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Comparison of Antioxidant Potentials of the Wild and Cultivated Forms of Edible *Pleurotus ostreatus* and *Agaricus bisporus* Mushrooms

Yenilebilir *Pleurotus ostreatus* ve *Agaricus bisporus* Mantarlarının Doğal ve Kültür Formlarının Antioksidan Potansiyellerinin Karşılaştırılması

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Abstract

The present study aimed to determine the Total Antioxidant Status (TAS), Total Oxidant Status (TOS) and Oxidative Stress Index (OSI) of the wild and cultivated forms of edible *Pleurotus ostreatus* and *Agaricus bisporus* mushrooms. Wild and cultivated mushroom samples were extracted with ethanol using a soxhlet device. TAS, TOS and OSI values were determined using Rel Assay Diagnostics kits. The study findings demonstrated that antioxidant and oxidant potentials of the wild mushrooms were higher than cultivated form. However, it was determined that the oxidative stress status of the cultivated forms was more adequate. In conclusion, it was determined that both the wild and cultivated forms of the mushrooms used in the study had antioxidant potential.

Key words: Edible mushrooms, Antioxidant, Oxidant, Oxidative stress.

Öz

Bu çalışmada, yenilebilir *Pleurotus ostreatus* ve *Agaricus bisporus* mantarlarının doğal formları ile kültür ortamından temin edilen örneklerinin Toplam Antioksidan Seviyeleri (TAS), Toplam Oksidan Seviyeleri (TOS) ve Oksidatif Stres İndekslerinin (OSI) belirlenmesi ve kıyaslanması amaçlanmıştır. Doğal ve kültür mantar örnekleri soxhlet aparatı kullanılarak etanol ile özütlenmiştir. TAS, TOS ve OSI değerleri Rel Assay Diagnostics kitleri kullanılarak belirlenmiştir. Yapılan çalışmalar sonucunda doğal formlarının antioksidan ve oksidan potansiyellerinin daha yüksek olduğu belirlenmiştir. Fakat kültür formlarının daha uygun oksidatif stres durumlarının olduğu tespit edilmiştir. Sonuç olarak çalışmada kullanılan mantarların hem doğal hem kültür formlarının antioksidan potansiyellerinin olduğu belirlenmiştir.

Anahtar kelimeler: Yenilebilir mantarlar, Antioksidan, Oksidan, Oksidatif stres.

1. Introduction

Mushrooms are considered to be an important component in the global cuisine. They have been considered as a culinary wonder by individuals especially due to their unique tastes. Macrofungi species is thought to be between 53-110 thousand in nature, but only a few considered as nutrients and cultivated commercially (Mueller et al. 2007). Mushrooms are rich in minerals and possess several essential amino acids, vitamin B-rich proteins (Mujić et al. 2010; Metin et al. 2013; Türköz-Altuğ and Çolak 2018). Mushrooms have several medicinal properties, in addition to their nutritional properties. Previous studies reported that mushrooms have significant potentials such as anticancer, antioxidant, antimicrobial, DNA preservative, cholesterol lowering and immune-stimulant properties (Kosanic et al. 2013; Gan et al. 2013; Orsine et al. 2014; Yılmaz et al. 2016; Akgül et al. 2017; Bal et al. 2017; Seçme et al. 2018; Sevindik et al. 2018a).

All living organisms, including mushrooms, are exposed to oxidative stress due to several environmental and structural factors. Depending on the oxidative stress levels, several health problems such as cancer, neurological disorders, high blood pressure, diabetes, acute respiratory distress and asthma may occur (Birben et al. 2012). In order to reduce oxidative stress damage or to prevent oxidative damage, antioxidant supplements could be consumed when endogenous antioxidants are not sufficient in the form antioxidant rich nutrients (Sarac et al. 2016; Selamoğlu et al. 2016). Thus, determination of the antioxidant potentials of mushrooms is very important in order to identify new natural antioxidant sources.

The present study aimed to determine and compare the Total Antioxidant Status (TAS), Total Oxidant Status (TOS) and Oxidative Stress Index (OSI) of edible wild and cultivated *Pleurotus ostreatus* (Jacq.) P. Kumm. and *Agaricus bisporus* (J.E. Lange) Imbach mushrooms.

2. Materials and Methods

2.1 Mushroom samples

In 2018, wild mushroom samples were collected from Isparta province in Turkey (Figs 1 and 2). The morphological and ecological properties of the photographed samples were noted. After field studies, the specimens were taken to the laboratory. Microscopic characteristics were determined with 3% KOH under light microscope (Leica DM750). Identification of the specimens was based on Breitenbach and Kränzlin (1991, 1995), Dähncke (2006), Elborne (2008), Knudsen et al. (2008). The cultivated form of *P. ostreatus* was cultivated in straw and cotton mixture, and wheat stalk was used to cultivated *A. bisporus* and pine soil was used as cover.

Fig. 1. *Pleurotus ostreatus*

Fig. 2. *Agaricus bisporus*

2.2 Extraction of mushroom samples

The mushroom samples collected in the field were dried in laboratory conditions using an incubator at 40^0 C. After the samples were dried, they were pulverized with a mechanical mill. Thirty grams of pulverized mushrooms were weighed and extracted with a Soxhlet device with ethanol at 50^0 C for about 6 hours (Gerhardt EV 14). The extracts were then concentrated under pressure with a rotary evaporator at 40^0 C (Heidolph Laborota 4000 Rotary Evaporator) and prepared for the tests at $+4^0$ C.

2.3 Determination of TAS, TOS and OSI

Mushroom Total Antioxidant Status (TAS) was measured with Rel Assay brand commercial kits (Assay Kit Rel Diagnostics, Turkey) where Trolox was used as the calibrator. The results were expressed in mmol Trolox equiv./L (Erel 2004). Total Oxidant Status (TOS) was measured with Rel Assay brand commercial kits using hydrogen peroxide as the calibrator. The results were expressed in μmol H_2O_2 equiv./L (Erel 2005). When calculating the Oxidative Stress Index (OSI) (Arbitrary Unit:AU), the mmol unit for the TAS test was converted to μmol unit similar to the TOS test (Erel 2005). The results are calculated with the following formula:

$$\text{OSI (AU)} = \frac{\text{TOS, μmol } H_2O_2 \text{ equiv./L}}{\text{TAS, mmol Trolox equiv./L} \times 10}$$

3. Results and Discussion

No previous studies were conducted to determine the TAS, TOS and OSI values of *P. ostreatus* and *A. bisporus* mushrooms that were used in the present study. The TAS, TOS, OSI values of the mushroom ethanol extracts are presented in Tab. 1.

Table 1. Mushroom TAS, TOS and OSI Values.

Mushrooms	TAS(mmol/L)	TOS(μmol/L)	OSI
P.W.*	2.023±0.108	7.048±0.136	0.351±0.025
P.C.*	1.153±0.070	1.071±0.138	0.092±0.007
A.W.**	1.256±0.043	11.473±0.133	0.915±0.021
A.C.**	1.084±0.099	4.168±0.096	0.389±0.026

* *P. ostreatus* wild form: PW, *P. ostreatus* cultivated form: PC
** *A. bisporus* wild form: AW, *A. bisporus* cultivated form: AC
***Values are presented as mean±SD; number of mushroom samples n=6; Experiments were conducted in 3 parallels

The study findings reflected that the highest OSI value was determined in the wild form of *A. bisporus* mushroom. This was followed by the cultivated form of *A. bisporus* mushroom, the wild form of *P. ostreatus* mushroom and the cultivated form of *P. ostreatus* mushroom, respectively. The highest TAS value was determined in the wild form of *P. ostreatus* mushroom. The lowest TAS value was determined in cultivated form of *A. bisporus* mushroom. The highest TOS was determined in the wild

form of *A. bisporus* mushroom. The lowest TOS was determined in cultivated form of *P. ostreatus* mushroom. On the other hand, as a result of the present study, it was determined that wild mushroom forms exhibited higher antioxidant and oxidant potentials when compared to the cultivated mushrooms. These findings demonstrated that mushrooms produced higher secondary metabolites with antioxidant and oxidant action in their natural environment. Furthermore, higher OSI values observed in wild mushrooms demonstrated that the cultivated forms were healthier in terms of oxidative stress when compared to the cultivated mushrooms.

Different mushroom species were used in previous TAS, TOS and OSI studies. Edible wild mushroom samples were used in previous studies and TAS values of *Gyrodon lividus* (Bull.) Sacc., *Auricularia auricula-judae* (Bull.) Quél, *Cyclocybe cylindracea* (DC.) Vizzini & Angelini, *Macrolepiota procera* (Scop.) Singer, *Tricholoma terreum* (Schaeff.) P. Kumm. and *Laetiporus sulphureus* (Bull.) Murrill mushrooms were determined as 2.077, 1.010, 4.325, 2.823, 0.38 and 2.195 mmol/L, TOS values were determined as 13.465, 23.910, 21.109, 10.349, 16.76 and 1.303 µmol/L, and OSI values were reported as 0.651, 2.367, 0.488, 0.367, 4.41 and 0.059, respectively (Akgül et al. 2016a; Akgül et al. 2016b; Akgül et al. 2017; Sevindik et al. 2018a; Sevindik et al. 2018b; Bal 2018). When compared to the above-mentioned studies, the TAS values of both the wild and cultivated forms of *P. ostreatus* and *A. bisporus* mushrooms that were used in our study were higher when compared to those of *A. auricula* and *T. terreum*. On the other hand, when compared to *G. lividus, C. cylindracea, M. procera* and *L. sulphureus* mushrooms, it was found that the TAS values of *P. ostreatus* and *A. bisporus* mushrooms were lower. It was suggested that these differences were due to the differences in the capacity of the mushrooms to produce antioxidant compounds. This was due to the differences in the antioxidant vitamin levels and the changes in the enzymatic and non-enzymatic antioxidant molecule levels, in addition to the differences in the count and diversity of phenolic compounds related to the synthesis and release of the secondary metabolites produced as a response by the organism to endogenous and exogenous factors and consequent defense mechanism.

Analysis of the TOS values demonstrated that the wild form of *P. ostreatus* mushroom exhibited a higher TOS value when compared to *L. sulphureus* mushroom, while the same value was lower when compared to those of *G. lividus, A. auricula*, *C. cylindracea, M. procera* and *T. terreum* mushrooms. The cultivated form of *P. ostreatus* mushroom was found to exhibit lower TOS values when compared to *G. lividus, A. auricula, C. cylindracea, M. procera, T. terreum* and *L. sulphureus*.

It was found that TOS value of the wild form of *A. bisporus* mushroom was higher when compared to *M. procera* and *L. sulphureus* mushrooms, while it was determined that the same TOS value was lower when compared to *G. lividus, A. auricula*, *C. cylindracea* and *T. terreum* mushrooms. The cultivated form of *A. bisporus* mushroom exhibited higher TOS values when compared to *L. sulphureus*, and lower TOS values when compared to *G. lividus, A. auricula, C. cylindracea, M. procera* and *T. terreum*. Differences between the TOS values of the mushrooms used in our study and the analysis conducted on wild mushrooms collected in different regions in previous studies were notable. It was suggested that the main reason behind the differences between TOS values were due to the differences in the collection regions and the ability of these differences to affect their capacity to produce and store oxidant compounds due to the differences in their metabolic processes. It is recommended that the consumption of mushrooms or any wild product with high TOS value should be more controlled when collected in these regions.

It is considered that agents with high TOS values reflect the above-mentioned biochemical data due to the impact of the environmental and metabolic factors, and these factors stimulate the defense mechanisms of mushrooms by stimulating the production of certain free radicals, especially reactive oxygen species, to protect themselves against environmental or endogenous harmful factors. The stimulation of the production of endogenous oxidant molecules within the defense mechanisms of organisms such as mushrooms provides protection of these organisms against several environmental pollutant factors as well. Thus, the findings of studies such as the present study are worthy social data in order to alert the society on reduction or controlled consumption of environmental toxic agents and pollutants in order to reduce and prevent the production of oxidant compounds induced by the effects of exogenous factors and the accumulations of oxidant substances.

Analysis of the obtained OSI values of wild and cultivated form for *P. ostreatus* mushroom demonstrated that these were higher when compared to *L. sulphureus* mushroom, and lower when compared to *G. lividus, A. auricula, C. cylindracea, M. procera* and *T. terreum* mushrooms. It was found that wild form of *A. bisporus* mushroom exhibited lower OSI values when compared to *A. auricula* and *T. terreum*, and higher OSI values when compared to *G. lividus, C. cylindracea, M. procera,* and *L. sulphureus*. It was identified that the cultivated form of *A. bisporus*mushroomhad lower OSI values than that of *G. lividus, A. auricula, C. cylindracea* and *T. terreum*, and higher OSI values than *M. procera* and *L. sulphureus*. OSI value demonstrated the extent to which the oxidant compounds produced by the mushroom due to the environmental and physical factors were inhibited by endogenous antioxidant compounds. Thus, it was suggested that the differences in OSI were due to the differences in antioxidant and oxidant potentials of the tested mushrooms.

4. Conclusion

The present study aimed to determine antioxidant and oxidant potentials of edible *P. ostreatus* and *A. bisporus* mushrooms collected in Isparta province (Turkey). Furthermore, the oxidative stress status induced by these properties were determined. The study findings demonstrated that the wild mushroom forms exhibited higher antioxidant and oxidant properties when compared to cultivated forms. In addition, it was determined that the cultivated forms of the mushrooms had better oxidative

stress status. Thus, it was determined that the cultivated forms were healthier with respect to the oxidative stress. In conclusion, it was determined that the mushrooms studies in the present research had antioxidant potential. Thus, the mushrooms possess serious potential in the field not only due to their nutritional values, but also due to their structural properties that exhibit antioxidant activities in the development of pharmacological agents, drug design and medical applications.

Conflicts of Interest: No conflict of interest was declared by the authors.

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