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## Nutritive value of wild edible and cultured mushrooms

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**Abstract:** The nutritive value of *Pleurotus ostreatus* (Jacq. ex Fr.) Kumm., *Pleurotus sajor-caju* (Fr.) Singer, and *Agaricus bisporus* (Large) Sign. was determined. Dry matter, moisture, crude ash, protein, fat, cellulose, organic matter, and nitrogen-free extract were 89.7%-90.3%, 9.7%-10.3%, 6.0%-13.7%, 27.8%-41.6%, 0.5%-1.3%, 10.0%-16.2%, 76.0%-84.0%, and 26.7%-36.8% of dry weight, respectively. Mineral element contents were 14.1-45.6 g K kg<sup>-1</sup>, 0.2-1.2 g Ca kg<sup>-1</sup>, 0.4-1.9 g Mg kg<sup>-1</sup>, and 0.2-0.9 g Na kg<sup>-1</sup> as macronutrients, and 176.5-838.0 mg Fe kg<sup>-1</sup>, 35.0-46.0 mg Zn kg<sup>-1</sup>, 4.8-65.4 mg Mn kg<sup>-1</sup>, 6.5-21.5 mg Cu kg<sup>-1</sup>, 0.0-11.5 mg Cr kg<sup>-1</sup>, and 0.0-1.65 mg Cd kg<sup>-1</sup> as micronutrients (dry wt). Furthermore, toxic elements, such as Pb, Ni, and Co, were not detected in any of the 3 species of mushroom.

**Key words:** *Pleurotus* spp., *A. bisporus*, nutritive value, mineral element

### Yenen yabani ve kültür mantarların besin değerleri

**Özet:** Bu çalışmada, *Pleurotus ostreatus* (Jacq. ex Fr.) Kumm., *Pleurotus sajor-caju* (Fr.) Singer ve *Agaricus bisporus* (Large) Sign.'in besin değerleri saptandı. Kuru madde, nem, ham kül, protein, yağ, selüloz, organik madde ve azotsuz öz madde miktarı sırasıyla; % 89,7-90,3, % 9,7-10,0, % 6,0-13,7, % 27,8-41,6, % 0,5-1,3, % 10,0-16,2, % 76,0-84,0 ve % 26,7-36,8 olarak gösterildi. Mineral element içerikleri; 14,1-45,6 K, 0,2-1,2 Ca, 0,4-1,9 Mg, 0,2-0,9 Na gibi makro elementler (g kg<sup>-1</sup>); 176,5-838,0 Fe, 35,0-46,0 Zn, 4,8-65,4 Mn, 6,5-21,5 Cu, 0,0-11,5 Cr ve 0,0-1,65 Cd gibi mikro elementler (mg kg<sup>-1</sup>) olarak belirlendi. Ayrıca, tüm mantar türlerinde Pb, Ni ve Co gibi toksik elementler ise saptanmadı.

**Anahtar sözcükler:** *Pleurotus* spp., *A. bisporus*, besinsel değer, mineral element

### Introduction

Edible mushrooms have been used to maintain health (1). Nowadays, they are undoubtedly consumed much more for their texture and flavor than for their nutritional and medicinal properties (2). More than 2000 mushroom species exist in nature, but only approximately 22 species are intensively cultivated (3). In most countries there is a significant consumer acceptance of cultivated mushrooms, such as *A. bisporus*, *Pleurotus* spp.,

*Lentinus edodes*, *Volvariella volvacea*, and *Auricularia* spp. (4). In general, they have higher protein contents than most vegetables rich in minerals, carbohydrate, and vitamins, and have low fat content (2,3,5-7). Previous studies have indicated that edible mushroom species are highly nutritious—their nutritional value comparing favorably with that of meat, eggs, and milk (8,9). The cultivation of mushrooms is economically important for the food industry worldwide, which has expanded in the past few years.

It was reported that trace element concentrations in mushrooms are considerably higher than those in agricultural crop plants, vegetables, and fruits (10). Some people collect macrofungi to make a substantial contribution to their food intake; therefore, it is necessary to know the levels of toxic and essential elements in edible mushrooms (11-13). The objective of the present study was to examine the nutritive value of *A. bisporus* and *Pleurotus* spp.

## Materials and methods

### Obtained materials

Fresh *P. ostreatus* and *P. sajor-caju* samples were obtained from the Cultured Mushroom Laboratory of Fırat University, Elazığ, Turkey, and *A. bisporus* was purchased from a mushroom farm in Gezin, Elazığ. In addition, wild samples of *P. ostreatus* were collected from the vicinity of Elazığ and Diyarbakır, Turkey. The samples were cleaned without washing, cut into slices, dried at room temperature for 15 days, and then stored.

### Proximate analysis

The proximate composition of *Pleurotus* spp. and *A. bisporus*, including moisture, dry matter, crude protein, crude fat, crude ash, and organic matter, was determined according to AOAC methods (14), and crude cellulose was estimated using the methods of Crampton and Maynard (15). Protein was determined using the Kjeldahl method and the nitrogen factor used for crude protein calculation was 4.38. Crude fat was determined by Soxhlet extraction, using ether as a solvent and total ash by incineration at 550 °C. Nitrogen-free extract (NFE) and organic matter were calculated as % dry matter – (% ash + % protein + % fat + % cellulose), and % dry matter – % ash.

### Mineral element analysis

Each mushroom sample mushroom was air-dried dried at 105 °C overnight, and crushed using a mortar and pestle. Digestion of the mushroom samples was performed using a mixture of HNO<sub>3</sub>:H<sub>2</sub>SO<sub>4</sub>:H<sub>2</sub>O<sub>2</sub> (10:1:1, 12 mL g<sup>-1</sup> of sample) and heating at 100 °C for about 10-15 min. After cooling, 50 mL of deionized water was added and filtered. All sample solutions were clear. While the amounts of Fe, Zn, Mn, Cu, Cr, Cd, Co, Ni, and Pb were determined using an atomic

absorption spectrometer (Perkin-Elmer model 370, The Perkin-Elmer Corporation, Norwalk, Connecticut, USA), those of K, Mg, Ca, and Na were determined using an atomic emission spectrometer (Eppendorf Geratebau, Netheler + HINZ GMBH Hamburg, Germany) (14).

### Statistical analysis

Experimental values are given as means ± standard deviation (SD). Statistical significance was determined by one-way variance analysis (ANOVA). Differences at P < 0.05 were considered to be significant. A Tukey HSD multiple comparison test to compare multiple means was used with the SPSS v.13.0 (SPSS, Chicago, Illinois, USA). The experiments were repeated 3 times.

## Results and discussion

Minimum and maximum values of dry matter and moisture were 89.7% and 90.3%, and 9.7% and 10.3%, respectively (Table 1). These results are consistent with the results reported by Ragunathan and Swaminathan (5), Chang et al. (16), Bisaria et al. (17), Khanna et al. (18), and Ragunathan et al. (19). In those studies most fresh mushrooms contained about 90% moisture and 10% dry matter, and dry mushrooms contained about 90% dry matter and 10% moisture. There were no significant differences in dry matter and moisture content between *A. bisporus* and *Pleurotus* spp. (Table 1).

The highest ash content was 13.7% in <sup>\*B</sup>*P. ostreatus*, whereas the lowest (6.0%) was in <sup>\*\*</sup>*P. ostreatus*, as shown in Table 1. Ash content in <sup>\*A</sup>*P. ostreatus* (12.7%), <sup>\*B</sup>*P. ostreatus* (13.7%), and <sup>\*\*</sup>*A. bisporus* (12.0%) was higher than in <sup>\*\*</sup>*P. ostreatus* (6.0%) and <sup>\*\*</sup>*P. sajor-caju* (6.3%). The reported ash content in mushrooms is 5.4%-27.6% (2,5,6,20). Ash content in *A. bisporus* and *Pleurotus* spp. was similar to that reported in similar studies (2,5-6,20), and was lower than that reported earlier (5).

Edible mushrooms are highly valued as a good source of protein and their protein contents usually range from 14.0% to 44.3% of dry weight (5-6,16-20). In the present study the highest protein content (41.6%) was obtained from <sup>\*</sup>*P. ostreatus*, while the lowest (27.8%) was obtained from <sup>\*B</sup>*P. ostreatus*.

Table 1. Nutrient content of wild edible and cultured mushrooms (% dry wt.).

Species	Dry Matter	Moisture	Crude Ash	Crude Protein	Crude Fat	Crude Cellulose	Organic Matter	Nitrogen-Free Extract
** <i>P. ostreatus</i>	90.0 ± 0.0 <sup>a</sup>	10.0 ± 0.0 <sup>a</sup>	6.0 ± 0.0 <sup>c</sup>	41.6 ± 0.2 <sup>c</sup>	0.5 ± 0.2 <sup>b</sup>	14.3 ± 4.5 <sup>a</sup>	84.0 ± 0.0 <sup>b</sup>	29.6 ± 2.0 <sup>a</sup>
<sup>a</sup> <i>P. ostreatus</i>	89.7 ± 0.6 <sup>a</sup>	10.3 ± 0.6 <sup>a</sup>	12.7 ± 0.6 <sup>ab</sup>	32.8 ± 2.3 <sup>b</sup>	1.3 ± 0.4 <sup>a</sup>	16.2 ± 0.5 <sup>a</sup>	76.0 ± 1.0 <sup>ac</sup>	26.7 ± 2.0 <sup>a</sup>
<sup>b</sup> <i>P. ostreatus</i>	89.7 ± 0.6 <sup>a</sup>	10.3 ± 0.6 <sup>a</sup>	13.7 ± 0.6 <sup>a</sup>	27.8 ± 0.3 <sup>a</sup>	0.9 ± 0.1 <sup>ab</sup>	10.4 ± 6.3 <sup>a</sup>	76.0 ± 0.9 <sup>a</sup>	36.8 ± 6.2 <sup>a</sup>
** <i>P. sajor-caju</i>	90.0 ± 0.0 <sup>a</sup>	10.0 ± 0.0 <sup>a</sup>	6.3 ± 0.5 <sup>c</sup>	37.4 ± 0.8 <sup>d</sup>	1.0 ± 0.2 <sup>ab</sup>	14.0 ± 5.0 <sup>a</sup>	83.7 ± 0.6 <sup>b</sup>	31.3 ± 5.3 <sup>a</sup>
** <i>A. bisporus</i>	90.3 ± 0.5 <sup>a</sup>	9.7 ± 0.6 <sup>a</sup>	12.0 ± 0.0 <sup>b</sup>	36.3 ± 0.9 <sup>d</sup>	0.8 ± 0.1 <sup>ab</sup>	10.0 ± 2.0 <sup>a</sup>	78.3 ± 0.5 <sup>c</sup>	31.2 ± 2.5 <sup>a</sup>

<sup>a</sup>Wild, <sup>\*\*</sup>cultured, collected from the vicinity of <sup>A</sup>Elazığ and <sup>B</sup>Diyarbakır, Turkey.

Each value is expressed the mean ± SD of 3 replicate analyses (n = 3).

Values with different superscript letters in the same column are significantly different at the 0.05 level (P < 0.05).

Protein contents of mushrooms were reported to vary according to genetic structure of species, and physical and chemical differences in growing medium (5,6,16-20). When compared with other mushrooms, the protein contents changed significantly, depending on the growing media (Table 1). This means that cultured mushrooms (<sup>\*\*</sup>*P. ostreatus*, <sup>\*\*</sup>*P. sajor-caju*, and <sup>\*\*</sup>*A. bisporus*) contain more protein than wild mushrooms (<sup>A</sup>*P. ostreatus* and <sup>B</sup>*P. ostreatus*). It seems that the quantity of crude protein is higher than that reported previously, but some values are different than those reported by other researchers (5,6,16-20).

Fat content ranged from 0.5% to 1.3% in *A. bisporus* and *Pleurotus* spp., as shown in Table 1. This means that they contained less fat in comparison with other common mushrooms (1.0%-9.5%) (6,16-20).

The highest crude cellulose content of 16.2% was in <sup>A</sup>*P. ostreatus*, whereas the lowest was 10.0%, in <sup>\*\*</sup>*A. bisporus* (Table 1). The reported cellulose values for mushrooms are 27.4%-46.2% (5,16-19). The levels of crude cellulose were relatively low compared to earlier published reports (5,16-19). Additionally, organic matter content was 84.0% in <sup>\*\*</sup>*P. ostreatus*, whereas in the other sporocarps it ranged from 76.0% to 83.7% (Table 1).

Edible mushrooms are highly valued as a good source of carbohydrate and their contents usually range from 40.6% to 53.3% of dry weight (16-19), or from 40.3% to 46.2% (5). The minimum nitrogen-free extract value (26.7%) was observed in <sup>A</sup>*P. ostreatus* and the maximum (36.8%) in <sup>B</sup>*P. ostreatus* (Table 1).

The levels of nitrogen-free extract were relatively low compared to earlier published reports (5,16-19).

Mineral elements are essential for human health. The concentration of elements has an important physiological effect on different organs and cellular mechanisms (13); therefore, it is necessary to know the levels of toxic and essential elements in mushrooms before using them. High accumulation of Cd, Co, Ni, Cr, Pb, and Hg in some edible mushrooms is of a great importance when considering human health.

Potassium content ranged from 14.1 to 45.6 g kg<sup>-1</sup> of dry weight in *Pleurotus* spp. and *A. bisporus*, which were obtained from various growing media (Table 1). The highest and lowest levels of potassium were in <sup>\*\*</sup>*P. ostreatus* and <sup>\*\*</sup>*A. bisporus*, respectively. The reported potassium values for *Pleurotus* spp. are 8.10-45.2 g kg<sup>-1</sup> (5,6,16-19). These data are consistent with the data presented in the present study.

The highest calcium content (1.2 g kg<sup>-1</sup>) was in <sup>A</sup>*P. ostreatus*, whereas the lowest (0.2 g kg<sup>-1</sup>) was in <sup>\*\*</sup>*P. ostreatus* and <sup>\*\*</sup>*A. bisporus* (Table 1). The reported calcium values for mushrooms are 0.19-2.45 g kg<sup>-1</sup> (5,6,16-19). Calcium content of the mushrooms varied from that reported by other researchers (5,6,16-19), but Ca levels in <sup>\*\*</sup>*A. bisporus*, <sup>\*\*</sup>*P. ostreatus*, and <sup>\*\*</sup>*P. sajor-caju* were lower than previously reported (5).

The low sodium concentration and the presence of a great quantity of potassium suggest the utilization of mushrooms in an anti-hypertensive diet; in fact,

potassium from fruit and vegetables lowers blood pressure, as stated by Manzi et al. (2). Sodium levels were 0.2 g kg<sup>-1</sup> in *P. sajor-caju* and 0.9 g kg<sup>-1</sup> in *P. ostreatus* (Table 1). The reported sodium value for mushrooms is 0.02-2.5 mg g<sup>-1</sup> (5,16-19). These data differ from those in the present study, and levels in *A. bisporus*, *P. ostreatus*, *P. ostreatus*, and *P. sajor-caju* were lower than previously reported (5). This difference probably was due to the use of mushroom samples obtained from different growing media.

The highest magnesium content (1.9 g kg<sup>-1</sup>) was in *P. ostreatus*, whereas the lowest (0.4 g kg<sup>-1</sup>) was in *A. bisporus* (Table 1). Mg content usually ranges from 0.5 to 1.6 g kg<sup>-1</sup> of dry weight (6), from 9.4 to 18.9 g kg<sup>-1</sup> (5), or from 1.52 to 14.3 g kg<sup>-1</sup> (16-19). In the present study Mg content in *P. sajor-caju*, *A. bisporus*, and *P. ostreatus* was lower than that previously reported (5,16-19) and similar to that in another investigation (6).

Maximum iron level (838.0 mg kg<sup>-1</sup>) was in *P. ostreatus*, whereas the minimum level (176.5 mg kg<sup>-1</sup>) was in *A. bisporus* (Table 2). Fe content usually ranges from 6.1 to 12.7 g kg<sup>-1</sup> in *Pleurotus* spp. (5), from 0.25 to 12.2 g kg<sup>-1</sup> in *Pleurotus* spp. (16-19), from 56.1 to 135.0 mg kg<sup>-1</sup> in *A. bisporus* (12), 290 mg kg<sup>-1</sup> in *A. bisporus*, 281 mg kg<sup>-1</sup> in *P. ostreatus* (21), 332 mg kg<sup>-1</sup> in *A. bisporus* (22), and 48.6 mg kg<sup>-1</sup> in *P. ostreatus* (23). The level of Fe determined in *A. bisporus* was lower than that in previous reports (21,22), and higher than previously reported (12);

iron content in *P. ostreatus*, *P. ostreatus*, and *P. ostreatus* was also lower than previously reported (5,16-19), and changeable to other investigations (21-23).

Zinc concentrations were high in *P. ostreatus* (46.0 mg kg<sup>-1</sup>) and ranged from 38.0 to 44.5 mg kg<sup>-1</sup> (Table 2). Reported zinc values are 33.2-57.2 mg kg<sup>-1</sup> for *A. bisporus* (12,21-22) and 19.3-48.8 mg kg<sup>-1</sup> for *P. ostreatus* (21,23). Zn content in *A. bisporus* was lower than that reported earlier (21-22) and higher than reported by other researchers (12,23); levels of Zn in *P. ostreatus*, *P. ostreatus*, and *P. ostreatus* were higher than those reported in a similar study (23), and were lower than those in another published report (21).

The highest Mn content (65.4 mg kg<sup>-1</sup>) was in *P. ostreatus*, whereas the lowest (4.8 mg kg<sup>-1</sup>) was in *A. bisporus* (Table 2). The reported Mn values are 6.78-25.9 mg kg<sup>-1</sup> for *A. bisporus* (12,21-22) and 10.3-20.5 mg kg<sup>-1</sup> for *P. ostreatus* (21,23). Mn content in *A. bisporus* was lower than that reported earlier (12,22) and higher than in another study (23); levels of Mn in *P. ostreatus*, *P. ostreatus*, and *P. ostreatus* differed from previous reports (21-23).

Copper contents ranged from 8.0 to 21.5 mg kg<sup>-1</sup> in *Pleurotus* spp. and *A. bisporus* (Table 2). The reported Cu values are 11.9-107 mg kg<sup>-1</sup> in *A. bisporus* (12,21,22), and were 5.0-8.5 mg kg<sup>-1</sup> in *P. ostreatus* (21,23). These data were very different from the data obtained in the present study (12,21-23).

Table 2. Mineral concentration of wild edible and cultured mushrooms (dry wt.).

Species	Macronutrients (g kg <sup>-1</sup> dry wt)				Micronutrients (mg kg <sup>-1</sup> dry wt)								
	K	Mg	Ca	Na	Fe	Zn	Mn	Cu	Cr	Cd	Co	Ni	Pb
<i>P. ostreatus</i>	14.1 ± 2.2 <sup>a</sup>	0.9 ± 0.4 <sup>ad</sup>	0.2 ± 0.1 <sup>a</sup>	0.3 ± 0.1 <sup>acd</sup>	647.0 ± 12.7 <sup>a</sup>	38.0 ± 3.0 <sup>a</sup>	5.4 ± 0.3 <sup>a</sup>	6.5 ± 0.3 <sup>ab</sup>	3.0 ± 1.0 <sup>a</sup>	0.63 ± 0.4 <sup>a</sup>	nd	nd	nd
<i>P. ostreatus</i>	41.2 ± 3.1 <sup>bd</sup>	1.7 ± 0.3 <sup>bc</sup>	1.2 ± 0.1 <sup>b</sup>	0.5 ± 0.1 <sup>ad</sup>	718.0 ± 7.0 <sup>b</sup>	46.0 ± 4.0 <sup>a</sup>	12.0 ± 1.5 <sup>b</sup>	10.5 ± 0.6 <sup>b</sup>	5.4 ± 0.2 <sup>a</sup>	0.75 ± 0.2 <sup>a</sup>	nd	nd	nd
<i>P. ostreatus</i>	29.9 ± 1.7 <sup>c</sup>	1.9 ± 0.1 <sup>c</sup>	0.9 ± 0.1 <sup>c</sup>	0.9 ± 0.2 <sup>bd</sup>	838.0 ± 8.8 <sup>c</sup>	44.5 ± 6.1 <sup>a</sup>	65.4 ± 3.7 <sup>c</sup>	14.0 ± 1.2 <sup>c</sup>	11.5 ± 1.0 <sup>b</sup>	1.65 ± 0.1 <sup>b</sup>	nd	nd	nd
<i>P. sajor-caju</i>	16.6 ± 0.4 <sup>a</sup>	0.5 ± 0.1 <sup>d</sup>	0.3 ± 0.1 <sup>a</sup>	0.2 ± 0.1 <sup>c</sup>	533.0 ± 4.4 <sup>d</sup>	35.0 ± 3.0 <sup>a</sup>	5.1 ± 0.2 <sup>a</sup>	8.0 ± 1.5 <sup>b</sup>	nd	nd	nd	nd	nd
<i>A. bisporus</i>	45.6 ± 1.9 <sup>d</sup>	0.4 ± 0.1 <sup>cd</sup>	0.2 ± 0.1 <sup>a</sup>	0.4 ± 0.2 <sup>d</sup>	176.5 ± 7.2 <sup>e</sup>	38.0 ± 2.0 <sup>a</sup>	4.8 ± 0.6 <sup>a</sup>	21.5 ± 1.0 <sup>d</sup>	nd	nd	nd	nd	nd

<sup>a</sup>Wild, <sup>cd</sup> cultured, collected from <sup>a</sup>Elazığ and <sup>b</sup>Diyarbakır, Turkey. nd: Not detected.

Each value is expressed as the mean ± SD of 3 replicate analyses (n = 3).

Values with different superscript letters in the same column are significantly different at the level of 0.05 (P < 0.05).

Levels of Pb, Ni, and Co were not detected in *A. bisporus* or *Pleurotus* spp. (Table 2), and concentrations of Cd and Cr were not determined in <sup>\*\*</sup>*A. bisporus* or <sup>\*\*</sup>*P. sajor-caju* (Table 2). Cd content in <sup>\*A</sup>*P. ostreatus*, <sup>\*B</sup>*P. ostreatus*, and <sup>\*\*</sup>*P. ostreatus* was higher than previously reported (23), and lower than previously reported (21); levels of Cr in <sup>\*A</sup>*P. ostreatus*, <sup>\*B</sup>*P. ostreatus*, and <sup>\*\*</sup>*P. ostreatus* were higher than previously reported (21). In the present study, Pb, Ni, and Co values in *A. bisporus* and *P. ostreatus* varied according to growth region and genetic structure of the species (10,21-23). This may be ascribed to differences in substrate composition, as determined by the ecosystem and great differences in uptake of individual metals by mushrooms species (10-13,21-23).

Concentrations of K, Mg, Ca, Na, Fe, Zn, Mn, Cu, Cr, Cd, Co, Pb, and Ni in *A. bisporus* and *Pleurotus* spp. differed from those previously reported (5,6,12,16-19,22,23). The metal concentration in mushrooms is mainly affected by acidic and organic

matter contents of the ecosystem and soil. The uptake of metal ions by mushrooms is in many respects different from that in plants; thus, concentrations of metals depend on mushroom species, and their ecosystems and soil (11,12).

In conclusion, wild edible and cultured mushrooms are an excellent food that can be used in a well-balanced diet for their low fat content, functional compounds, and other nutritional values.

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