A comparison of fatty acid content in three species of the genus *Pleurotus*

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NOTA CORTA

Comparación del contenido de ácidos grasos en tres especies del género *Pleurotus*

Resumen. Se compararon los perfiles de Ácidos Grasos (AG) de *Pleurotus ostreatus* y *P. levis* cultivados en paja de cebada. Los AG mayoritarios encontrados en ambas especies fueron el linoleico, oleico y palmítico; sin embargo, al cultivar *P. levis* en bagazo de maguey-paja de cebada 1:1 (w/w), el AG mayoritario fue el oleico. Adicionalmente, estos resultados se compararon con una cepa comercial de *Pleurotus* sp. cultivada en paja de trigo-rastrojo de maíz. Por otro lado, se detectó la presencia del ácido elaídico en *P. levis* y el hongo comercial. Basados en trabajos previos, se comprueba que la composición de los AG en cultivos de hongos comestibles puede variar de acuerdo al sustrato empleado.

Palabras clave: Ácidos Grasos Monoinsaturados (AGMI), Ácidos Grasos Poliinsaturados (AGPI), Ácidos Grasos Saturados (AGS), ácido elaídico, setas.

Abstract.A comparison was made of fatty acid profiles (FA) of *Pleurotus ostreatus* and *P. levis* grown on a barley straw substrate. The major FAs found in both species were linoleic, oleic and palmitic fatty acids. However, in the case of cultivating *P. levis* on a maguey bagasse-barley straw 1:1 (w/w) substrate, the major acid found was oleic acid. These results were compared with a commercial strain of *Pleurotus* sp. grown on wheat straw-corn bagasse, where elaidic acid was detected in *P. levis* and the commercial mushroom. Based on previous works it was found that the composition of the FA in mushrooms cultivation varies according to the substrate used.

Key words: Monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), elaidic acid, oyster mushroom

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Edible mushrooms have a low lipid content, varying from 1.1 to 8.3% (dry weight), with an average of 4.0% (Chang and Miles, 2004) and a high proportion of polyunsaturated fatty acids (PUFAs), which gives them added value as a healthy food, recommended for including in the diet of people with high concentration of cholesterol in blood (Chang and Buswell, 1996; Heleno *et al*., 2009; Kavishree *et al*., 2008). Furthermore, PUFAs are a key factor to the sensory evaluation of edible mushrooms (Sinanoglou *et al*., 2013).

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Linoleic acid produces a serie of omega-6 fatty acids and it is the predecessor of volatile compounds of eight carbons, 1-octen-3-ol, 3-octanol, 1-octen-3-one and 3-octanone (Combet *et al*., 2006), which are the components that contribute to the characteristic flavor and aroma in most edible mushroom species (Ribeiro *et al*., 2009). Furthermore, FA profiles provide physiological data that can be used together with their morphological characteristics and they could be used to taxonomically classify a large number of mushroom strains (Jabaji-Hare, 1988; Lechevalier and Lechevalier, 1988). Therefore, a detailed analysis of lipids

and fatty acids (FA) is useful in evaluating mushrooms for nutritional and nutraceutical characteristics and also for taxonomical classification (Kavishree *et al*., 2008). The study of edible native strains such as *Pleurotus levis* (Berk. & M. A. Curtis) Singer could offer new market alternatives based on their morphological, organoleptic and nutritional characteristics among others. Therefore, the aim of this study was to determine and compare the fatty acid profile between *Pleurotus ostreatus* and *P. levis*. Additionally, the nutritional value of these mushrooms was also evaluated.

In this study, three strains of *Pleurotus* genus were used: *P. ostreatus* (IE-137), *P. levis* (IE-771) as well as a commercial *Pleurotus* strain. The first two are stored at the Ceparium of the Institute of Ecology (IE) in Xalapa, Mexico, and were grown on barley straw (S) following the general methodology of Gaitán-Hernández *et al.* (2006). The third mushroom (*Pleurotus* sp.) used was "Hongos San Miguel" and was purchased in a local commercial store grown on wheat straw-corn bagasse. Additionally, *P. levis* was also cultivated in a mixture (M) of barley straw-maguey bagasse 1:1 (w/w).

Approximately 500 g of sporophores and stipe of each mushroom were lyophilized (LABCONCO lyophilizer model 77530). Once dry, they were reduced to a fine powder using a food processor (Moulinex). For lipid extraction, about 4 g of each sample were weighed and extracted for 20 h in a Soxhlet apparatus with 200 mL of redistilled hexane (AOAC). Three extractions were performed for each mushroom species, removing the solvent by distillation under reduced pressure.

Fatty acids were hydrolyzed and methylated with borontrifluoride 14% in metanol (BF3-MeOH, Sigma-Aldrich) and the derivatives were extracted using hexane (Yilmaz *et al*., 2006; Pedneault *et al*., 2007; Ribeiro *et al*., 2009).The methyl esters were identified and quantified using a gas chromatograph coupled to a mass spectrometer (Agilent Technologies 6890N). Gas chromatography was carried out using He as carrier gas at a flow of 1mL/min at a pressure of 24.87 psi. To identify volatile derivatives, the mass spectra obtained for each methyl ester were compared to the database (HP Chemstation-NIST 05 Mass spectral search program, version 2.0d). A comparison using a standard of fatty acid methyl ester (F.A.M.E mix, C8:C22, catalog No. 18920-1AMP, Sigma-Aldrich), analyzed under the same conditions, was also made. Means and standard deviations of the values of the major fatty acids were obtained as percentages. The data obtained were processed using an analysis of variance (ANOVA) with post hoc Tukey test at 0.05% to determine significant differences amongthe means, using the Statistica 7.0 software.

Results showed that linoleic acid was the main fatty acid found in *Pleurotus ostreatus* as in *P. levis* grown on S substrate (Table 1), followed by oleic and palmitic FAs and the same result was found for the commercial mushroom grown on wheat straw-corn bagasse, this results agree with Reis *et al*. (2012) who reported the same profile for *Pleurotus* FAs. However, when *P. levis* grown on M was analyzed, the major FA encountered was oleic, followed by linoleic and palmitic FAs (Table 1). It has been reported that, when compared with plants, animals, bacteria and yeasts, fungi have a less diversity of FAs, usually containing six or seven at the most (Stahl and Klug, 1996). In the majority of the studies reported for wild and cultivated edible mushrooms, the main FA found is linoleic (C18: 2) followed by oleic (C18: 1) and palmitic (C16: 0) (Barros *et al*., 2008; Diez and Alvarez, 2001; Gutiérrez *et al*., 2002; Jing *et al*., 2012). Moreover, in the present work the presence of elaidic acid (C18: 1 trans-9) was detected in a very small amount in *Pleurotus levis* grown on both substrates, S and M. On the other hand *Pleurotus* sp. contains 5 % of this isomer of oleic acid (Table 1). Elaidic acid was first reported in wild edible mushrooms from Canada by Pedneault *et al*., (2008). This is a "trans" acid that is usually found in aliments such as milk fat, animal tissue of ruminants and occasionally in oil seeds. Furthermore, the decapentanoic

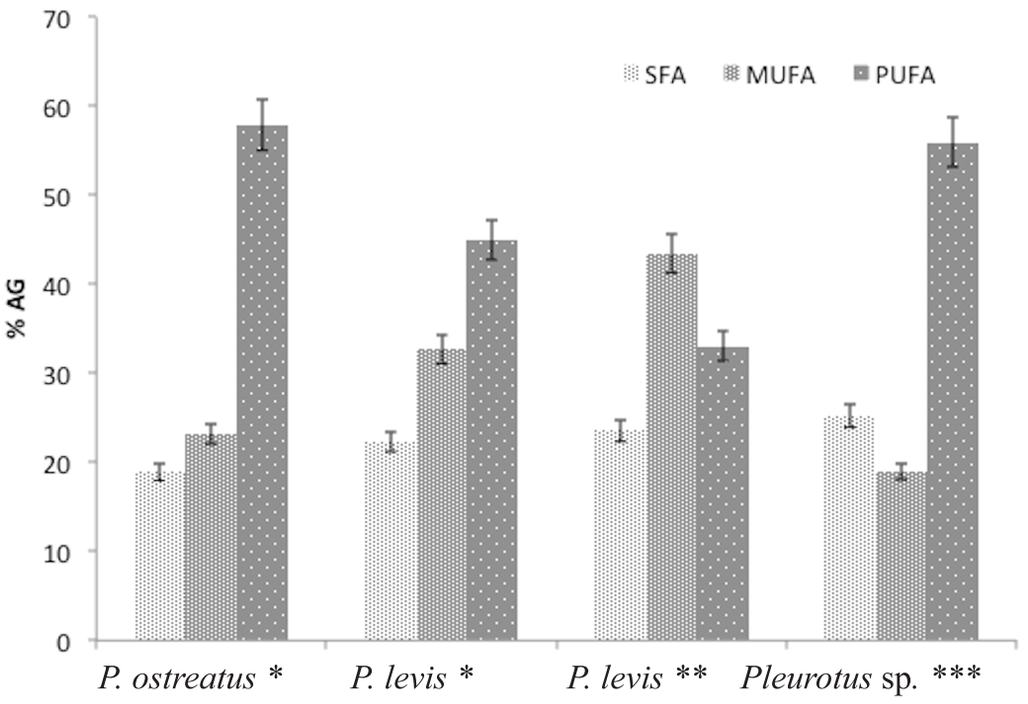
Table 1. Fatty acid composition of *Pleurotus* species grown on different substrates

FA	*P. ostreatus*	*P. levis*	*P. levis*	*Pleurotus* sp.
	Barley straw		Barley straw-maguey bagasse 1:1	Wheat straw-corn bagasse
C15:0	2.09[b]	0.53[a]	0.64[a]	6.42[c]
C16:0	14.08[a]	19.3[a]	19.97[a]	17.26[a]
C16:1	0.29[a]	1.46[a]	1.00[a]	7.54[b]
C18:0	2.73[a]	2.61[a]	2.92[a]	1.51[a]
C18:1Δ9cis	22.88[a]	30.72[ab]	41.96[b]	6.4[c]
C18:1isomers	ND	0.73[a]	0.66[a]	5.00[b]
C18:2	57.93[a]	44.74[ab]	32.98[b]	55.88[a]
PUFA/SFA	3.07[b]	2.03[ab]	1.69[a]	2.33[ab]

The composition of FA (fatty acids) is represented as a percentage of area (% of total area). C15: 0 pentadecanoic acid, C16: 0, palmitic acid, C16: 1 palmitoleic acid, C18: 0, stearic acid, C18: 1, oleic acid, C18: 2, linoleic acid. ND, not detected. PUFA Polyunsaturated fatty acids (C18: 2) / SFA saturated fatty acids (C15: 0, C16: 0, C18: 0). Each value represents the mean of three replicates. Values in the same row followed by the same letter are not significantly different according to the Tukey test ($p < 0.05$).

acid content (C15: 0) is statistically different in the three species of *Pleurotus*. In this regard Ergönul *et al*., (2012) report that the odd numbered FAs were detected in trace amounts in edible mushrooms in Turkey, in contrast to edible mushrooms in northwest Spain as *Tricholoma portentosum* and *T. terreum*, where FAs have not been identified with an odd number (Diez and Alvarez, 2001). This is relevant because the FA may contain valuable taxonomic and physiological information (Pedneault *et al*., 2008) and in particular a minimum quantity of FAs can prove to be distinctive of certain species (Stahl and Klug, 1996). However, in some studies in Basidiomycetes, it has not been possible to identify a minimum quantity of FAs due to inadequate methodologies used in their extraction (Brondz *et al*., 2004). From a nutritional standpoint, the ratios PUFA/SFA of the mushrooms studied had values above 0.45, indicating that they are healthy foods since it has been reported that ratios greater than or equal to 0.45 have a strong hypocholesterolemic effect (Chang and Huang, 1998; Takahashi and Carvalho, 2010). It is worth noticing that *P. ostreatus* presented the best value for this ratio and for *P. levis* is the first time that this parameter was evaluated.

Figure 1 shows the proportions of saturated and unsaturated FAs in both *Pleurotus* species grown on barley straw as well as the commercial mushroom and *P. levis* cultivated on maguey bagasse- barley straw. When comparing *P. levis* and *P. ostreatus* grown on P, the proportion of SFA, MUFA and PUFA showed similar behavior, the main FA being linoleic FA, followed by MUFA and SFA to a lesser extent. Nevertheless, when comparing the composition of FA of *P. levis* on P and M, unlike the mushrooms grown on P, the majority of FAs on M were monounsaturated which shows that a change in the composition of the substrate can generate a change in the profiles of FAs (Erwin, 1973). Both *P. ostreatus* and the commercial mushroom showed the highest values of PUFA, and the lowest proportion of SFA was found only in the commercial mushroom. In all cases, the predominant FAs were unsaturated, which is consistent with those reported for other edible species like *Russula delica, Boletus, edulis*, *Cantharellus cibarius, Amanita caesarea* among others (Heleno *et al*., 2009; Ribeiro *et al*., 2009). The studied strains proved to be excellent food, due to their low saturated fat content and they can be consumed by people whit high blood cholesterol levels. This study opens the possibility for further research based on the characteristics of the strains and the type of substrate used in mushroom cultivation, with the aim of improving nutritional quality relating to FAs and obtain commercial mushrooms with higher coefficients of PUFA/SFA.



SFA Saturated Fatty Acids (C15: 0, pentadecanoic acid, C16: 0, palmitic acid, C18: 0, stearic acid), MUFA Monounsaturated Fatty Acids (C16: 1 palmitoleic acid, C18: 1, oleic acid) fatty acids PUFA acids (C18: 2 linoleic acid). *cultivated on barley straw substrate, **barley straw -maguey bagasse 1:1 (w / w), *** wheat straw-corn bagasse. Error bars correspond to the standard deviation.

Figure 1. Percentages of SFA, MUFA and PUFA neutral lipid in *Pleurotus* species cultivated on different substrates.

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