

## SOME BIOACTIVE PROPERTIES OF WILD AND COMMERCIAL MUSHROOM SPECIES

Sibel Yıldız<sup>1</sup> ORCID ID: [0000-0001-8448-4628](https://orcid.org/0000-0001-8448-4628), Ayşenur Yılmaz<sup>1</sup> ORCID ID: [0000-0003-4545-2644](https://orcid.org/0000-0003-4545-2644),  
Zehra Can<sup>2</sup> ORCID ID: [0000-0002-7156-4941](https://orcid.org/0000-0002-7156-4941), Sana Adel Tabbouche<sup>3</sup> ORCID ID: [0000-0003-2072-4594](https://orcid.org/0000-0003-2072-4594),  
Ali Osman Kılıç<sup>3</sup> ORCID ID: [0000-0002-5506-0866](https://orcid.org/0000-0002-5506-0866), Ertuğrul Sesli<sup>4</sup> ORCID ID: [0000-0002-3779-9704](https://orcid.org/0000-0002-3779-9704)

<sup>1</sup> Department of Forest Industry Engineering, Faculty of Forestry, Karadeniz Technical University, Turkey

<sup>2</sup> Department of Food Technology, Giresun University, Turkey

<sup>3</sup> Department of Medical Microbiology, Faculty of Medicine, Karadeniz Technical University, Turkey

<sup>4</sup> Department of Biology Education, Karadeniz Technical University, Turkey

Received: 29.03.2017

Accepted: 21.06.2017

Published online: 22.09.2017

Corresponding author:

Sibel Yıldız, Department of Forest Industry Engineering,  
Faculty of Forestry, Karadeniz Technical University, Turkey

E-mail: [sibilyildiz@gmail.com](mailto:sibilyildiz@gmail.com)

### Abstract:

In this study, the protein and total phenolic contents of some commercially cultivated (*Agaricus bisporus*, *Pleurotus ostreatus*) and wild mushrooms (*Amanita caesarea*, *Fistulina hepatica*, *Meripilus giganteus*) were determined. Antioxidant and antimicrobial properties of these mushrooms against *Escherichia coli*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Salmonella typhimurium*, *Acinetobacter haemolyticus*, *Proteus mirabilis*, *Pseudomonas aeruginosa* and *Candida albicans* were also investigated. The protein contents, total phenolic contents and antioxidant activities of the mushrooms were found in the range of 11.00 - 25.1%, 1.111 - 3.858 mg GAE g<sup>-1</sup>, and 1.528 - 9.340 μmol FeSO<sub>4</sub>·7H<sub>2</sub>O g<sup>-1</sup>, respectively. *Meripilus giganteus* had higher protein than all the tested mushrooms. The highest total phenolic content was detected in *Agaricus bisporus* obtained from B company (3.858 mg GAE g<sup>-1</sup>), whereas the lowest total phenolic content was observed in *Meripilus giganteus* (1.111 mg GAE g<sup>-1</sup>). Total phenolic and antioxidant properties of mushrooms were found significantly different (P<0.05) by Duncan's multiple range test. Methanolic extracts of the tested mushrooms showed no inhibitory activity against bacteria and yeast.

**Keywords:** Antioxidant, Antimicrobial, Mushroom, Protein, Total phenolic content

JOURNAL OF FOOD AND HEALTH SCIENCE

E-ISSN: 2149-0473

3(4): 161-169 (2017) doi: 10.3153/JFHS17019

© 2015-2017 ScientificWebJournals (SWJ)

## Introduction

Most of edible mushrooms such as basidiomycetes are known as high nutritional value food rich in biologically active compounds (Breene, 1990). These mushrooms naturally grow on soils, trunks and on the roots of the trees (Iwalokun *et al.*, 2007). Mushrooms are generally rich in vegetable proteins, vitamins and minerals with low levels of calories, fats and essential fatty acids. (Barros *et al.*, 2007a). Many of these ingredients include molecules with medical activities such as anti-inflammatory, antitumor, antibacterial, antioxidant and antiviral activities (Barros *et al.*, 2007b).

Human body provides its needs in protein from meat and meat products and vegetarian peoples usually get difficulties to recompense their protein supply for a healthy life with their restricted food sources. However, mushroom may constitute an important and natural alternative of essential proteins and vitamins for these cases. Some researchers reported that protein values of mushrooms are higher than some vegetables and fruits as asparagus, potatoes, tomatoes, carrots, and oranges (Jiskani, 2001; Adejumo and Awosanya, 2005).

Mushrooms also contain phenolic compounds that are important scavengers of free radicals (Murcia *et al.* 2002). These phenolic compounds may inhibit atherosclerosis and cancer (Diplock *et al.*, 1998) (Williams *et al.*, 1999) without considerable mutagenic effects (Ishikawa *et al.*, 1984). Undoubtedly, the toxic effects of chemical and synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) may be prevented by the use of mushrooms constituents as natural antioxidant compounds (Lee *et al.*, 2007). For this reason, such types of natural antioxidants gained importance especially in the medical researches. Recently, infections with multi-drug resistant microorganisms have increased due to the irregular overuse of antimicrobials. This situation has forced scientists to search for new antimicrobial compounds in natural sources like mushrooms (Karaman *et al.*, 2003).

Mushroom is considered a valuable food for Turkish people and *Agaricus bisporus* is one of the most commercially cultivated mushroom varieties in Turkey. Moreover, the habit of consumption of wild edible mushrooms is also very common in Turkey.

The objectives of this study were: (i) to determine protein and total phenolic contents of some wild (*Amanita caesarea*, *Fistulina hepatica*, *Meripilus*

*giganteus*) and commercially cultivated mushrooms (*Agaricus bisporus* obtained from four different companies, *Pleurotus ostreatus* obtained from one company) grown in Turkey, (ii) to investigate antioxidant and antimicrobial properties of these mushrooms. This study is one of a few recent researches that compare the bioactive performance of wild and cultivated mushrooms.

## Materials and Methods

### Mushrooms

Wild mushrooms (*Amanita caesarea*, *Fistulina hepatica*, *Meripilus giganteus*) were collected from the province of Kastamonu, located in the northwest of Turkey, in October 2014. The morphological and ecological characteristics of mushrooms were noticed and photographed in their natural habitats. Cultivated mushrooms, *Pleurotus ostreatus* were obtained from one company and *Agaricus bisporus* were obtained from four different companies, in Trabzon, Turkey. Ethically, the commercial mushroom companies were coded as A, B, C, and D. Mushrooms were identified based on their morphological characteristics and dried for future analysis. Some information about the mushrooms used in this study such as species, habitat, location and edibility are given in Table 1.

### Determination of protein content, carbon (C), hydrogen (H), nitrogen (N) values

Each mushroom was dried at 40°C before the analysis. Dried mushroom samples were crushed and powdered for passing a 40 mm mesh sieve. Protein contents of mushrooms were determined according to Dumas method (Ebeling, 1968). Briefly, 0.5 - 0.7 mg dried mushroom samples were weighed and placed on 5 × 9 mm tin capsules. The capsules were then placed into Costech ECS 4010 elemental analysis instrument and were burned. The values of carbon, hydrogen and nitrogen were determined using Costech ECS 4010 program. Protein contents were determined by multiplying (%) of nitrogen results with conversion factor (4.38) (Crisan and Sands, 1978).

### Measurement of total phenolic content

#### Extraction method

Mushrooms were dried 60°C for 24 hour (Profilo, PFD1350W, Turkey). Four grams of dried sample was extracted with 40 mL methanol by shaking at 150 rpm for 24 h and filtered through Whatman

No. 4 filter paper pore size 20-25  $\mu\text{m}$ . Then solutions were filtrated from hydrophilic polyvinylidene fluoride (PVDF) 0.45  $\mu\text{m}$  for sterilization. The final volume of the solution was adjusted by the level of methanol. Extracts were stored at 4°C for future use.

#### Total phenolic content

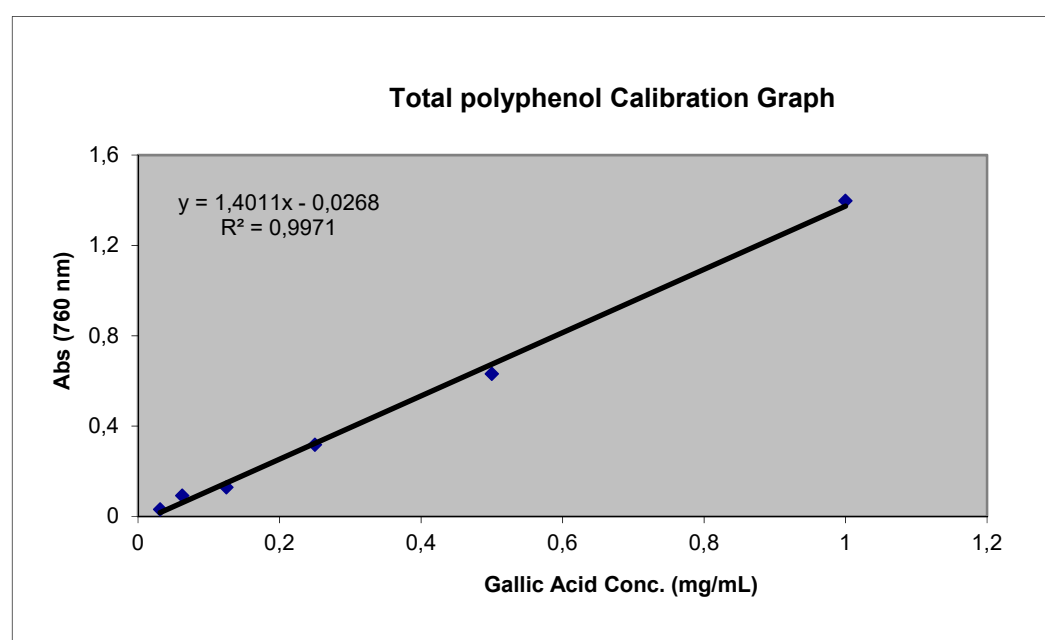
The total phenolic contents of the methanolic extracts were determined according to Folin–Ciocalteu method using gallic acid standard (Slinkard and Singleton, 1977). The Folin assay was based on all phenolic contents including phenolic acids, flavonoids, and anthocyanins in the aquatic solution, which gives a blue color complex whose

maximum absorbance can be read at 760 nm. Briefly, 680  $\mu\text{L}$  distilled water, 20  $\mu\text{L}$  methanolic extract and 400  $\mu\text{L}$  of 0.5 N Folin-Ciocalteu reagents were mixed in a test tube, vortexed for 2 min, then 400  $\mu\text{L}$   $\text{Na}_2\text{CO}_3$  10% (v/v) was added and incubated for 2 hours at room temperature. Following the incubation, absorbance of the mixtures was measured at 760 nm on an ATI-Unicam UV-2 UV-VIS spectrophotometer (Cambridge, U.K.). The concentration of total phenolic compounds was calculated as mg gallic acid equivalents (GAE)  $\text{g}^{-1}$  of dry weight. Total polyphenol calibration graph was shown in Figure 1.

**Table 1.** Some properties of mushrooms examined in the study

No	Mushroom species	Habitat and Location	Edibility	Growing Form
1	<i>Amanita caesarea</i>	On soil, Kastamonu	Edible	Wild
2	<i>Fistulina hepatica</i>	On woods, Kastamonu	Edible*	Wild
3	<i>Meripilus giganteus</i>	On woods, Kastamonu	Edible	Wild
4	<i>Agaricus bisporus</i> (A)	On compost, Trabzon	Edible	Cultivated
5	<i>Agaricus bisporus</i> (B)	On compost, Trabzon	Edible	Cultivated
6	<i>Agaricus bisporus</i> (C)	On compost, Trabzon	Edible	Cultivated
7	<i>Agaricus bisporus</i> (D)	On compost, Trabzon	Edible	Cultivated
8	<i>Pleurotus ostreatus</i>	On compost, Trabzon	Edible	Cultivated

\*: It is known as poisonous in the current location



**Figure 1.** Total polyphenol calibration graph

*Determination of antioxidant activity*

The antioxidant activity of the mushroom extracts was determined according to Ferric-reducing antioxidant power (FRAP) method. The reducing ability of ferric tripyridyltriazine (Fe-III-TPTZ) complex was used for total antioxidant capacity assay (Benzie and Strain, 1999) with some modifications. Working FRAP reagent was prepared as required by mixing of 300 mM acetate buffer, pH 3.6 with 10 mM TPTZ solution in 40 mM HCl and 20 mM FeCl<sub>3</sub>·6H<sub>2</sub>O solution. Three milliliters freshly prepared FRAP reagent, 100 µL of samples was mixed and incubated for 4 min at 37 °C, and the absorbance was read at 593 nm against reagent blank containing distilled water. FeSO<sub>4</sub>·7H<sub>2</sub>O was used as positive control. The ferric-reducing antioxidant power of the antioxidants in the extracts was calculated by comparison with FeSO<sub>4</sub>·7H<sub>2</sub>O as µmol FeSO<sub>4</sub>·7H<sub>2</sub>O g<sup>-1</sup> dry weight of mushrooms.

*Antimicrobial activity testing*

Mushroom extracts were tested for antimicrobial activity by agar-well diffusion method in accordance with the Clinical & Laboratory Standards Institute (CLSI) (M100-S22; 2012). Tested microorganisms included *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Enterococcus faecalis* ATCC 29212, *Acinetobacter haemolyticus* ATCC 19002, *Klebsiella pneumoniae* ATCC 13883, *Salmonella typhimurium* ATCC 14028, *Proteus mirabilis* ATCC 7002 and *Candida albicans* ATCC 10231. Microorganisms were obtained from Karadeniz Technical University, Department of Medical Microbiology, Faculty of Medicine Trabzon, Turkey.

Several bacterial colonies were suspended in 5 mL of sterile isotonic sodium chloride solution and turbidity was adjusted to 0.5 McFarland standards. The microbial suspension was spread on Mueller Hinton agar using sterile cotton swabs. The wells were made in agar plates using the wide end of a blunted sterile Pasteur pipette. Each well was filled with 100 µL of mushroom extracts. Commercial Ampicillin, Gentamicin, Cefotaxime and Amphotericin B solutions were used as positive control (10 µg for each well) and methanol was tested as negative control. The cultures were incubated at 37 °C for 24 hours. Activity was determined by visual inspection and measurement of the diameter of clear inhibition zones around the agar-wells.

**Statistical analysis**

Total phenolic content and antioxidant analyses were performed in triplicates. The data were recorded as means ± standard deviations and analyzed by using Statistical Package for Social Sciences (SPSS version 23.0). The data related to total phenolic content and antioxidant property were analyzed by ANOVA and tests of significance were carried out using Duncan's multiple range tests. Differences among the means at 5% (p < 0.05) level were considered as significant. Pearson correlation coefficient was used to determine the relationship between protein content, total phenolic content and the antioxidant activity in the same sample.

**Results and Discussion***Protein content, Carbon (C), Hydrogen (H) and Nitrogen (N) Values of Mushrooms*

Carbon, hydrogen, nitrogen values and protein contents of wild and cultivated mushrooms were given in Table 2.

Nitrogen content of mushrooms were ranged from 2.42 to 5.75%. The lowest value was determined in *P. ostreatus*. The amounts given in the references for the desirable nitrogen content at the outset of composting vary between 1.5% and 2.0% computed on dry weight basis (Vedder, 1978; Demirer *et al.*, 2005). However, as a wild mushroom, *M. giganteus* showed higher protein and nitrogen content than that of *A. bisporus* grown commercially. Thus, the nature has met the requirements of *M. giganteus* in the best way. Some researchers reported that the excess or lack of N content in the substrate might be a limiting factor for fungus growth (Carlile *et al.*, 2001).

Protein content of mushrooms ranged from 11.00 to 25.19%. The result can be compared with different mushrooms protein contents that varies between 8.6% and 42.5% (Peksen *et al.*, 2008; Cohen *et al.*, 2014). It was observed a linear relationship between the amount of protein and nitrogen ratio. The previous studies showed that the protein contents of mushrooms were affected by many factors, such as mushroom species, growth conditions, compost mixture, mycelium quality, the part sampled, level of nitrogen available and the location (Al-Momany and Gücel 2012, Yildiz *et al.*, 2015).

Some researchers already reported that the protein contents in the mushrooms were higher than that

of some fruits such as grape (*Vitis vulpina*), hackberry (*Celtis occidentalis*) (Halls, 1977; Johnson *et al.*, 1985). Mushrooms are a good source in terms of protein and amino acids compared to foods of plant origin (Kurtzman *et al.*, 1993). According to the literature, the amino acid configurations of mushrooms are comparable to some animal proteins (Longvah and Deosthale, 1998; Mattila *et al.*, 2001).

#### Total phenolic content and ferric reducing antioxidant capacity

The total phenolic content and ferric reducing antioxidant capacity of mushrooms are presented in Table 3.

In the study, the total phenolic content ranged from 1.111 to 3.858 mg GAE g<sup>-1</sup>. While the highest total phenolic content was determined in *A. bisporus* obtained from B company (3.858 mg GAE g<sup>-1</sup>), the lowest value was detected in *M. giganteus* (1.111 mg GAE g<sup>-1</sup>). Average of total phenolic content values (2.341 mg GAE g<sup>-1</sup>) was found higher than some fresh vegetables, such as loquat at a level of 1.994 mg GAE g<sup>-1</sup> (Lin and Tang, 2007) and carrot, lettuce, white cabbage, and cauliflower at 0.132, 0.134, 0.153, 0.278 mg GAE g<sup>-1</sup>, respectively (Bahorun *et al.*, 2004).

In a recent study; it was reported that the total phenolic content of methanolic extracts of 4 wild mushrooms (*Ganoderma lucidum*, *Morchella esculenta*, *Lentinula edodes* and *Hericium erinaceus*) varied from 5.81 to 26.40 mg g<sup>-1</sup> dw (Yildiz

*et al.*, 2005). The composition of phenolic contents of mushrooms generally depends on genetic, environmental and other factors. It was recorded that the phenolic structure in mushrooms might be affected by a number of factors such as composition of growth media, mushroom species, time of harvest, the types and ratios of substrate supplements (Heleno *et al.*, 2010).

In this study, the second highest phenolic content (3.101 mg GAE g<sup>-1</sup>) was determined in *F. hepatica*. However, Heleno *et al.*, (2010) reported that the total phenolic content of the same mushroom grown in Portuguese was 4.44 mg GAE g<sup>-1</sup>. *F. hepatica*, also known as beefsteak fungus or ox tongue because of the color and texture of the edible fruiting body, is a cosmopolitan fungus (Keleş *et al.*, 2011). As one of the wild edible species; *F. hepatica* exhibited a relatively high phenolic content. This result can be considered as a satisfactory situation. The presence of such a high total phenolic contents in these mushrooms makes them important natural source of phenolic compounds. These kinds of mushrooms are very precious because of their use as a foodstuff and in medical applications (Yildiz *et al.*, 2005). The phenolic compounds were reported as natural antioxidants. They are stopping the free radical reactions; therefore, arise of many diseases such as cancer, and lung diseases are being prevented (Nizamlioğlu and Nas 2010). In addition, total phenolic contents of the mushrooms used in this study were found significantly different (P < 0.05) from each other by Duncan's multiple range test.

**Table 2.** Carbon (C), hydrogen (H), nitrogen (N) values and protein contents of wild and cultivated mushrooms\*

Mushroom species	H (%)	C (%)	N (%)	Protein (%)
<i>Amanita caesarea</i>	6.41	38.95	3.46	15.15
<i>Fistulina hepatica</i>	6.28	40.72	2.67	11.70
<i>Meripilus giganteus</i>	6.36	43.30	5.75	25.19
<i>Agaricus bisporus</i> (A)	6.31	36.94	3.68	16.11
<i>Agaricus bisporus</i> (B)	5.98	38.23	4.22	18.48
<i>Agaricus bisporus</i> (C)	6.33	38.44	4.03	17.65
<i>Agaricus bisporus</i> (D)	6.18	39.46	3.98	17.43
<i>Pleurotus ostreatus</i>	6.37	38.15	2.42	11.00

\*: The values were expressed on dry weight basis.

FRAP activities ranged from 1.528 to 9.340  $\mu\text{mol FeSO}_4 \cdot 7\text{H}_2\text{O g}^{-1}$ . The average FRAP activity for the mushrooms used in this study (5.778  $\mu\text{mol FeSO}_4 \cdot 7\text{H}_2\text{O g}^{-1}$ ) was found higher than that of some fresh vegetables such as carrot, lettuce, tomato, white cabbage (0.60, 0.68, 0.78, 1.56  $\mu\text{mol Fe}^{2+} \text{g}^{-1}$ ; respectively) (Bahorun *et al.*, 2004).

The results showed that FRAP activity for the mushrooms used in this study (5.778  $\mu\text{mol FeSO}_4 \cdot 7\text{H}_2\text{O g}^{-1}$ ) were higher than some fresh wild edible mushrooms (*Lactarius deliciosus*, *L. sanguifluus*, *L. semisanguifluus*, *Russula delica*, *Suillus bellinii*) grown in the island of Lesvos, Greece (0.271– 0.523  $\mu\text{mol Fe}^{2+} \text{g}^{-1}$ , respectively) studied by Kalogeropoulos *et al.*, (2013).

Ferric reducing antioxidant capacity among the mushrooms used in this study was significantly different ( $P < 0.05$ ) by Duncan's multiple range test. Extraction conditions are the basis factors to improve the efficiency of antioxidative natural resources. In previous studies, it was reported that solvent type, concentration, extraction time, temperature and particle size etc. influenced the total phenolic content and antioxidant activity of extracts (SengYim *et al.*, 2009; Slawinska *et al.*, 2013).

### Antimicrobial activity

Antimicrobial activity of some mushrooms has been determined against some microorganisms (Barros *et al.*, 2007b) (Vazirian *et al.*, 2014). However, the methanolic extracts of mushrooms used in this study showed no inhibitory activity against the tested bacteria or yeast. Moreover, Öztürk *et al.* (2011) also reported that methanolic extract of *Agaricus bisporus* did not show any antibacterial activity against Gram-negative bacteria. However, Vamanu *et al.*, (2011) found out that *P. ostreatus* (ethanol and methanol extraction) was able to inhibit *Escherichia coli*, *Bacillus cereus*, *Listeria innocua* and other gram positive and negative bacteria and fungi. Giri *et al.*, (2012) also presented that *F. hepatica* (methanol extract) was able to inhibit *Proteus vulgaris*, *Escherichia coli*, and *P. ostreatus* inhibited *Staphylococcus aureus*, *Bacillus subtilis*, *Proteus vulgaris*, *Escherichia coli*. It can be said that there is no antimicrobial effect in this study because it is studied at low concentration.

### Correlation between protein content, total phenolic content and antioxidant activity

The statistical test results showed that there was a positive correlation ( $r = 0.885$ ) between total phenolic content and values of ferric reducing antioxidant capacity. In general, it was found a linear correlation between higher antioxidant activity and larger amount of total phenolic compounds in the mushroom extracts.

**Table 3.** Total phenolic content and ferric reducing antioxidant capacity of mushrooms

Mushroom species	Total phenolic content (mg GAE $\text{g}^{-1}$ )*	FRAP** ( $\mu\text{mol FeSO}_4 \cdot 7\text{H}_2\text{O g}^{-1}$ )*
<i>Amanita caesarea</i>	2.979 $\pm$ 0.039 <sup>e</sup>	5.228 $\pm$ 0.063 <sup>d</sup>
<i>Fistulina hepatica</i>	3.101 $\pm$ 0.009 <sup>f</sup>	8.141 $\pm$ 0.008 <sup>f</sup>
<i>Meripilus giganteus</i>	1.111 $\pm$ 0.017 <sup>a</sup>	3.088 $\pm$ 0.031 <sup>b</sup>
<i>Agaricus bisporus</i> (A)	2.662 $\pm$ 0.035 <sup>d</sup>	7.148 $\pm$ 0.013 <sup>e</sup>
<i>Agaricus bisporus</i> (B)	3.858 $\pm$ 0.130 <sup>g</sup>	9.340 $\pm$ 1.069 <sup>g</sup>
<i>Agaricus bisporus</i> (C)	2.442 $\pm$ 0.078 <sup>c</sup>	7.608 $\pm$ 0.014 <sup>ef</sup>
<i>Agaricus bisporus</i> (D)	1.300 $\pm$ 0.052 <sup>b</sup>	4.144 $\pm$ 0.012 <sup>c</sup>
<i>Pleurotus ostreatus</i>	1.276 $\pm$ 0.065 <sup>b</sup>	1.528 $\pm$ 0.042 <sup>a</sup>

\* Means having the different superscript letters are significantly different ( $P < 0.05$ ) by Duncan's multiple range test.

\*\*FRAP: Ferric Reducing Antioxidant Capacity

## Conclusions

In this study, protein and total phenolic contents, antioxidant and antimicrobial properties of some cultivated (*A. bisporus*, *P. ostreatus*) and wild mushrooms (*A. caesarea*, *F. hepatica*, *M. giganteus*) were investigated. Protein content of mushrooms varied from 11.00 to 25.19% and total phenolic amounts ranged from 1.111 to 3.858 mg GAE g<sup>-1</sup> while antioxidant activities were determined as 1.528 - 9.340 μmol FeSO<sub>4</sub>·7H<sub>2</sub>O g<sup>-1</sup>.

As a wild mushroom, *M. giganteus* had a higher protein and nitrogen content than that of other commercially cultivated and wild mushrooms studied in this research. The natural conditions met the requirements of the *M. giganteus* in the best way. While the highest total phenolic content was detected in *A. bisporus* obtained from B company (3.858 mg GAE g<sup>-1</sup>), the lowest value was determined in *M. giganteus* (1.111 mg GAE g<sup>-1</sup>).

The results of this study indicated that methanolic extracts of the mushrooms possessed the antioxidant activity and phenolic capacity. The antioxidant activity of mushroom extracts highly depends on the type of mushroom and extraction process. Bioactive properties of commercial mushrooms can be different from each other because of the differences in compost types, growth conditions, chemicals types and quantities used for hygiene during the cultivation process.

Because of total phenolic, antioxidant properties of mushrooms were found significantly different (P<0.05) from each other by Duncan's multiple range test. In order to obtain the better results from mushrooms extracts, different solvent types, concentrations and different extraction methods can be tested.

## Abbreviations

**A; B; C; D**, The code names of the commercial companies that supplied the *Agaricus bisporus* mushrooms; **C**, Carbon; **FRAP**, Ferric-reducing antioxidant power; **H**, hydrogen; **N**, nitrogen; **P**, significant level; **r**, correlation coefficients.

## References

- Adejumo, T., & Awosanya, O. (2005). Proximate and mineral composition of four edible mushroom species from South Western Nigeria. *African Journal of Biotechnology*, 4, 1084-1088.
- Al-Momany A.M., & Gücel, S. (2012). Chemical compositions and nutritional value of three edible mushrooms widely consumed in Cyprus. *Jordan Journal of Agricultural Sciences*, 7, 540-548.
- Bahorun, T., Luximon-Ramma, A., Crozier, A., & Aruoma, O.I. (2004). Total phenol, flavonoid, proanthocyanidin and vitamin C levels and antioxidant activities of Mauritian vegetables. *Journal of the Science of Food and Agriculture*, 84, 1553-1561.
- Barros, L., Baptista, P., Estevinho, L.M, & Ferreira, I.C. (2007)a. Effect of fruiting body maturity stage on chemical composition and antimicrobial activity of *Lactarius* sp. mushrooms. *Journal of Agricultural and Food Chemistry*, 55, 8766-8771.
- Barros, L., Calhelha, R.C., Vaz, J.A., Ferreira, I.C., Baptista, P., & Estevinho, L.M. (2007)b. Antimicrobial activity and bioactive compounds of Portuguese wild edible mushrooms methanolic extracts. *European Food Research and Technology*, 225, 151-156.
- Benzie, I.F., & Strain, J. (1999). Ferric reducing/antioxidant power assay: Direct measure of total antioxidant activity of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. *Method in Enzymology*, 299, 15-27.
- Breene, W.M. (1990). Nutritional and medicinal value of specialty mushrooms. *Journal of Food Protection*, 53, 883-899.
- Carlile, M.J., Watkinson, S.C., & Gooday, G.W. (2001). *The Fungi*. Academic Press, ISBN: 9780127384467.
- Cohen, N., Cohen, J., Asatiani, M.D., Varshney, V.K., Yu, H.T., Yang, Y.C., Li, Y.H., Mau, J.L., & Wasser, S.P. (2014). Chemical composition and nutritional and medicinal value of fruit bodies and submerged cultured mycelia of culinary-medicinal higher Basidiomycetes mushrooms. *International Journal of Medicinal Mushrooms*, 16, 273-291.

- Crisan, E.V., & Sands, A. (1978). Nutritional value. In: S.T. Chang and W.A. Hayes (Eds). *The biology and cultivation of edible mushrooms* (p. 137-165). London: Academic Press Inc.
- Demirer, T., Röck-Okuyucu B., & Özer, I. (2005). Effect of different types and doses of nitrogen fertilizers on yield and quality characteristics of mushrooms (*Agaricus bisporus* (Lange) Sing) cultivated on wheat straw compost. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 106, 71-77.
- Diplock. A., Charuleux. J.L., Crozier-Willi, G., Kok, F., Rice-Evans, C., Roberfroid, M., Stahl, W., & Vina-Ribes, J. (1998). Functional food science and defence against reactive oxidative species. *British Journal of Nutrition*, 80, 77-112.
- Ebeling, M.E. (1968). The Dumas method for nitrogen in feeds. *Journal Association of Official Analytical Chemists*, 51, 766-770.
- Giri, S., Biswas, G., Pradhan, P., Mandal, S.C., & Acharya, K. (2012). Antimicrobial activities of basidiocarps of wild edible mushrooms of West Bengal, India. I *International Journal of PharmTech Research*, 4, 1554-1560.
- Halls, L.K. (1977). Southern fruit-producing woody plants used by wildlife. USDA Forest Service General Technical Report, Southern Forest Experiment Station(SO-16).
- Heleno, S.A., Barros, L., Sousa, M.J., Martins, A., & Ferreira, I.C. (2010). Tocopherols composition of Portuguese wild mushrooms with antioxidant capacity. *Food Chemistry*, 119, 1443-1450.
- Ishikawa, Y., Morimoto, K., & Hamasaki, T. (1984). Flavoglucin, a metabolite of *Eurotium chevalieri*, its antioxidation and synergism with tocopherol. *Journal of the American Oil Chemists' Society*, 61, 1864-1868.
- Iwalokun, B., Usen, U., Otunba, A., & Olukoya, D. (2007). Comparative phytochemical evaluation, antimicrobial and antioxidant properties of *Pleurotus ostreatus*. *African Journal of Biotechnology*, 6, 1732-1739.
- Jiskani, M. (2001). Energy potential of mushrooms. *The DAWN Economic and Business Review*, 15-21.
- Johnson, R.A., Willson, M.F., Thompson, J.N., & Bertin, R.I. (1985). Nutritional values of wild fruits and consumption by migrant frugivorous birds. *Ecology*, 66, 819-827.
- Kalogeropoulos, N., Yanni, A.E., Koutrotsios, G., & Aloupi, M. (2013). Bioactive microconstituents and antioxidant properties of wild edible mushrooms from the island of Lesbos, Greece. *Food and Chemical Toxicology*, 55, 378-385.
- Karaman, I., Şahin, F., Güllüce, M., Ögütçü, H., Şengül, M., & Adıgüzel, A. (2003). Antimicrobial activity of aqueous and methanol extracts of *Juniperus oxycedrus* L. *Journal of Ethnopharmacology*, 85, 231-235.
- Keleş, A., Koca, I., & Gençcelep, H. (2011). Antioxidant properties of wild edible mushrooms. *Journal of Food Processing & Technology*, 2, 130-136.
- Kurtzman, R., Chang, S., Buswell, J., & Chiu, S. (1993). Analysis, digestibility and the nutritional value of mushrooms. Mushroom Biology and Mushroom Products. Eds. Chang, S.T., Buswell, J.A. and Chiu, S.W. Chinese University Press, Shatin, NT Hong Kong.
- CLSI. (2012). Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Second Informational Supplement. CLSI document M100-S22. Wayne, PA: Clinical and Laboratory Standards Institute; 2012.
- Lee, I.K., Kim, Y.S., Jang, Y.W., Jung, J.Y., & Yun, B.S. (2007). New antioxidant polyphenols from the medicinal mushroom *Inonotus obliquus*. *Bioorganic & Medicinal Chemistry Letters*, 17, 6678-6681.
- Lin, J.Y., & Tang, C.Y. (2007). Determination of total phenolic and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation. *Food Chemistry*, 101, 140-147.
- Longvah, T., & Deosthale, Y. (1998). Compositional and nutritional studies on



- edible wild mushroom from northeast India. *Food Chemistry*, 63, 331-334.
- Mattila, P., Könkö, K., Euroala, M., Pihlava, J.M., Astola, J., Vahteristo, L., Hietaniemi, V., Kumpulainen, J., Valtonen, M., & Piironen, V. (2001). Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. *Journal of Agricultural and Food Chemistry*, 49, 2343-2348.
- Murcia, M.A., Martínez-Tomé, M., Jiménez, A.M., Vera, A.M., Honrubia, M., & Parras, P. (2002). Antioxidant activity of edible fungi (truffles and mushrooms): losses during industrial processing. *Journal of Food Protection*, 65, 1614-1622.
- Nizamlioglu, N., & Nas, S. (2010). The phenolic compounds in vegetables and fruit; structures and their importance. *Electronic Journal of Food Technologies*, 5, 20-35.
- Öztürk, M., Duru, M.E., Kivrak, Ş., Mercan-Doğan, N., Türkoglu, A., & Özler, M.A. (2011). In vitro antioxidant, anticholinesterase and antimicrobial activity studies on three *Agaricus* species with fatty acid compositions and iron contents: A comparative study on the three most edible mushrooms. *Food and Chemical Toxicology*, 49, 1353-1360.
- Peksen, A., Yakupoglu, G., & Kibar, B. (2008). Some chemical components of *Lactarius pyrogalus* from diverse locations. *Asian Journal of Chemistry*, 20, 3109-3114.
- SengYim, H., Yee Chye, F., KhengHo, S., & Wai Ho, C. (2009). Phenolic profiles of selected edible wild mushrooms as affected by extraction solvent, time and temperature. *Asian Journal of Food and Agro-Industry*, 2, 392-401.
- Slawinska, A., Radzki, W., & Kalbarczyk, J. (2013). Antioxidant activities and polyphenolics content of *Flammulina velutipes* mushroom extracts. *Herba Polonica*, 59, 26-36.
- Slinkard, K., & Singleton, V.L. (1977). Total phenol analysis: automation and comparison with manual methods. *American Journal of Enology and Viticulture*, 28, 49-55.
- Vamanu, E., Ene, M., Vamanu, A., Smarandache, D., Sârbu, I., Popa, O., Băbeanu, N., Nita, S., & Veaceslav, B. (2011). Antioxidant and antibacterial properties of the extracts from *Pleurotus ostreatus* EVFB1 and EVFB4. *Romanian Biotechnological Letters*, 16, 40-46.
- Vazirian, M., Faramarzi, M.A., Ebrahimi, S.E.S., Esfahani, H.R.M., Samadi, N., Hosseini, S.A., Asghari, A., Manayi, A., Mousazadeh, S.A., & Asef, M.R. (2014). Antimicrobial effect of the Lingzhi or Reishi medicinal mushroom, *Ganoderma lucidum* (higher Basidiomycetes) and its main compounds. *International Journal of Medicinal Mushrooms*, 16, 77-84.
- Vedder, P.J.C. (1978) Modern mushroom growing. London: Educaboek.
- Williams, G., Iatropoulos, M., & Whysner, J. (1999). Safety assessment of butylated hydroxyanisole and butylated hydroxytoluene as antioxidant food additives. *Food and Chemical Toxicology*, 37, 1027-1038.
- Yildiz, A., Yeşil, Ö.F., Yavuz, Ö., & Karakaplan, M. (2005). Organic elements and protein in some macrofungi of south east Anatolia in Turkey. *Food Chemistry*, 89, 605-609.
- Yildiz, O., Can, Z., Laghari, A.Q., Şahin, H., & Malkoç, M. (2015). Wild edible mushrooms as a natural source of phenolics and antioxidants. *Journal of Food Biochemistry*, 39, 148-154.