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Nutritional Composition of Some Wild Edible Mushrooms

[Bazı Yabani Yenilenebilir Mantarların Besinsel İçeriği]

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ABSTRACT

Objectives: The aim of this study is to determine the nutritional content of some wild edible mushrooms from Turkey Trabzon-Maçka District.

Methods: Eight different species of wild edible mushrooms (*Craterellus cornucopioides* (L.) P. Karst, *Armillaria mellea (*Vahl) P. Kumm., *Sarcodon imbricatus* (L.) P. Karst., *Lycoperdon perlatum* Pers., *Lactarius volemus* (Fr.) Fr., *Ramaria flava* (Schaeff.) Quél. *Cantharellus cibarius* Fr., *Hydnum repandum* L.) were analyzed in terms of moisture, protein, crude fat, carbohydrate, ash zinc, manganese, iron and copper contents. The identification of the species was made according to anatomical and morphological properties of mushrooms.

Results: The protein, crude fat and carbohydrate contents (limit values%:avarage) of investigated mushroom samples were found to be 21.12-50.10:34.08, 1.40-10.58:6.34 and 34-70:55, respectively. The zinc, manganese, iron and copper contents of the mushrooms samples were found to be in the range of 47.00-370.00 mg/kg, 7.10-143.00 mg/kg, 30.20-550.00 mg/kg and 15.20-330.00 mg/kg, respectively.

Conclusion: It is shown that the investigated mushrooms were rich sources of protein and carbohydrates and had low amounts of fat. Metal contents and energy values of the studied mushrooms were nearly similar to each other and agreed-well with the previous data. The results make these wild edible mushrooms popular to consume as good food sources.

Key Words: biochemical composition, edible mushroom, micronutrient elements.

ÖZET

Amaç: Bu çalışmanın amacı, Türkiye'de Trabzon-Maçka bölgesinde bulunan bazı yenilebilir yabani mantarların besinsel içeriklerini belirlemektir.

Yöntem: Sekiz farklı yenilebilir yabani mantar türü (*Craterellus cornucopioides* (L.) P. Karst, *Armillaria mellea* (Vahl) P. Kumm., *Sarcodon imbricatus* (L.) P. Karst., *Lycoperdon perlatum* Pers., *Lactarius volemus* (Fr.) Fr., *Ramaria flava* (Schaeff.) Quél., *Cantharellus cibarius* Fr., *Hydnum repandum* L.); nem, protein, ham yağ, karbohidrat, kül ve mikroelement olarak çinko, mangan, demir ve bakır içerikleri açısından incelendi. Türlerin teşhisi, matarların anatomik ve morfolojik özellikleri göz önüne alınarak yapılmıştır.

Bulgular: İncelenen mantarların protein, ham yağ ve karbohidrat içerikleri (%hudut aralığı:ortalama değer) sırasıyla 21.12-50.10:34.08, 1.40-10.58:6.34 ve 34-70:55 olarak belirlendi. Mantar örneklerinin çinko içeriğinin, 47.00-370.00 mg/kg, mangan içeriğinin, 7.10-143.00 mg/kg, demir içeriğinin, 30.20-550.00 mg/kg ve bakır içeriğinin ise 15.20-330.00 mg/kg aralığında değişkenlik gösterdiği tespit edildi.

Sonuçlar: Çalışılan yabani yenilebilir mantarların zengin birer protein ve karbohidrat kaynağı oldukları ve az miktarda lipid içerdikleri belirlendi. İncelenen mantarların metal içerikleri ve enerji değerleri birbirine çok yakın ve daha önceki verilerle uyum içerisindedir. Elde edilen sonuçlar, bu yabani yenilebilir mantarları, besin kaynağı olarak tüketilebilirlikleri açısından popüler kılmaktadır.

Anahtar Kelimeler: biyokimyasal içerik, yenilebilir mantar, mikroelement.

Introduction

Wild edible mushrooms are traditionally used by many Asian countries as food and medicine (1,2), and are becoming more and more important in our diet for their nutritional characteristics. Some edible mushroom species are sources of physiological agents for medicinal applications, possessing antitumour, cardiovascular, antiviral, antibacterial and other activities (3,4,5). Each mushroom type produces a specific set of metabolites capable of dealing with the set of microbes that coexist in that specific environment (6).

The consumption of wild edible mushrooms is increasing due to a good content of proteins and trace minerals. Mushrooms are valuable healthy foods, low in calories, fats, and essentials fatty acids, and high in vegetable proteins, vitamins and minerals (7, 8).

Turkey has a large edible mushroom potential because it possesses favorable environmental conditions for the growth of mushrooms. Therefore, Turkey is becoming an important exporter for wild edible mushrooms. In the East Black Sea region, the climate, especially in spring and autumn, is ideal for fungal growth (9).

Despite of the potential economic importance of these wild growing mushrooms in the collecting area (Maçka district of Trabzon-Turkey), this is the first study has been carried out on their biochemical composition. In this investigation, we have examined the proximate biochemical composition of eight different wild edible mushrooms species (Figure 1), in terms of moisture, protein, crude fat, carbohydrate, ash and micronutrient elements. We hope that the results may be valuable for chemotaxonomical and cultivation purposes of mushrooms.

Materials and Methods

Mushroom materials, microscopic examinations and chemicals

In the period of August-September, 2004, eight wild edible mushroom species (Table 1 and Figure 1) were collected from Lisar High Plateau of Maçka (1500 meter above sea level) in Trabzon which is in the East Black Sea region of Turkey. The colour, odour and other apparent properties of the mushroom and vegetation were noted in the field. The photographs of specimens were taken in the field and the mushrooms were examined microscopically in the laboratory in three days after collection. Spore prints were made to determine the colour of the spores and used for the measurements. Microscopic examinations (spore, hyphae, basidia and cystidia) were performed using Nikon research microscopes. Fungus pilei were moistened by adding a few drops of potassium hydroxide solution and were sectioned. The sections were subsequently stained with methylene blue and examined. The identification of the species was made according to above systematical criteria obtained from macroscopic and microscopic examinations (10, 11, 12). Mushroom samples were carried into the laboratory in an ice bath and stored deep-frozen at –34°C until used. All other biochemical studies were completed in ten days. All reagents were of analytical grade and used as obtained.

Sample preparation

The whole mushroom samples (without division into pileus and stipe) were used in this study. Fresh samples, after removal of external material such as mud, bush, soil, plant etc. by washing with demineralized water, were airdried between filter papers. Approximately 5 g of each sample were taken immediately for determination of moisture. Remaining samples were stored in deep-frozen until analysis (13). While examining the nutritional composition of mushroom samples, the maturation stage of them was not considered. It must be emphasized that this is an effective factor on diversity of the measured parameters for each mushroom sample.

Chemical analysis

The following components were determined on airdried material: moisture, by drying in a moisture determination apparatus (Precisa HA60) at 110 ºC until circulation

Table 1. Some Properties of the Analyzed Mushroom Species

Name	Edibility	Habitat	Family
Craterellus cornucopioides (L.) P. Karst.	Good	In deciduous woods	Cantharellaceae
Armillaria mellea (Vahl) P. Kumm.	Edible	On or around of trees	Marasmiaceae
Sarcodon imbricatus (L.) P. Karst.	Edible	In coniferous woods	Bankeraceae
Lycoperdon perlatum Pers.	Edible	In woodland	Lycoperdaceae
Lactarius volemus (Fr.) Fr.	Good	Under trees	Russulaceae
Ramaria flava (Schaeff.) Quél.	Edible	In mixed woods	Gomphaceae
Cantharellus cibarius Fr.	Edible	In woodland	Cantharellaceae
Hydnum repandum L.	Edible	In woodland	Hydnaceae

(A)

(B)

(C)

(D)

(E)

(F)

(G)

(H)

Figure 1. Fructification organs of investigated mushroom species (photographed by E. Sesli).
(A) *C. cornucopioides*
(B) *A. mellea*
(C) *S. imbricatus*
(D) *L. perlatum*
(E) *L. volemus*
(F) *R. flava*
(G) *C. cibarius*
(H) *H. repandum*

was completed; ash, from the incinerated residue obtained at 550°C after 3 h; crude protein, by the Kjeldahl method with a conversion factor of 6.25 (14,15); crude fat, gravimetrically determined after Soxhlet extraction with petroleum ether (2,13). The total carbohydrate was calculated as 100% - (% moisture+ % ash+ % crude protein+ % fat) (13, 15, 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 (17). In all tables, data points represent mean of three determinations.

Trace Element analysis

Fresh mushrooms, after removal of external material, were dried in an oven at 105 °C for 24 h after airdried 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 ashed at 450 °C for 20 h; then the ash was dissolved in 1 mL concentrated HNO_3, evaporated to dryness, heated again at 450 °C for 4 h, treated with 1 mL concentrated H_2SO_4, 1 mL HNO_3 and 1 mL H_2O_2, and then diluted with double deionized water up to a volume of 10 mL. The blank samples were treated in the same way (13).

For the determination of metal contents, an ATI Unicam 929 model Atomic Absorption Spectrometer (AAS) was used. The determination of all metal contents was carried out in an air/acetylene flame. The maximum absorbance was obtained by adjusting the hallow cathode lamps at the operation conditions. All the experimental results were means ±SD of three parallel measurements (13).

Results and Discussion

Chemical analysis

The chemical composition and calculated energy values for investigated mushroom species are shown in Table 2. While examining the nutritional composition of mushroom samples, the maturation stage of them was not considered. It must be emphasized that this is an effective factor on diversity of the measured parameters for each mushroom sample. It is known from the previous data that dry matter content of fresh mushrooms are generally 5-15% and the nutritional profiles of mushrooms are directly affected with their moisture content (1,7,18). In addition, it is also known that the 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 (7). The moisture content of all studied mushroom species ranged from 70.00% to 93.31%. In the literature, dry matter content of *Armillaria mellea* harvested from East Black Sea region, *Cantharellus cibarius* harvested from the forest of Maglehaya, *Sarcodon imbricatus* harvested from Northeast Portugal were found to be 9.70%, 15.90% and 6.11%, respectively (8,9,19). When these results were compared with the values obtained from this study for the same mushrooms, it can be easily seen that the value from our study for *C. cibarius* (12.08%) is lower and the values for *S. imbricatus* (10.80%) and *A. mellea* (16.18%) are higher. But, moisture content of each studied mushroom species was generally similar to each other. The results are consistent with the literature related to *Macrolepiota mastoidea*, *Lepista nuda, Handkea excipuliformis*, *Amanita ru-*

Table 2. Chemical Composition of the Mushroom Samples (g/100 g)

	Moisture (%)	Nitrogen (%)	Protein (%)	Crude Fat (%)	Total Carbohydrate (%)	Ash (%)	Energy (kcal/100 g)
C. cornucopioides	89.65±5.00	8.00±0.50	50.10±2.90	5.89±0.01	34±7	10.26±0.80	388.29±15.70
A. mellea	83.82±5.00	3.30±0.10	21.12±3.00	6.08±0.10	70±5	3.16±0.30	417.64±17.50
S. imbricatus	89.20±5.00	4.30±0.20	27.45±2.10	8.85±0.30	57±5	6.71±0.04	417.21±16.00
L. perlatum	70.00±4.00	7.10±0.10	44.93±3.00	10.58±0.30	42±6	2.00±0.40	444.70±18.20
L. volemus	87.57±4.00	4.00±0.40	25.21±2.00	3.98±0.20	64±4	2.91±0.05	393.06±16.10
R. flava	93.31±5.00	5.6±0.30	35.55±2.10	5.20±0.20	65±7	3.05±0.06	450.20±14.00
C. cibarius	87.92±5.00	5.40±0.20	34.17±2.60	1.40±3.00	57±4	7.78±0.60	367.88±13.90
H. repandum	93.31±5.00	5.70±0.20	34.14±3.00	8.80±0.20	55±5	11.38±0.07	434.20±16.80
Avarage±SD	**86.84±7.40**	**5.2±1.60**	**34.08±9.80**	**6.34±3.00**	**55±12**	**5.90±3.60**	**414.14±29.10**
Limit values	**84.82-93.31**	**3.30-8.00**	**21.12-50.10**	**1.40-10.58**	**34-70**	**2.00-11.38**	**367.88-450.20**

All parameters except moisture were presented for dried matter.

bescens and *Boletus queletii* which were harvested from the same area (13) and *Cantharellus cinerea, Russula integra, Ramaria brevispora, Gomphus floccosus* (8).

The ash content of analysed mushrooms were observed between 2.00% and 11.38%. Mattila et al. (20) reported that the main constituents in the mushroom ash were K and P (totaly 60%). Low ash content in *Lycoperdon perlatum* (*L. perlatum,* 2.00%), *A. mellea* (3.16%), *Ramaria flava* (*R. flava,* 3.05%) and *Lactarius volemus* (*L. volemus,* 2.91%) can be attributed to their low K and P content (not determined). The ash contents of *C. cibarius* and *S. imbricatus* were 7.78%, 6.71%, respetively. Agrahar-Murugkar and Subbulakshmi (8) reported 13.20% ash content for *C. cibarius* and Demirbaş (9) also reported 7.70% for *A. mellea*. Both mushrooms were investigated in terms of ash content in this study but ash contents were found lower than these reports. Barros et al. (19) were also studied *S. imbricatus* ash content (4.75%) and it is said that they had a mushroom with lower ash content than the same species analysed in this study. Ash contents of the other studied mushrooms are consistent with the earlier data (2,8,13,16).

Lipid compounds such as free fatty acids, tri-, di- and monoglycerides, phospholipids, sterols and derivatives can be extracted from mushrooms as crude fat (7). Mushrooms are consumed for low-calorie diet because of their low crude fat content. In the previous reports, it is possible to see various fat content from 0.80% to 27.50% in dry mushrooms (4,8,13,21,22,23). The petroleum ether extract contents (fats) of *C. cibarius* (1.40%) and *A. mellea* (6.08%) in this study are consistent with Agrahar-Murugkar and Subbulakshm (8) and Demirbaş (9), respectively, but Barros et al. (19) reported very lower total fat content for *S. imbricatus* (1.47%) harvested from Braganca when compared with this study.

The major compounds of mushrooms are proteins and carbohydrates. It is reported that the protein contents 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). Total protein content, varying between 21-50%, can be accepted high when compared with meat, milk, egg, fish such as some commercially important fish species form the Black sea region (15) and some other mushroom species (8,9). In this study, the highest protein content was found for *Craterellus cornucopioides* (*C. cornucopioides*, 50.10%) and the lowest was found for *A. mellea* (21.12%). Demirbaş (9) and Agrahar-Murugkar and Subbulakshm (8) reported lower protein contents for *A. mellea* (16.40%) and *C. cibarius* (21.10%), respectively, than we observed for the same species. However, Barros et al. (19) reported higher protein content for *S. imbricatus* (38.46%). It can be understood from the data that the studied mushrooms are good protein source.

Mushroom carbohydrates include glucans, mono- and disaccharides, sugar alcohol, glycogen and chitin (25). The carbohydrate contents of some wild edible mushrooms from nitrogen free extracts were found to be between 41.00% and 65.00% (2). Colak et al. (13) found carbohydrate contents of *M. mastoidea, L. nuda, H. excipuliformis* and *A. rubescens* as 55.80%, 41.90%, 62.84%, 29.70%, 65.30%, respectively. In this study, the total carbohydrate content of *A. mellea* was the highest (70%) and it was found higher than reported by Demirbaş (9), Sanmee et al. (2), Colak et al. (13). Similar carbohydrate content for *S. imbricatus* was reported by Barros et al. (19). Protein, fat and carbohydrate profiles similar with previous data make these mushrooms ideal food sources.

Energy values of each analyzed mushroom species were calculated according to the Italian Law previously described (17). Calculated energy values of edible wild mushrooms varied from 367.88 kcal/100 g to 450.20 kcal/100 g in dry matter basis (Table 2). These values were found to be higher than previous data obtained from some cultivated and wild edible mushrooms such as *Pleurotus ostreatus, Lentinula edodes, M. mastoidea* and *H. excipuliformis* (13,16).

Microelement analysis

The trace metal content of mushrooms are related to species of mushroom, collecting site of the sample, age of fruiting bodies and mycelium, distance from sources of pollution (26) and remainly affected by acidic and organic matter content of the soil. Metal ion uptake of mushrooms is considerably higher than plants because of their effective take up mechanism (27).

In this study, Zn, Mn, Fe and Cu concentrations as micronutrients in dry matter basis of *Craterellus cornucopioides, Armillaria mellea, Sarcodon imbricatus*, *Lycoperdon perlatum, Lactarius volemus, Ramaria flava, Cantharellus cibarius* and *Hydnum repandum* were analyzed (Table 3).

The micronutrient metal composition of wild edible mushrooms used in this study were investigated (9,28,29,30,31). The observation of different results can be attributed that the trace element profile of mushrooms has been affected by environmental factors such as climate, growing conditions, region and soil content.

In this study, the highest (370.00 mg/kg d.w.) and the lowest (47.00 mg/kg d.w.) Zn content was found in *R. flava* and *L. perlatum*, respectively. Zinc is widespread among living organisms due to its biological significance. Mushrooms are known as zinc accumulators (30). *L. perlatum* Zn content was lower than reported by Mendil et al. (30) and, Sesli and Tüzen (29). *L. volemus*, *R. flava*, *C. cibarius*, *C. cornucopioides* Zn levels were also reported to be considerably lower than found in this study for muhrooms harvested from the same region in 1999 (29). However, *A. mellea* and *C. cibarius* Zn content was found to be higher than previous studies (9,29,31,32). Zinc level in *H. repandum* in the literature has been re-

Table 3. Concentrations of Zn, Mn, Fe and Cu of Analyzed Mushroom Samples (mg/kg dry weight)

	Zn	Mn	Fe	Cu
Wavelenght/ Band width (nm)	213.9/0.5	279.5/0.2	248.3/0.2	324.8/0.5
C. cornucopioides	344.00±12.00	7.10±0.90	90.60±3.20	15.20±1.10
A. mellea	96.50±5.20	96.10±5.90	47.00±3.10	330.00±9.00
S. imbricatus	80.0±5.00	75.10±1.50	50.60±3.20	15.80±1.00
L. perlatum	47.00±3.10	60.50±2.40	550.00±15.00	49.10±3.10
L. volemus	330.00±9.00	143.00±8.00	154.00±14.00	185.00±9.00
R. flava	370.00±9.00	22.80±2.10	30.20±2.90	17.60±1.20
C. cibarius	149.00±8.00	28.80±2.80	250.00±8.00	15.90±1.20
H. repandum	55.00±8.00	23.50±1.20	50.00±4.00	20.00±1.20

ported to be in the range of 14.10-35.90 mg/kg d.w. which is lower than found in this study (28,29,31,33).

The Cu contents of *C. cornucopioides*, *S. imbricatus*, *R. flava*, *H. repandum* and *L. perlatum* changed from 15.20 mg/kg d.w. to 49.10 mg/kg d.w. These Cu levels for the same species were in accordance with Sesli and Tüzen (29), Mendil et al. (30) and Ouzouni et al. (31). *C. cibarius* Cu level (15.90 mg/kg d.w.) was considerably lower than reported Sesli and Tüzen (29). The Recommended Dietary Allowances (RDA) for adults is 0.90 mg copper/day (34). Present concentrations of copper in mushrooms are not considered a health risk (31). In general, copper contents in mushrooms are higher than those in green plant and vegetables and should be considered as a nutritional source of this element (35). The Cu contents of *A. mellea* (330.00 mg/kg d.w.) and *L. volemus* (185.00 mg/kg d.w.) were found to be higher than literatures (9,28,29,32).

Minimum and maximum Fe levels, in the present study, were 30.20 mg/kg d.w. and 550 mg/kg d.w. for *R. flava* and *L. perlatum*, respectively. Higher Fe levels were reported for *C. cornucopioides, A. mellea, S. imbricatus, R. flava, H. repandum* and *C. cibarius* whereas lower Fe levels were reported for *L. perlatum* and *L .volemus* (28,29,30,31). In this study, Mn contents of wild edible mushroom samples were measured in the range of 7.10-143.00 mg/kg d.w. Lower Mn levels for *C. cornucopioides*, *L. volemus*, *A. mellea*, *C. cibarius*, *S. imbircatus* were reported (9,28,29,31,32) whereas higher Mn levels of *L. perlatum* and *L. volemus* were found (29,30). However, similar Mn levels for *L. perlatum* and *H. repandum* were reported (28,29,31).

It can be concluded that the investigated wild edible mushrooms are good food sources in terms of protein, carbohydrate, crude fat, and energy values and may be cultivated. Our micronutrient values are in agreement with reports in the literature. So, it can be said that these determinations make the investigated wild edible mushroom popular and easily able to consume.

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