B. edulis	19.48 ±0.12 j	0.39 ±0.01 k	15.69 ±0.15 a	129.51 ±0.21 m
C. cornucopioides	51.62 ±0.12 a	9.23 ±0.11 c	1.83 ±0.10 i	343.55 ±0.18 a
G. lucidium	37.55 ±0.15 h	1.09 ±0.02 i	0.26 ±0.01 k	245.42 ±0.15 j
H. erinaceus	48.42 ±0.16 b	9.81 ±0.11 b	0.22 ±0.01 k	322.93 ±0.08 b
L. deliciosus	41.43 ±0.17 e	6.39 ±0.12 d	5.20 ±0.05 f	275.54 ±0.22 e
L. sulphureus	40.49 ±0.21 f	6.31 ±0.14 de	0.32 ±0.00 k	266.82 ±0.41 f
L. edodes	38.85 ±0.09 g	13.47 ±0.04 a	1.28 ±0.01 j	259.61 ±0.18 g
M. oreades	37.65 ±0.22 h	0.67 ±0.01 j	4.24 ±0.11 g	250.68 ±0.17 i
M. conica	42.55 ±0.15 c	6.13 ±0.07 e	5.58 ±0.02 e	281.69 ±0.14 c
P. ostreatus-1	38.70 ±0.07 g	2.80 ±0.05 h	2.85 ±0.07 h	257.51 ±0.20 h
P. ostreatus-2	33.36 ±0.10 i	0.05 ±0.01 l	12.13 ±0.02 b	222.61 ±0.19 l
P. ostreatus-3	8.96 ±0.08 l	0.33 ±0.01 k	10.90 ±0.06 c	59.89 ±0.15 o
P. ostreatus-4	41.90 ±0.03 d	4.71 ±0.14 g	12.17 ±0.11 b	279.32 ±0.16 d
R. botrytis	16.29 ±0.14 k	2.61 ±0.03 h	6.76 ±0.12 d	107.57 ±0.15 n
T. terreum	33.45 ±0.17 i	5.47 ±0.19 f	5.48 ±0.11 e	223.14 ±0.08 k

Means indicated with different letters within same column are significantly different ($P < 0.05$)

of mushrooms is higher than vegetables [Jiskani 2001]. Mushrooms with high protein content could be consumed as alternative protein sources to fish and meat particularly in rural areas.

Total free amino acid content varied between 2.77 (*L. deliciosus*) and 7.55 mg g^{-1} (*M. oreades*) depending on the mushroom species. The free amino acids existed in mushrooms contribute to their characteristic flavour [Yang et al. 2001]. The free amino acid content of edible and medicinal Korean mushrooms [Kim et al. 2009] were higher than means determined in the present study.

The mushrooms investigated in this study had quite high total phenolic content. Total phenolic contents of the mushrooms changed between 28.68 and 157.39 mg g^{-1} and were in the following decreasing order: *B. edulis* > *R. botrytis* > *M. oreades* > *P. ostreatus*-3 > *P. ostreatus*-4 > *P. ostreatus*-2 > *M. conica* > *T. terreum* > *L. deliciosus* > *G. lucidium* > *P. ostreatus*-1 > *C. cornucopioides* > *L. edodes* > *H. erinaceus* > *L. sulphureus*. Total phenolic content recorded in *B. edulis*, *R. botrytis M. oreades* and *P. ostreatus*-3, 4 and 2 were higher than 100 mg g^{-1}. The total phenolic content in *B. edulis* was almost five times higher than that in *L. sulphureus*. The total flavonoid content in the mushrooms analyzed varied from 8.55 mg g^{-1} in *P. ostreatus*-1 to 30.66 mg g^{-1} in *G. lucidium*. Relatively higher total flavonoid contents were determined in *G. lucidium*, *M. oreades*, *B. edulis*, *R. botrytis*, *T. terreum*, *L. deliciosus* and *M. conica* (above 20 mg g^{-1}) as compared to other species. The mean contents of total phenolic and flavonoid in wild growing mushrooms were found to be higher than cultivated mushrooms. Similarly to our results, *B. edulis* showed the highest total phenolic content among different mushrooms in the study conducted by Palacios et al. [2011]. Total phenolic contents in mushrooms obtained in the range of 4.45–14.44 mg GAE g^{-1} [Abugri and McElhenney 2013] and 4.94–35.56 mg GAE g^{-1} [Alispahic et al. 2015]. Our findings related on total phenolic content was found in agreement with the results of Orhan and Ustun [2011] for selected edible mushrooms from Turkey. On the contrary, the values obtained for total phenolic and flavonoid contents in the present study were higher than the results of Sarikurkcu et al. [2008] and Gursoy et al. [2009]. Some researchers reported that the flavonoid contents ranged from 0.9 to 3.0 mg g^{-1} of dried matter in eight types of edible mushrooms [Palacios et al. 2011], and 4.26 to 349.60 mg g^{-1} in mycelium cultures of culinary-medicinal mushrooms [Jeong et al. 2013]. Mushroom species/strain, growing conditions, environmental factors, harvesting time, storage conditions, ways of expressing the results, extraction and analytical methods may affect contents of total phenolic and flavonoids. The antioxidant activity of mushrooms is usually closely related with total phenolic and flavonoid contents [Barros et al. 2007, Ferreira et al. 2009]. The consumption of mushrooms contained high levels of total phenolic and flavonoid such as *B. edulis*, *R. botrytis*, *M. oreades and P. ostreatus*-3 can potentially protects the human body against various diseases due to their important antioxidant activity. Polyphenolic compounds have inhibitory effects on carcinogenesis and mutagenesis in humans, when up to 1.0 g is ingested daily [Tanaka et al. 1998].

As seen in Table 3, there were significant differences ($P < 0.05$) in terms of total soluble carbohydrates, glucose, fructose and sucrose (saccharose) contents among mushroom species. Glucose, fructose and sucrose contents of the mushrooms ranged from 8.96–51.62 mg g^{-1}, 0.05–13.47 mg g^{-1} and 0.22–15.69 mg g^{-1}, respectively. The highest glucose, fructose and sucrose contents were determined in *C. cornucopioides*, *L. edodes* and *B. edulis*, respectively. In relation to the individual sugar composition, glucose was the most abundant sugar detected in all of the mushrooms evaluated except for *P. ostreatus*-3. The mean contents of individual sugars among investigated mushrooms were in the descending order as glucose > sucrose > fructose. The amount of glucose in the mushrooms was about seven times higher than that of fructose. Among the mushroom species analysed, *C. cornucopioides* had the highest total soluble carbohydrate content (343.55 mg g^{-1}), with the highest level of glucose (51.62 mg g^{-1}). This was followed closely by *H. erinaceus* with a value of 322.93 mg g^{-1}. On the other hand, the lowest total soluble carbohydrate content (59.89 mg g^{-1}) was

exhibited by *P. ostreatus*-3, which was considerably lower than that of other mushrooms. Tsai et al. [2009] reported the presence of myo-inositol, trehalose, mannitol, arabitol and glucose in samples from Taiwan. Whereas, Reis et al. [2012] stated that not found glucose, mannose, myo-inositol or arabitol in the studied cultivated sample. The individual sugar composition and total soluble carbohydrate content of mushrooms can be affected by parameters including genetic factors, the development stage of fruiting body, pre- and post-harvest conditions.

The glucose, fructose and sucrose contents obtained in this study were in accordance with the findings of previous results [Kim et al. 2009, Tsai et al. 2009]. Our findings related to the total soluble carbohydrate content were in line with the results of Tsai et al. [2009], but higher than those reported by Kim et al. [2009] for some edible and medicinal mushrooms. Mannitol and trehalose was found to be the most widespread free sugars for many mushrooms [Kalac 2009]. The total soluble carbohydrate and sugar contents of mushrooms can be contribute to their sweet taste. So, the fairly high levels of sugars in especially edible mushrooms is a desirable characteristic.

The contents of some elements showing a great variations in wild growing and cultivated mushrooms are given in Table 4. The differences for the element contents may be depend on genetic factors, mushroom species/strain, growing conditions, environmental factors, geographical variations, the development stage of fruiting body during harvesting, part of the mushroom used, storage conditions after harvesting, the element content of soil/substrate and analytical methods [Mattila et al. 2001, Falandysz et al. 2008]. Variability within a mushrooms species for the chemical composition is greater than that of plants, much more so than within cultivars of a crop [Mleczek et al. 2016].

The most abundant element among the determined elements was potassium and this was followed by sulphur, phosphorus and chlorine (tab. 4). Potassium contents of various mushrooms were also found the highest by some researchers [Falandysz et al. 2001, Kalac 2009, Genccelep et al. 2009]. However, niobium, iodine, silver, bismuth, lanthanum and barium were absent or present at very low amounts in the mushrooms analyzed. In addition to, germanium were not detected in any of the mushroom species.

As shown in Table 4, potassium content of mushrooms had high variability ranged from 1345.07 to 9310.17 mg kg^{-1}. Among the mushroom species, *C. cornucopioides* had the highest potassium content, followed by *T. terreum*. On the other hand, the lowest potassium content was determined in *G. lucidium*. The level of potassium of *C. cornucopioides* was almost seven times high than that of *G. lucidium*. In previous studies, the potassium content was within the range of 9973.8–51000 mg kg^{-1} for various edible mushrooms from Turkey [Demirbas 2001, Dursun et al. 2006, Genccelep et al. 2009, Turhan et al. 2010]. Our values for potassium content were clearly lower than that of these researchers. The recommended daily intake (RDI) of potassium for adults is changed from 3500 to 4700 mg day^{-1} [FDA 2013]. These mushrooms could help to meet the daily potassium requirement.

The sulphur was the second major mineral element found in the mushrooms and the mushrooms contained remarkably high amount of sulphur, in excess of 952 mg kg^{-1}. *B. edulis* contained the highest sulphur value (12486.63 mg kg^{-1}), while *L. sulphureus* had the lowest value (952.41 mg kg^{-1}) (tab. 4).

All of the mushrooms had reasonably high amounts of phosphorus. The highest phosphorus content was determined to be 6159.45 mg kg^{-1} in *M. oreades*, whereas phosphorus content in *C. cornucopioides* (1462.44 mg kg^{-1}) was found to be much lower than other species (tab. 4). The phosphorus values obtained in this study were similar to results reported by Dursun et al. [2006] and Genccelep et al. [2009]. Considering the recommended daily intake of phosphorus (1000 mg day^{-1}) for adults [FDA 2013], these mushrooms could contribute substantially to the RDI.

The magnesium contents of different mushroom species were highly close to each other and ranged between 12.77 (*H. erinaceus*) and 26.83 mg kg^{-1} (*P. ostreatus*-3) (tab. 4). The magnesium contents of mushrooms detected in the present study were highly low compared to earlier reports [Demirbas 2001, Dursun et al. 2006, Genccelep et al. 2009]. For adults, the RDI value of magnesium is 400 mg day^{-1} [FDA 2013].

The calcium contents of mushrooms showed a wide range of variation from 18.78 to 349.15 mg kg^{-1}. The minimum and maximum values for calcium were determined in *M. conica* and *L. sulphureus*, respectively. The calcium value of *M. conica* was considerably higher than that of the other species (tab. 4). The calcium levels obtained in this study were parallel to earlier reports [Demirbas 2001, Dursun et al. 2006]. The RDI suggested for males and females is 1000 mg day^{-1} [Otten et al. 2006, FDA 2013]. The calcium amounts in the mushrooms analyzed except for *M. conica* was not sufficient to meet Ca requirements. Therefore, supplementation with calcium of the diet is required.

The sodium contents of mushrooms were rather similar to each other, ranging from 6.46 (*G. lucidium*) to 11.23 (*B. edulis*) mg kg^{-1} (tab. 4). The sodium contents obtained in this study were lower than that of in the previous studies [Demirbas 2001, Dursun et al. 2006, Genccelep et al. 2009]. The daily sodium requirement for adults is 1500 mg [Otten et al. 2006]. But, sodium values obtained from these mushrooms were highly low to meet the RDI. On the other hand, these mushrooms could be said to be nutritionally beneficial foods especially for hypertension patients.

According to Table 4, the chlorine values of the mushrooms varied from 175.44 mg kg^{-1} in *H. erinaceus* to 4005.12 mg kg^{-1} in *C. cornucopioides*. All of the mushrooms also contained nutritionally significant amounts of zinc. *M. conica* and *M. oreades* possessed considerably high amounts of zinc (>520 mg kg^{-1}), while *G. lucidium* (103.26 mg kg^{-1}) contained the lowest level of zinc. Our findings for zinc were in agreement with the results reported previously [Demirbas 2001, Dursun et al. 2006, Yamac et al. 2007, Turhan et al. 2010, Obodai et al. 2014]. Otten et al. [2006] reported that the RDI of zinc for adult males and females suggested is 8 and 11 mg day^{-1}, respectively. This implies that these mushrooms are excellent sources of zinc.

With regard to manganese, *C. cornucopioides* (147.57 mg kg^{-1}), *R. botrytis* (135.55 mg kg^{-1}) and *M. conica* (117.30 mg kg^{-1}) were richer regarding manganese content than the other species, while the lowest manganese content was observed in *P. ostreatus*-1 (22.65 mg kg^{-1}) (tab. 4). In previous studies, the manganese content was found in a wide range from 3.0 to 480 mg kg^{-1} for various edible mushrooms from Turkey [Demirbas 2001, Dursun et al. 2006, Yamac et al. 2007, Genccelep et al. 2009, Turhan et al. 2010]. For adult males and females, the RDI of manganese is 1.8 and 2.3 mg day^{-1}, respectively [Otten et al. 2006]. This means that these mushrooms contain also significiant amounts of manganese to meet the RDI.

All of the analyzed mushrooms had considerable amounts of iron. *T. terreum* was the richest for iron with the content of 606.26 mg kg^{-1}. It was closely followed by *C. cornucopioides*. However, the iron content was the lowest in *L. sulphureus* (80.62 mg kg^{-1}) (tab. 4). Iron is a very important trace element for hemoglobin formation and its deficiency leads to anemia, which influences more than one billion people in the world [Trowbridge and Martorell 2002]. Therefore, these mushrooms with high level of Fe could be used in diets to reduce anemia problem widely seen in Turkey. These mushrooms are also important foods for the vegetarians to meet adequate iron in diet. Otten et al. [2006] reported that the RDI of iron for adult females and males is 8 and 18 mg day^{-1}, respectively. Iron levels of various mushrooms from Turkey were found in the ranges of 33.5–596 mg kg^{-1} [Demirbas 2001], 50.1–842 mg kg^{-1} [Genccelep et al. 2009], 64.09–2970.56 mg kg^{-1} [Turhan et al. 2010] and 52.43–340.34 mg kg^{-1} [Georgescu and Busuioc 2011].

The maximum and minimum copper contents were obtained from *M. oreades* (256.26 mg kg^{-1}) and *L. sulphureus* (14.35 mg kg^{-1}), respectively (tab. 4). The amount of copper accumulated in mushrooms is usually 100–300 mg kg^{-1} and it is not considered as risk for health [Kalac and Svoboda 2000]. The copper contents of various mushrooms have been reported in the range of 5.11–92.5 [Demirbas 2001], 10.60–144.20 [Yamac et al. 2007], 9.23–107 [Genccelep et al. 2009] and 12.67–99.08 mg kg^{-1} [Turhan et al. 2010]. The RDI value of copper is 2 mg day^{-1} [FDA 2013]. Copper intake excessively into human body may be cause some health problems.

Table 4. The element contents of selected wild growing and cultivated mushroom species

Mushroom species	Element contents (mg kg^{-1})								
	Ag	Al	As	Ba	Bi	Br	Ca	Cd	Cl
B. edulis	nd	41.84 ±0.11	4.90 ±0.015	nd	nd	220.11 ±0.20	48.45 ±0.58	0.87 ±0.004	3012.65 ±32.535
C. cornucopioides	nd	177.54 ±0.52	9.26 ±0.004	nd	nd	13.50 ±0.012	163.64 ±0.95	1.59 ±0.021	4005.12 ±17.681
G. lucidium	nd	19.95 ±0.29	1.10 ±0.001	nd	nd	4.96 ±0.06	246.21 ±0.69	0.13 ±0.003	741.16 ±10.150
H. erinaceus	0.000076 ±1E-06	25.07 ±0.15	4.13 ±0.004	nd	nd	5.71 ±0.011	23.06 ±1.06	0.28 ±0.006	175.44 ±5.780
L. deliciosus	0.00001 ±5E-05	42.82 ±0.40	17.50 ±0.05	0.000368±1E-06	nd	11.18 ±0.017	102.03 ±1.12	0.99 ±0.010	429.14 ±4.539
L. sulphureus	0.000023 ±7E-07	27.96 ±0.18	2.04 ±0.002	nd	0.000079 ±1E-06	6.88 ±0.058	18.78 ±0.06	0.41 ±0.020	285.89 ±9.851
L. edodes	nd	31.92 ±0.41	8.50 ±0.013	nd	nd	7.13 ±0.021	101.23 ±0.59	0.52 ±0.028	2782.33 ±29.577
M. oreades	nd	67.47 ±0.51	10.04 ±0.003	nd	nd	41.47 ±0.17	242.53 ±0.68	0.08 ±0.003	1495.32 ±17.217
M. conica	0.000092 ±1E-06	65.84 ±0.34	6.98 ±0.002	0.000324±3E-06	nd	19.20 ±0.12	117.99 ±0.59	1.05 ±0.035	403.01 ±13.995
P. ostreatus-1	0.000066 ±3E-06	29.15 ±0.22	5.83 ±0.004	nd	nd	6.84 ±0.046	39.60 ±0.17	1.00 ±0.021	482.08 ±4.996
P. ostreatus-2	0.000058 ±4E-07	47.74 ±0.31	3.74 ±0.009	nd	nd	10.48 ±0.40	83.20 ±1.23	2.41 ±0.010	384.35 ±12.539
P. ostreatus-3	0.000069 ±6E-07	29.08 ±0.21	5.65 ±0.005	nd	nd	6.55 ±0.029	47.35 ±0.40	1.91 ±0.010	284.84 ±4.950
P. ostreatus-4	nd	35.67 ±0.25	3.10 ±0.044	nd	nd	11.34 ±0.040	159.17 ±2.06	2.23 ±0.020	442.60 ±6.490
R. botrytis	nd	46.46 ±0.16	92.93 ±0.01	0.000212±2E-06	nd	114.75 ±0.23	80.56 ±0.73	1.56 ±0.047	1204.51 ±15.750
T. terreum	nd	88.89 ±0.36	5.42 ±0.004	nd	nd	8.39 ±0.058	349.15 ±3.12	0.65 ±0.040	440.37 ±7.275

Mushroom species	Element contents (mg kg^{-1})								
	Co	Cr	Cu	Fe	Ga	Ge	Hg	Hf	I
B. edulis	1.76 ±0.035	4.72 ±0.20	109.13 ±0.139	148.34 ±1.04	nd	nd	8.57 ±0.031	4.48 ±0.010	nd
C. cornucopioides	0.90 ±0.001	11.01 ±0.01	108.53 ±0.084	598.33 ±1.03	4.63 ±0.01	nd	1.35 ±0.020	2.68 ±0.005	nd
G. lucidium	2.17 ±0.060	4.92 ±0.050	37.00 ±0.605	109.42 ±0.28	2.63 ±0.005	nd	3.20 ±0.111	3.97 ±0.020	nd
H. erinaceus	2.19 ±0.005	44.00 ±0.660	62.42 ±0.102	96.77 ±0.21	nd	nd	2.02 ±0.012	4.81 ±0.010	nd
L. deliciosus	1.73 ±0.025	5.83 ±0.145	31.22 ±0.121	293.66 ±1.53	1.44 ±0.007	nd	3.35 ±0.080	3.49 ±0.020	nd
L. sulphureus	1.76 ±0.040	4.03 ±0.030	14.35 ±0.108	80.62 ±0.54	37.73 ±0.01	nd	3.35 ±0.077	3.69 ±0.024	0.000158 ±1E-06
L. edodes	1.85 ±0.040	5.52 ±0.030	22.01 ±0.158	286.09 ±1.03	1.79 ±0.004	nd	2.26 ±0.008	4.20 ±0.040	0.000115 ±1.1E-06
M. oreades	0.83 ±0.030	5.36 ±0.100	256.26 ±0.357	578.68 ±1.93	11.70 ±0.013	nd	4.45 ±0.067	4.44 ±0.029	nd
M. conica	1.07 ±0.020	9.33 ±0.100	74.38 ±0.161	335.00 ±0.17	2.05 ±0.002	nd	nd	2.69 ±0.005	nd
P. ostreatus-1	2.15 ±0.045	4.03 ±0.030	19.37 ±0.132	160.81 ±0.68	2.03 ±0.050	nd	2.79 ±0.017	3.79 ±0.010	nd
P. ostreatus-2	0.41 ±0.012	7.02 ±0.035	38.76 ±0.144	391.35 ±0.81	1.70 ±0.009	nd	nd	3.18 ±0.025	nd
P. ostreatus-3	2.07 ±0.046	4.75 ±0.100	28.45 ±0.050	168.37 ±0.88	1.27 ±0.006	nd	3.70 ±0.040	4.85 ±0.027	nd
P. ostreatus-4	1.13 ±0.021	6.03 ±0.030	31.20 ±0.137	193.69 ±1.00	nd	nd	nd	4.19 ±0.010	nd
R. botrytis	2.88 ±0.085	9.38 ±0.070	111.18 ±0.24	203.68 ±0.88	2.18 ±0.003	nd	5.14 ±0.132	3.21 ±0.005	nd
T. terreum	1.30 ±0.050	8.66 ±0.060	97.96 ±0.035	606.26 ±0.17	22.05 ±0.300	nd	0.41 ±0.092	3.48 ±0.030	0.000176 ±1E-06

Mushroom species	Element contents (mg kg^{-1})									
	K	La	Mg	Mn	Mo	Na	Nb	Nd	Ni	P
B. edulis	5471.86 ±11.12	2.14 ±0.05	17.43 ±0.9	33.34 ±0.10	5.78 ±0.017	11.23 ±0.5	0.0000304 ±1E-06	2.79 ±0.005	11.73 ±0.23	3006.10 ±9.32
C. cornucopioides	9310.17 ±14.67	nd	17.60 ±0.7	147.57 ±0.26	0.72 ±0.031	9.98 ±0.3	0.0000512 ±3E-06	3.53 ±0.001	10.29 ±0.57	1462.44 ±3.85
G. lucidium	1345.07 ±9.27	1.71 ±0.01	16.19 ±0.5	25.55 ±0.11	0.15 ±0.020	6.46 ±0.1	nd	1.96 ±0.001	10.29 ±0.32	1662.06 ±9.87
H. erinaceus	4572.73 ±11.17	2.45 ±0.02	12.77 ±0.3	28.56 ±0.18	0.36 ±0.010	6.99 ±0.6	nd	1.59 ±0.000	10.10 ±0.41	2121.17 ±6.16
L. deliciosus	4848.35 ±6.18	nd	17.36 ±0.5	66.05 ±0.15	1.24 ±0.019	8.67 ±0.1	0.000002 ±1E-06	3.37 ±0.002	10.39 ±0.33	2162.92 ±3.56
L. sulphureus	5752.54 ±8.32	nd	16.86 ±0.9	99.49 ±0.41	0.71 ±0.038	8.00 ±0.3	nd	11.53 ±005	9.54 ±0.15	1524.50 ±4.32
L. edodes	5346.11 ±10.56	nd	24.78 ±1.0	71.12 ±0.14	0.23 ±0.022	8.25 ±0.1	0.0000044 ±1E-06	2.89 ±0.001	9.55 ±0.27	3061.48 ±9.32
M. oreades	5631.02 ±4.18	nd	24.71 ±1.1	97.34 ±0.20	1.15 ±0.180	9.83 ±0.5	nd	3.19 ±0.002	9.91 ±0.41	6159.45 ±10.27
M. conica	7399.77 ±22.12	2.47 ±0.01	26.31 ±0.8	117.30 ±0.19	0.85 ±0.031	6.81 ±0.2	0.0000197 ±1E-06	2.98 ±0.001	12.18 ±0.17	5947.36 ±9.67
P. ostreatus-1	5513.58 ±3.67	nd	21.22 ±0.9	22.65 ±0.15	0.80 ±0.016	8.44 ±0.1	0.0000142 ±2E-06	1.81 ±0.003	9.10 ±0.67	2531.34 ±6.38
P. ostreatus-2	5040.51 ±20.16	nd	25.94 ±0.5	50.74 ±0.22	0.72 ±0.012	7.65 ±0.5	nd	3.25 ±0.001	10.83 ±0.50	3276.97 ±8.17
P. ostreatus-3	4454.06 ±6.87	1.97 ±0.03	26.83 ±0.7	31.25 ±0.09	0.77 ±0.013	8.48 ±0.6	0.000026 ±2E-06	2.08 ±0.00	10.15 ±0.47	2498.50 ±5.64
P. ostreatus-4	5146.64 ±9.17	4.94 ±0.05	24.11 ±1.1	76.20 ±0.16	1.29 ±0.035	7.73 ±0.4	nd	3.47 ±0.001	10.44 ±0.19	2407.23 ±10.01
R. botrytis	7766.46 ±3.87	nd	24.07 ±1.5	135.55 ±0.32	0.50 ±0.010	9.83 ±0.1	nd	5.64 ±0.004	28.55 ±0.31	2386.51 ±11.01
T. terreum	8579.85 ±9.11	nd	23.92 ±0.9	37.89 ±0.10	0.43 ±0.012	8.02 ±0.5	0.0000349 ±1E-06	2.83 ±0.003	10.14 ±0.22	2718.40 ±4.27

Mushroom species	Element contents (mg kg^{-1})									
	Pb	Pr	Rb	S	Sb	Se	Si	Sn	Sr	Ta
B. edulis	nd	1.81 ±0.01	1605.69 ±1.51	12486.63 ±24.87	2.81 ±0.005	115.40 ±24.00	58.25 ±10.50	7.82 ±0.03	16.66 ±3.12	27.51 ±0.11
C. cornucopioides	4.00 ±0.025	1.26 ±0.08	590.06 ±0.99	1067.34 ±17.12	3.19 ±0.001	nd	1829.56 ±14.64	7.96 ±0.01	124.96 ±12.17	25.67 ±0.14
G. lucidium	3.87 ±0.081	0.79 ±0.01	29.08 ±0.68	1789.93 ±10.11	2.16 ±0.004	2.47 ±1.14	31.10 ±1.27	4.74 ±0.005	40.65 ±4.50	21.63 ±0.10
H. erinaceus	1.13 ±0.036	0.82 ±0.005	122.70 ±0.57	1162.63 ±10.57	2.86 ±0.002	1.75 ±1.40	46.43 ±9.32	5.48 ±0.02	8.43 ±1.60	25.68 ±0.09
L. deliciosus	1.34 ±0.050	1.28 ±0.01	462.31 ±1.03	1362.07 ±9.87	4.58 ±0.003	8.75 ±3.30	173.19 ±6.17	8.66 ±0.03	29.61 ±1.00	30.12 ±0.16
L. sulphureus	2.45 ±0.010	1.18 ±0.02	50.87 ±0.67	952.41 ±9.87	2.92 ±0.001	2.66 ±1.00	35.70 ±8.59	5.49 ±0.01	11.70 ±2.20	22.33 ±0.08
L. edodes	2.28 ±0.030	1.44 ±0.01	230.35 ±0.82	4389.62 ±6.51	4.43 ±0.007	1.85 ±0.30	55.23 ±10.02	5.86 ±0.004	24.00 ±1.23	24.32 ±0.22
M. oreades	nd	1.62 ±0.04	50.89 ±0.50	10235.68 ±15.12	4.68 ±0.005	11.26 ±0.17	260.62 ±30.29	7.43 ±0.02	133.64 ±24.01	26.49 ±010
M. conica	0.31 ±0.002	1.23 ±0.01	106.11 ±0.98	3550.92 ±9.32	3.11 ±0.002	0.47 ±0.23	392.80 ±23.67	7.13 ±0.01	116.84 ±18.00	25.86 ±0.20
P. ostreatus-1	1.63 ±0.420	1.43 ±0.005	136.24 ±0.99	2449.14 ±8.57	3.92 ±0.001	9.97 ±0.40	40.39 ±1.05	7.52 ±0.005	9.55 ±0.35	26.89 ±0.05
P. ostreatus-2	nd	2.17 ±0.02	417.22 ±1.01	2353.92 ±5.67	4.46 ±0.003	0.01 ±0.001	156.23 ±20.37	7.75 ±0.01	73.50 ±3.27	31.55 ±0.30
P. ostreatus-3	nd	0.76 ±0.03	21.58 ±0.50	3204.11 ±10.41	3.62 ±0.001	2.69 ±1.21	49.66 ±5.92	6.25 ±0.02	8.22 ±1.10	29.09 ±0.90
P. ostreatus-4	nd	1.18 ±0.01	761.94 ±0.86	2268.98 ±6.37	4.46 ±0.001	nd	91.65 ±9.52	8.30 ±0.03	45.23 ±10.17	34.10 ±0.01
R. botrytis	1.63 ±0.020	1.25 ±0.01	9751.90 ±1.53	3257.19 ±6.89	3.83 ±0.004	21.68 ±2.57	207.19 ±4.19	7.47 ±0.02	36.37 ±4.50	29.78 ±0.25
T. terreum	0.08 ±0.009	1.52 ±0.005	704.12 ±1.47	1785.48 ±5.47	4.61 ±0.003	nd	516.24 ±22.12	5.80 ±0.005	105.12 ±12.07	26.59 ±0.73

Table 4 cont.

Mushroom species	Element contents (mg kg^{-1})									
	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
B. edulis	8.54 ±1.50	7.36 ±1.40	5.12 ±0.90	2.61 ±0.18	12.12 ±1.40	1.32 ±0.19	nd	nd	275.76 ±27.23	0.56 ±0.28
C. cornucopioides	7.67 ±2.80	3.81 ±1.00	54.37 ±1.40	1.40 ±0.84	6.38 ±1.00	3.31 ±1.60	1.14 ±0.01	nd	378.50 ±6.15	3.64 ±0.40
G. lucidium	7.66 ±1.60	5.83 ±0.24	2.06 ±0.22	4.11 ±0.22	nd	0.48 ±0.30	2.29 ±0.02	27.87 ±5.00	103.26 ±10.21	0.57 ±0.20
H. erinaceus	8.67 ±1.13	3.28 ±1.00	2.92 ±0.16	3.41 ±0.15	4.65 ±2.40	0.39 ±0.50	2.39 ±0.02	7.06 ±2.30	154.98 ±31.00	0.42 ±0.30
L. deliciosus	8.22 ±0.50	3.47 ±0.30	15.12 ±1.67	2.45 ±0.34	9.10 ±2.70	2.15 ±0.30	1.63 ±0.01	nd	392.97 ±24.57	0.87 ±0.21
L. sulphureus	7.04 ±0.30	2.86 ±1.20	3.88 ±1.05	3.58 ±0.64	6.29 ±1.17	0.67 ±0.14	nd	13.43 ±2.60	113.63 ±9.47	0.60 ±0.05
L. edodes	5.75 ±1.50	3.37 ±0.17	12.44 ±1.57	2.75 ±0.03	5.99 ±1.23	1.11 ±0.23	1.69 ±0.03	nd	284.04 ±10.16	0.69 ±0.27
M. oreades	10.86 ±2.70	2.12 ±0.23	20.70 ±3.23	2.19 ±0.60	4.18 ±2.40	2.72 ±0.50	1.63 ±0.01	8.38 ±3.17	521.26 ±18.40	0.99 ±0.25
M. conica	7.83 ±3.20	nd	16.51 ±1.15	1.46 ±0.14	2.24 ±0.09	1.70 ±0.27	0.54 ±0.01	6.45 ±1.63	522.81 ±4.12	1.69 ±0.56
P. ostreatus-1	9.12 ±0.25	0.95 ±0.05	3.14 ±0.80	2.32 ±0.07	6.14 ±1.60	0.82 ±0.14	1.34 ±0.02	8.56 ±2.45	453.59 ±18.16	0.61 ±0.32
P. ostreatus-2	10.89 ±1.17	nd	15.50 ±1.17	3.44 ±0.09	nd	1.54 ±0.30	1.15 ±0.04	nd	425.51 ±3.87	1.52 ±0.15
P. ostreatus-3	10.10 ±2.05	1.07 ±0.07	4.02 ±1.00	4.61 ±0.24	0.94 ±0.23	0.55 ±0.16	nd	5.52 ±1.15	305.60 ±11.37	0.58 ±0.05
P. ostreatus-4	9.58 ±0.32	nd	8.97 ±0.90	nd	nd	1.69 ±0.70	nd	nd	391.85 ±1.57	0.50 ±0.01
R. botrytis	8.17 ±2.70	25.85 ±1.57	12.26 ±1.31	nd	54.27 ±3.52	5.21 ±0.14	nd	nd	371.65 ±11.45	1.11 ±0.58
T. terreum	9.93 ±2.10	5.12 ±1.05	33.64 ±2.32	1.41 ±0.08	9.94 ±0.98	2.86 ±0.05	1.59 ±0.01	nd	376.85 ±35.18	2.15 ±0.25

nd: not detected

There were a wide range variations in the selenium content of mushrooms. Selenium was not detected in *C. cornucopioides*, *P. ostreatus*-4 and *T. terreum*. However, extraordinarily high content of selenium was found in *B. edulis* (115.40 mg kg^{-1}). Our results for selenium were in agreement with previous studies of Cocchi et al. [2006] and Falandysz [2008], which reported that the Boletus spp. contained the highest levels of selenium among different mushrooms. In addition to, the selenium values of studied mushrooms in the present study were similar to results reported by Dursun et al. [2006]. Recently, the great interest for Se is due to both the importance of this element in nutrition and being a strong antioxidant [Charanjeet et al. 2003]. The RDI of selenium is 70 μg day^{-1} [FDA 2013]. With the exception of *C. cornucopioides*, *P. ostreatus*-4 and *T. terreum*, all of the studied mushrooms had sufficient selenium content to meet the RDI.

Rubidium was one of the most abundant elements in this study and was in the ranges of 21.58–9751.90 mg kg^{-1} (tab. 4). Rubidium content was even higher than that of calcium, magnesium, zinc, iron, sodium, manganese and copper, which is consistent with the results reported on some edible wild mushrooms of Poland [Falandysz et al. 2001].

The mean contents of potassium, phosphorus, sulphur, chlorine, sodium, iron, calcium, manganese, selenium, zinc and copper in wild growing mushrooms were found much higher than that in the cultivated mushrooms. Likewise, it was found that the mineral contents of cultivated mushrooms were lower than that of edible wild ones [Rudawska and Leski 2005]. When compared with fruits and vegetables, the studied mushroom species had much higher contents in terms of many essential minerals [Roe et al. 2013].

The mean contents of toxic elements or heavy metals among all of the studied mushrooms were in the decreasing order: aluminium > arsenic > nickel > chromium > mercury > thallium > lead > cadmium > silver. The contents of aluminium, arsenic, nickel, chromium, mercury, thallium, lead, cadmium and silver were found at the ranges of 19.95–177.54, 1.10–92.93, 9.10–28.55, 4.03–44.0, 0–8.57, 0–4.61, 0–4.0, 0.08–2.41 and 0–0.000092 mg kg^{-1}, respectively. For mentioned above toxic elements, the highest values were determined in *C. cornucopioides*, *R. botrytis*, *H. erinaceus*, *B. edulis*, *P. ostreatus*-3, *C. cornucopioides*, *P. ostreatus*-2 and *M. conica*, respectively (tab. 4). Metal concentrations strongly depend on mushroom species [Severoglu et al. 2013]. Some mushrooms are able to accumulate high concentrations of toxic elements much more effectively than others [Lavola et al. 2011].

In this study, *C. cornucopioides* was determined as efficient accumulators of aluminium and lead. Also, *R. botrytis* was found to be efficient accumulators of arsenic and nickel (tab. 4). Similarly to our results, *B. edulis* was reported as a very effective accumulator of mercury among different mushrooms [Kalac and Slapetowa 1997]. The mean contents of aluminium, arsenic, mercury and nickel in wild growing mushrooms were higher than cultivated mushrooms (tab. 4). This result was compatible with the report of Kalac and Svoboda [2000], which pointed out that wild growing mushrooms are more exposed to contamination by toxic elements than cultivated mushrooms, especially in aeras polluted by industry. Heavy metals such as lead, cadmium and mercury of edible mushrooms could be considered as delimiting metals [Falandysz et al. 2008]. The provisional tolerable weekly intake values recommended by the Joint FAO/WHO Expert Committee on Food Additives for arsenic, cadmium, lead and mercury are 0.015, 0.007, 0.025 and 0.005 mg kg^{-1} body weight, respectively. Thus, these mushroom species can be mostly considered as safely food for consumption. However, the attention should be paid to the amount and frequency of consumption of these species because *R. botrytis* and *B. edulis* were efficient accumulators of arsenic and mercury, respectively. The contents of toxic elements and other trace elements obtained in the current study were generally similar to previous reports concerning some edible wild mushrooms of Turkey [Demirbas 2001, Dursun et al. 2006, Yamac et al. 2007, Genccelep et al. 2009, Turhan et al. 2010].

CONCLUSIONS

The results from the present study revealed that the investigated mushrooms had significant nutritional potential in both wild edible and cultivated

mushrooms. Differences regarding the contents of total free amino acid, soluble protein, phenolic, flavonoid, soluble carbohydrate, glucose, fructose and sucrose were significant ($P < 0.05$) among investigated mushrooms. Also, mineral element contents of mushrooms varied largely depending on the species.

In conclusion, these wild growing and cultivated mushrooms could be used as fairly good and cheap sources of protein, phenolics, flavonoids, carbohydrates and minerals and their consumption can contribute considerably to the nutritional requirements of people particularly in the rural areas. The regular and adequate consumption of these mushrooms may help to meet the recommended daily intake most of the nutrients. To know the nutritional and bioactive properties of these mushrooms will increase conscious consumption of them. Nevertheless, additional studies are needed to evaluate the bioavailability of nutrients and on the presence of antinutritional factors in these mushrooms.

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