CAN EDIBLE MUSHROOMS BE USED AS A MEAT PRESERVATIVE?

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Abstract – Edible mushrooms have been described as an important source of biological compounds, such as phenolic compounds, which can reduce free radical levels and pathogenic bacteria load. The aim of this study was to evaluate the chemical composition in addition to the antioxidant and antimicrobial activity (TPC, total phenolic content; TFC, total flavonoid content; antiradical DPPH$^{•}$ and ABTS$^{•+}$ activity; RP, reducing power; and MIC, minimum inhibitory concentration) of different extracts obtained from edible mushrooms (*Agaricus brasiliensis*, *Ganoderma lucidum* and *Pleurotus ostreatus*). The results show that edible mushroom extracts (EME), mainly *P. ostreatus* (*P*<0.05), exerted high antioxidant and antibacterial activity. In conclusion, edible mushroom extracts have great potential as a source of antioxidant and antibacterial components and may be used in the preservation of meat and meat products.

Key Words – aqueous-ethanolic extract, antioxidant, antibacterial, meat.

I. INTRODUCTION

Lipid oxidation is one of the major factors that limits the shelf life of meat products. In particular, lipid oxidation involves the formation of hydroperoxides that are easily broken down into different volatile organic compounds such as alkanes, alkenes, aldehydes, ketones, alcohols, esters and acids, which cause rancid and unpleasant flavours and reduce the sensorial quality of meat products. The development of a global meat market and the increasing distance between producers and consumers has led to the use of different preservation techniques. Currently, synthetic antioxidants (SAx) (including butylated hydroxyanisole [BHA] and butylated hydroxytoluene [BHT]) and antibiotics (ABx) are widely used to inhibit oxidation reactions and microbial growth, respectively; however, their use has also recently been limited, as several studies have provided evidence of their potential risks to human health [1,2]. Therefore, one solution for addressing the disadvantages of SAx and ABx is to research other sources of natural antioxidants and antimicrobials. Edible mushrooms play an important role in traditional medicine due to their pharmacological effects (anti-tumour and immunomodulatory, among others) [2]. On the basis of these characteristics, the objective of the present study was to evaluate the antioxidant and antibacterial activity of different extracts obtained from the edible mushrooms of *Agaricus brasiliensis*, *Ganoderma lucidum* and *Pleurotus ostreatus*.

II. MATERIALS AND METHODS

Proximate chemical composition was determined following the method established by the Association of Official Analytical Chemists (AOAC) [3]. Antioxidant *in vitro* properties were evaluated by determining the total phenolic content (TPC) using Folin-Ciocalteu´s method and total flavonoid content (TFC) using the AlC_{l3} method in addition to antiradical activity (DPPH$^{•}$, 1,1- diphenyl-2-picrylhydrazyl), ABTS$^{•+}$ activity and the reducing power (RP) according to the ferricyanide/prussian blue method. The antimicrobial properties were evaluated against Gram-positive (*Staphylococcus aureus* and *Listeria innocua*) and Gram-negative (*Escherichia coli* and *Salmonella thypimurium*) bacteria by the halo method [2]. An analysis of variance (ANOVA) was used to analyse the data, and the Tukey-Kramer method was used to compare the averages (*P*<0.05).

III. RESULTS AND DISCUSSION

A descriptive analysis of the proximate chemical composition of the edible mushroom flours of *A. brasiliensis*, *G. lucidum* and *P. ostreatus* is shown in Table 1. The lowest moisture (<1%), ash (<6%) and lipid (<2%) content was found for *P. ostreatus* (P<0.05). Correspondingly, the protein (>8%) and carbohydrate content (>83%) was also the greatest for this species. The results for the chemical composition of the mushrooms follow the patterns found in a similar work [4], corroborating the quality of our samples.

The tests for TPC and TFC as well as antioxidant properties of edible mushrooms are summarised in Table 2. The results indicate that these values oscillated between 18.3–34.8 mg of gallic acid equivalent and 11.0–15.5 mg quercetin equivalent, respectively (P<0.05). According to the Argentine norm, the minimum concentrations required for the development of a natural extract product are 50 mg of GAE and 5 mg rutin equivalent/g per dried extract [5], which indicate that EME fulfils these established quality requirements. With respect to antioxidant activity, the antiradical power showed 53.4–56.4% and 84.4–91.1% inhibition in the DPPH$^{\bullet}$ and ABTS$^{\bullet+}$ assays, respectively (P<0.05). Also, the results showed that *P. ostreatus* had the highest TPC, TFC and antioxidant levels. In regard to antimicrobial properties (Table 3), the results showed that *P. ostreatus* exerted the greatest effect on Gram-positive bacteria (*L. innocua* > *S. aureus*) in comparison to Gram-negative bacteria (*E. coli* > *S. thypimurium*) (P<0.05). These results could be associated with the presence of phenolic constituents in the extract [6].

Table 1. Proximate chemical composition of edible mushroom powders (%).

Mushroom	Moisture	Ash	Protein	Lipid	Carbohydrate
A. brasiliensis	4.6 ± 0.1^c	6.7 ± 0.1^b	6.4 ± 0.1^b	2.9 ± 0.3^c	79.4^a
G. lucidum	3.4 ± 0.1^b	7.8 ± 0.1^c	5.9 ± 0.1^a	1.4 ± 0.1^a	81.5^b
P. ostreatus	0.9 ± 0.5^a	5.2 ± 0.1^a	8.4 ± 0.1^c	1.7 ± 0.3^b	83.8^c

Different superscripts ($^{a\text{-}c}$) indicate significant differences among mushrooms (P<0.05).

Table 2. Antioxidant properties of aqueous-ethanolic edible mushroom extracts.

Extract	TPC^A	TFC^B	DPPH$^{\bullet C}$	ABTS$^{\bullet+D}$	RP^E
A. brasiliensis	19.5 ± 0.6^a	11.0 ± 0.6^a	53.4 ± 0.8^a	84.4 ± 0.2^b	0.20 ± 0.04^b
G. lucidum	18.3 ± 1.2^a	13.0 ± 0.1^b	52.4 ± 0.7^a	81.6 ± 0.5^a	0.16 ± 0.02^a
P. ostreatus	34.8 ±1.4^b	15.5 ± 0.2^c	56.4 ± 0.6^b	91.1 ± 0.8^c	0.43 ± 0.02^c

^{A} mg gallic acid equivalents/mg sample; ^{B} mg quercetin equivalents/mg sample;
^{C,D} results expressed as percentage (%) of inhibition; ^{C} absorbance (700 nm).
Different superscripts ($^{a\text{-}c}$) indicate significant differences among extracts (P<0.05).

Table 3. Antibacterial activity of aqueous-ethanolic edible mushroom extracts.

Extract	Gram (+)		Gram (-)	
	S. aureus	*L. innocua*	*E. coli*	*S. thypimurium*
A. brasiliensis	+	++	++	-
G. lucidum	++	+++	+	++
P. ostreatus	++	++	++	++

(-), no inhibition (0–5 mm); + (<8 mm), ++ (>8 mm to <12 mm), +++ (>12 mm).

IV. CONCLUSION

The results of this study demonstrated that the aqueous-ethanolic edible mushroom extracts (*A. brasiliensis*, *G. lucidum* and *P. ostreatus*) had the highest total phenolic content (TPC) and exerted high antioxidant and antimicrobial activity. The extract obtained from *P. ostreatus* showed the best activities. Therefore, edible mushrooms can be used as stabilisers of oxidative reactions and to reduce the growth of certain pathogenic microorganisms.

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REFERENCES

1. Faustman, C., Sun, Q., Mancini, R., & Suman, S. P. (2010). Myoglobin and lipid oxidation interactions: Mechanistic bases and control. Meat Science 86(1): 86-94.
2. Elmastas, M., Isildak, O., Turkekul, I., & Temur, N. (2007). Determination of antioxidant activity and antioxidant compounds in wild edible mushrooms. Journal of Food Composition and Analysis 20(3): 337-345.
3. Association of Official Analytical Chemists (AOAC). (2005). Official methods of analysis of the AOAC. 18th. Ed. AOAC, Arlington, VA.
4. Kalač, P. (2009). Chemical composition and nutritional value of European species of wild growing mushrooms: A review. Food Chemistry 113(1): 9-16.
5. IRAM. (2004). Norma IRAM 15935-1 Scheme 1. Buenos Aires: Instituto Argentino de Normalización - Subcomité de productos agroalimentarios del NOA; 2004.
6. Vargas-Sánchez, R. D., Torrescano-Urrutia, G. R., Acedo-Félix, E., Carvajal-Millán, E., González-Córdova, A. F., Vallejo-Galland, B., Torres-Llanez, M. J. & Sánchez-Escalante, A. (2014). Antioxidant and antimicrobial activity of commercial propolis extract in beef patties. Journal of Food Science 79(8): C1499-C1504.

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