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Chemical characterization and bioactivity of the most widely appreciated cultivated mushrooms: studies in fruiting bodies and mycelia

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ABSTRACT

Mushrooms are part of the human diet for thousands of years, and their consumption increased greatly in recent times. One of the main reasons for this increase is the combination of their nutritional value as well as for their medicinal and nutraceutical properties. The present work reports a comparative study of highly consumed fresh cultivated mushroom species worldwide: *Agaricus bisporus* (white and brown), *Pleurotus ostreatus* (oyster mushroom), *Pleurotus eryngii* (king oyster mushroom) and *Lentinula edodes* (shiitake). It was assessed the nutritional value and chemical composition of the mushrooms, and their mycelia were produced by *in vitro* culture to make a comparative analysis of the antioxidant activity and phenolic profile of fruiting bodies and the corresponding mycelium. *L. edodes* (shiitake) revealed the highest levels of macronutrients, unless proteins, as also the highest sugars, tocopherols and polyunsaturated fatty acids (PUFA) levels, and the lowest saturated fatty acids (SFA) content. Although phenolic compounds and derivatives investigated have been found in both fruiting bodies and mycelia, generally the species *in vivo* showed a higher antioxidant potential than the mycelium obtained by *in vitro* culture.

1. INTRODUCTION

Mushrooms are widely consumed for their great nutritional value [1,2] being also known for their nutraceutical and medicinal properties [3,4]. Thus, they might be used directly in human diet and promote health, taking advantage of the additive and synergistic effects of all the bioactive compounds present [3], including compounds reported as enhancers of their medicinal properties, such as phenolic compounds [3,4]. The production and consumption of mushrooms continuously increases over the time, being China the biggest producer [5]. The most cultivated mushroom worldwide is *Agaricus bisporus*, followed by *Lentinula edodes*, *Pleurotus* spp. and *Flammulina velutipes* [5]. With this in mind, it is important the diffusion of information about the nutritional value and chemical composition of the most common and highly consumed fresh cultivated mushrooms in Portugal and worldwide.

2. MATERIALS E METHODS

2.1. Samples

The mushroom samples were obtained in local supermarkets (Bragança, Northeastern Portugal) in March and April 2011. From each package, 2-3 samples of mushrooms were selected for *in vitro* culture. All the samples (fruiting bodies and mycelia) were lyophilized, reduced to a fine powder (20 mesh) and mixed to obtain homogenate samples for further analysis [6,7].

2.2. Nutritional value

The samples were analysed for chemical composition (moisture, proteins, fat, carbohydrates and ash) using official procedures.

2.3. Sugars, fatty acids and tocopherols composition

Free sugars were determined by HPLC coupled to a refraction index detector (RI). Fatty acids were determined after a transesterification process and the profile was analyzed by gas-liquid chromatography with flame ionization detection (GC-FID). Tocopherols composition was determined by HPLC-fluorescence [6].

2.4. Antioxidant activity

The samples (1.5 g for mushrooms and 0.5 g for mycelia) were dissolved in methanol (final concentration 20 mg/mL). Successive dilutions were made from the stock solution to realize the assays. The results were expressed in EC_{50} values (the sample concentrations providing 50% of antioxidant activity or 0.5 of absorbance for the Ferricyanide/Prussian blue assay). Trolox was used as standard [7].

The reducing power of the samples was evaluated by *Folin-Ciocalteu* assay (mg of gallic acid equivalents (GAE) per g of extract) and Ferricyanide/Prussian blue assay. The radical scavenging activity was determined through the DPPH radical-scavenging activity assay and the lipid peroxidation inhibition was determined by the β-carotene/linoleate assay [7].

2.5. Phenolic acids composition

The phenolics acids were determined by ultra fast liquid cromatography (UFLC), and the results were expressed in μg per g of dry weight (dw) [7].

2.6. Statistical analysis

For each one of the mushroom species (fruiting bodies and mycelia) three samples were used and all the assays were carried out in triplicate. The results were expressed as mean values and standard deviation (SD). The results were analyzed using one-way analysis of variance (ANOVA) followed by Tukey's HSD Test with $\alpha = 0.05$. This analysis was carried out using SPSS v. 18.0 program.

3. RESULTS AND DISCUSSION

Lentinula edodes (shiitake) revealed the highest levels of macronutrients, unless proteins (Table 1), as also the highest sugars, tocopherols and polyunsaturated fatty acids (PUFA) levels, and the lowest saturated fatty acids (SFA) (Figure 1).

Table 1. Nutritional value of the studied edible mushrooms (mean ± SD). In each row, different letters mean significant differences between species (p<0.05).

	A. bisporus (white)	*A. bisporus* (brown)	*P. ostreatus*	*P. eryngii*	*L. edodes*
Moisture (g/100 g fw)	91.27 ± 0.45^{ba}	91.64 ± 0.99^{a}	89.17 ± 2.12^{ba}	89.00 ± 1.39^{ba}	79.78 ± 1.31^{c}
Ash (g/100 g fw)	0.85 ± 0.17^{cb}	0.95 ± 0.02^{b}	0.62 ± 0.08^{d}	0.68 ± 0.06^{dc}	1.36 ± 0.05^{a}
Proteins (g/100 g fw)	1.06 ± 0.02^{a}	1.10 ± 0.03^{a}	0.65 ± 0.05^{b}	1.04 ± 0.02^{a}	0.76 ± 0.08^{b}
Fat (g/100 g fw)	0.19 ± 0.03^{cb}	0.14 ± 0.02^{d}	0.15 ± 0.02^{dc}	0.16 ± 0.03^{dcb}	0.35 ± 0.02^{a}
Carbohydrates (g/100 g fw)	6.63 ± 0.57^{c}	6.17 ± 1.02^{c}	9.41 ± 2.08^{cb}	9.12 ± 1.04^{cb}	17.75 ± 1.30^{a}
Energy (kcal/100 g fw)	32.47 ± 2.13^{cb}	30.34 ± 3.96^{c}	41.59 ± 8.27^{cb}	42.08 ± 3.99^{cb}	77.19 ± 5.30^{a}

fw – fresh weight

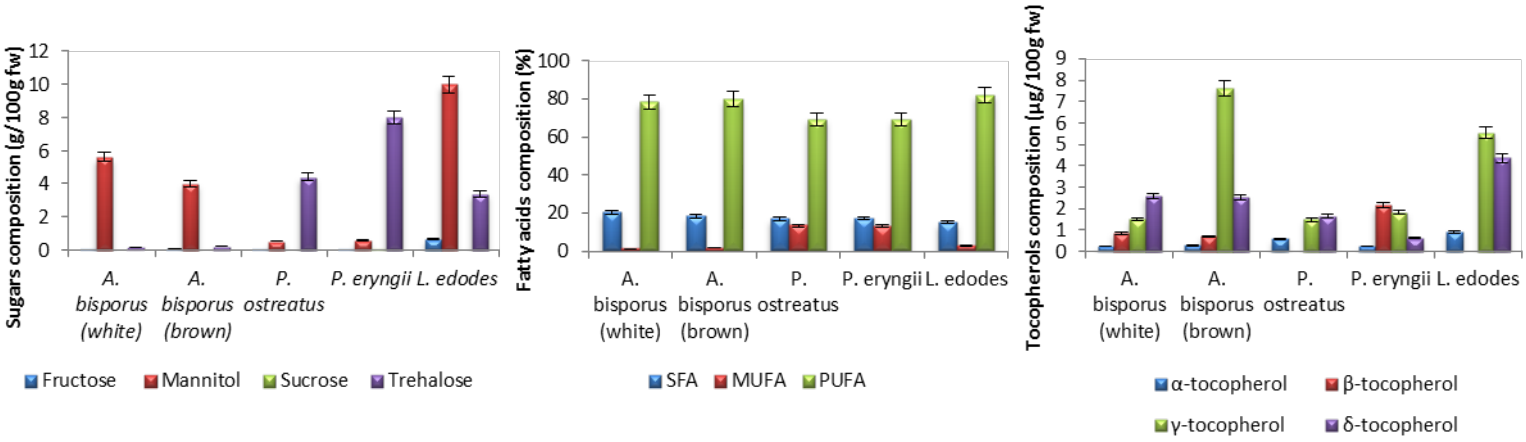

Figure 1. Sugars, fatty acids and tocopherols composition of the studied edible mushrooms (mean ± SD).

Comparing the commercial mushrooms with the mycelia obtained by *in vitro* culture (Table 2), we verify that, generally, the latter revealed lower antioxidant potential (higher EC_{50} values). The species that demonstrate the highest content in phenolic acids and related compounds was *A. bisporus* (white) (Figure 2).

Table 2. Antioxidant activity of the studied edible mushrooms (mean ± SD). In each row, different letters mean significant differences between species (p<0.05).

Species	Sample	*Folin-Ciocalteu* assay (mg GAE/g extract)	Ferricyanide/Prussian blue assay (EC_{50}; mg/mL)	DPPH radical-scavenging activity assay (EC_{50}; mg/mL)	β-carotene/linoleate assay (EC_{50}; mg/mL)
A.bisporus (white)	Mushroom	23.34 ± 0.36^{b}	1.80 ± 0.03^{i}	3.13 ± 0.09^{f}	3.42 ± 1.35^{b}
	Mycelium	4.22 ± 0.04^{f}	8.12 ± 0.06^{a}	39.68 ± 1.60^{b}	2.38 ± 0.60^{b}
A.bisporus (brown)	Mushroom	37.33 ± 0.23^{a}	1.47 ± 0.06^{j}	2.29 ± 0.06^{f}	4.85 ± 0.17^{b}
	Mycelium	8.06 ± 0.53^{ed}	4.02 ± 0.05^{c}	8.71 ± 0.19^{d}	0.15 ± 0.00^{b}
P.ostreatus	Mushroom	12.54 ± 0.18^{c}	3.31 ± 0.03^{f}	6.54 ± 0.16^{e}	2.74 ± 0.16^{b}
	Mycelium	5.19 ± 0.14^{f}	4.73 ± 0.18^{b}	58.13 ± 3.02^{a}	16.95 ± 21.95^{a}
P.eryngii	Mushroom	7.14 ± 2.01^{e}	3.72 ± 0.09^{e}	8.67 ± 0.12^{d}	4.68 ± 0.60^{b}
	Mycelium	9.11 ± 0.23^{d}	3.81 ± 0.02^{d}	25.40 ± 0.33^{c}	1.43 ± 0.60^{b}
L.edodes	Mushroom	8.84 ± 0.91^{d}	2.62 ± 0.05^{g}	6.43 ± 0.66^{e}	3.92 ± 0.32^{b}
	Mycelium	12.53 ± 0.30^{c}	2.26 ± 0.03^{h}	7.82 ± 0.56^{ed}	4.65 ± 0.68^{b}

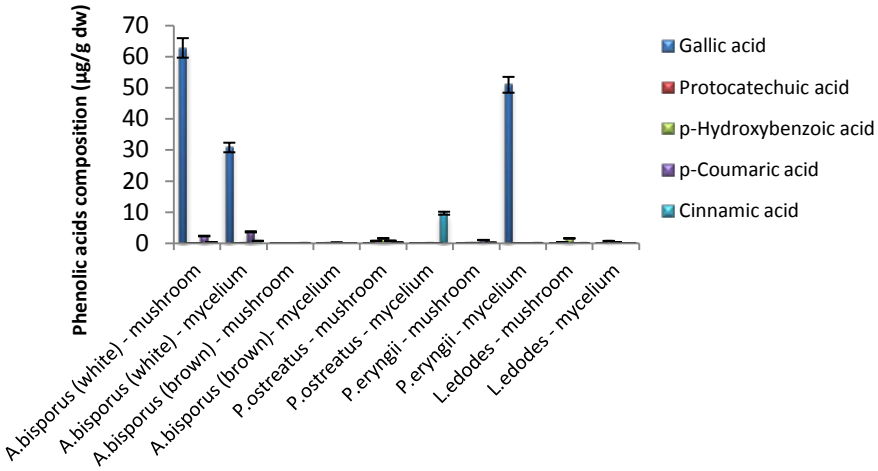

Figure 2. Phenolic acids composition and related compounds of the studied edible mushrooms (mean ± SD).

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References

[1] SA Heleno, L Barros, MJ Sousa, A Martins, ICFR Ferreira, Food Chem, 2010, 119, 1443-1450.

[2] P Mattila, K Könkö, M Eurola, JM Pihlava, J Astola, L Vahteristo, V Hietaniemi, J. Kumpulainen, M Valtonen, V Piironen, J Agric Food Chem, 49, 2343-2348.

[3] ICFR Ferreira, L Barros, RMV Abreu, Cur Med Chem, 2009, 16, 1543-1560.

[4] JA Vaz, L Barros, A Martins, JS Morais, MH Vasconcelos, ICFR Ferreira, LWT-Food Sci Technol, 2011, 44, 343-346.

[5] FMNA Aida, M Shuhaimi, M Yazid, AG Maaruf, Trends Food Sci Tech, 2009, 20, 567-575.

[6] FS Reis, L Barros, A Martins, ICFR Ferreira, Food and Chem Toxicol, 2012, 50, 191-197.

[7] FS Reis, A Martins, L Barros, ICFR Ferreira, Food and Chem Toxicol, 2012, 50, 1201-1207.