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Food Chemistry 94 (2006) 494–497
Food Chemistry
www.elsevier.com/locate/foodchem

Biological quality of proteins from three strains of *Pleurotus* spp.

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Received 20 October 2003; accepted 25 November 2004

Abstract

Three *Pleurotus* strains (IE136, INI8, and PORO) were grown on a commercial substrate. Fruit bodies of all strains presented high protein content, around 27%, with very high protein in vitro digestibility (98%). The highest aPER value was shown by strain PORO (2.38) and true digestibility values were 97.5%, 97.7% and 98.3% for strains IE136, INI8 and PORO, respectively. Fruit bodies with the highest biological value were produced by strain PORO (88.4%), while strain IE136 produced those with the lowest value (86.0%). Similarly, PORO fruit bodies showed the highest computed net protein utilization values, i.e., 86.9%, as well as the highest net protein ratio values (4.18). Although significant differences are found when comparing the values determined for the three strains with those corresponding to casein, such values are rather close to those of casein.

Keywords: Biological quality; Nutritional value; PER; *Pleurotus* spp.

1. Introduction

There are few publications about the biological value of proteins in edible fungi (Khana & Garcha, 1986; Longvah & Deosthale, 1998). Usually the content of essential amino acids, as determined by chemical analysis of fruit bodies, is used to evaluate their protein quality. Such methodology offers some advantages, i.e., the limiting amino acids and deficit of other amino acids can be easily established, nevertheless, there are some inconveniencies for its application. The presence of amino acids that are not susceptible to hydrolysis during intestinal passage, and therefore are not biologically available (Madl, 1993) is not taken into consideration. Furthermore, an other important factor not taken into consideration with these methods is the presence of anti nutritional substances such as chitin, chitosans and β-glucans, which are abundant in fungi. They diminish the biological digestibility of protein, thus reducing assimilation of essential amino acids by living organisms and increasing loss through faeces (Crisan & Sands, 1978; Hsu, Sutton, Banjo, Satterlee, & Kendrick, 1978). Additionally, chemical composition and biological quality of proteins from fungal fruit bodies are affected by different strains, substrate composition and method of preparation, growing techniques, age and the stage of development of fruit bodies (Crisan & Sands, 1978; Vetter & Rimoczi, 1993).

In this study, the biological quality of the protein of the fruit bodies from three *Pleurotus* spp. strains grown on a commercial substrate was evaluated to elucidate their nutritional contribution to human diet.

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doi:10.1016/j.foodchem.2004.11.053

2. Materials and methods

2.1. Biological materials

Pleurotus spp. strains IE136 and INI8 were obtained from Dr. Gaston Guzmán (Instituto de Ecología, Jalapa, Mexico) and strain PORO from Dr. Ernesto Sanchez (Ecosur, Chiapas of México). All strains are stored in the culture collection of the Department of Food Science and Biotechnology, Faculty of Chemistry, UNAM. For storage of strains and propagation of mycelium, 10 ml malt extract agar (MEA) plates were used. MEA was prepared by dissolving malt extract (15%) and agar (2%) in distilled water and then sterilizing in an autoclave at 121 °C and 15 lb/in^2 for 30 min, and 10 ml sterile medium were poured in sterile petri dishes. Plates with solidified medium were wrapped in plastic bags and incubated at 28 °C for 2 days to check sterility and then used. Production of fruit bodies was carried out on pasteurized wheat straw substrate provided by a commercial grower (Hongos Leben, Edo. Mexico). Substrate was placed in polypropylene–ethylene bags (32 × 49 cm), inoculated with 5% spawn and incubated at 28 °C. After 15 days, bags were transferred to the fruiting room and production of fruit bodies were induced by regular watering (three times a day for 20 min), 2 h ventilation with humid air after each watering period and 12 h illumination per day and temperature of 15 and 30 °C.

To determine biological value, 25 mice (strain cd-1) of either sex with weight variability of ±3 g were randomly allocated onto five groups of five mice each. Mice were placed in individual metabolic cages at 22 °C and a photoperiod of 12 h daylight per day. After an adaptability period of 1 day, when they ingested only water ad libitum, mice were then fed with the specific group diet (Table 1) following ad libitum feeding and drinking schemes throughout the experiments. Mice weight, food intake and the amount of food not eaten were recorded daily in order to adjust protein intake.

2.2. Chemical analysis of fruit bodies, in vitro digestibility and biological evaluation of proteins

Protein, lipid, water content, ash and crude fiber were determined as previously reported by Valencia-del Toro, Garín-Aguilar, and Vázquez (1997). To determine in vitro digestibility, 2 g of the fatless sample were digested in a 500 ml flask by adding 430 ml of distilled water, 1 g pepsin and 16 ml of HCl (10%) for 48 h at 39 °C ± 1 °C with intermittent stirring. After 16, 24 and 40 h, 11 ml of HCl were added and after 48 h the digesting solution was placed in ice to cool, filtered and then washed with hot water. The nitrogen content of the solid residue was determined by the Micro–Kjeldahl method. Adjusted protein efficiency ratio (aPER), net protein ratio (NPR), computed net protein utilization (C-NPU), true digestibility in vivo (D) and biological value (BV) were assessed according to Beltran (1983) using diets indicated in Table 1.

3. Results and discussion

The chemical composition of fruit bodies from the three *Pleurotus* strains tested in this experiment are shown in Table 2. Variance analysis indicated that in spite of the very small differences in the values obtained for each component, differences were significant among strains in all cases. Water content ranged from 92.2% for PORO to 93.3% for IE 136. Protein content was 26.7%, 27.8% and 28.2% for strains INI8, IE136 and PORO, respectively. Lipid content of these strains was much lower, 4.58%, 4.61% and 5.19%, correspondingly. Strain INI8 showed the highest crude fiber content, 11.9%, for strain IE136 this value was 11.1% and the lowest value (11.0%) was shown by PORO. Ash contents ranged from 3.6% for INI8 to 4.04% for PORO and 4.42% for IE136.

Table 3 shows results of the biological evaluation of fruit body proteins from *Pleurotus* spp. Despite a

Table 1
Composition of diets for evaluation of protein quality (g/100 g)

Components	Diets				
	Protein free	Casein	INI8	PORO	IE136
Corn oil	10.0	10.0	10.0	10.0	10.0
Vitamin mixture	1.0	1.0	1.0	1.0	1.0
Minerals mixture	4.0	4.0	4.0	4.0	4.0
Cellulose	1.5	1.5	1.5	1.5	1.5
Casein	–	10	–	–	–
INI8	–	–	37.3	–	–
PORO	–	–	–	35.4	–
IE136	–	–	–	–	35.9
Corn starch	83.5	73.5	46.2	48.1	47.6

Diets were prepared according to Longvah and Deosthale (1998).

Table 2
Chemical composition (g/100 g dry weight) of fruit bodies from *Pleurotus* spp. strains[a]

Component	Strains		
	IE136	PORO	INI8
Humidity[b]	93.3 ± 0.1[a]	92.2 ± 0.0[c]	92.8 ± 0.0[b]
Protein (Nx4.38)[c]	27.8 ± 0.0[b]	28.2 ± 0.0[a]	26.7 ± 0.0[c]
Crude fiber	11.1 ± 0.0[b]	11.0 ± 0.0[c]	11.9 ± 0.0[a]
Lipids	4.58 ± 0.06[b]	4.61 ± 0.01[b]	5.19 ± 0.03[a]
Ashes	4.42 ± 0.05[a]	4.04 ± 0.01[b]	3.60 ± 0.02[c]

Different letters indicate significant differences for each parameter according Tukey HDS ($p \leqslant 0.05$).

[a] Average of three determinations ±SEM (standard error mean).

[b] g/100 g Fresh weight.

[c] According to Crisan and Sands (1978).

Table 3
In vitro and true digestibility, PER, NPR, NPU and biological value of *Pleurotus* spp. fruit bodies

Diet	In vitro digestibility (%)	Adjusted PER[a]	True digestibility (%)	NPR	Biological value (%)	Computed NPU (%)
Casein	100.0[a]	2.50[a]	98.9[a]	4.24[a]	95.3[a]	94.2[a]
PORO	98.1[b]	2.38[b]	98.3[b]	4.18[b]	88.4[b]	86.9[b]
INI8	98.1[b]	2.35[c]	97.7[c]	4.07[c]	86.8[c]	84.8[c]
IE136	98.0[b]	2.35[c]	97.5[d]	4.08[c]	86.0[d]	83.9[d]

Values are means of five animals in each group and different letters indicate significant differences at $p < 0.05$.
[a] Data were adjusted to casein = 2.5.

difference of 2%. in vitro digestibility of proteins from IE136 (98.0%,) INI8 (98.1%) and PORO (98.1%) was significantly lower than that of casein (100%). The protein efficiency ratio (PER) was adjusted considering a 2.5 value for casein, which was significantly higher than the 2.38 value obtained by PORO and 2.35 given by both IE 136 and INI8. The highest true digestibility for casein (98.9%) was followed by 98.3%, 97.7% and 97.5% for PORO, INI8 and IE136, respectively. Casein gave the highest net protein ratio (NPR) (4.24) followed by PORO with 4.18 and 4.07 for IE136 and INI8. Similarly, casein gave the highest biological value (95.3%), followed by PORO with 88.37%, a value significantly higher than 86.8% and 86.03% for INI8 and IE136. Finally, computed net protein utilization (NPU) of casein (94.2%) was higher than that for PORO, INI8 and IE136 (86.9%, 84.8% and 83.9%).

Chemical composition of fruit bodies yielded by the three strains tested in this study showed similar values to those previously published by other authors (Chang & Miles, 1989; Crisan & Sands, 1978; Hadar & Cohen-Araz, 1986; Yildiz, Karakaplan, & Aydin, 1998; Zakia, Bnagyas, & Srinivasa, 1981) and by ourselves (Valencia-del Toro et al., 1997) confirming the good nutritional properties of this fungus. Rather high values of in vitro digestibility were determined in this study for fruit bodies of the three strains tested, around 98%, which were notably superior to earlier reports mentioning values in the range of 63–89% (Khana & Garcha, 1986; Zakia et al., 1981). Although in vitro digestibility is an important instrument for assessing the nutritional potential of a specific diet, it may overestimate the real nutritional value of a food since it does not consider that amino acids may be present in certain forms not available for hydrolysis during intestinal digestion and therefore not biologically available.

Though significantly different, adjusted PER (aPER) values of diets with proteins from fruit bodies were close to casein and weight gain was therefore above 3 g for each gram of protein consumed in all cases. This indicates that proteins from the three tested strains can promote growth of a living organism and, furthermore, by comparison with aPER values from other common foods (Hackler, 1977; Hsu et al., 1978), their aPER values were superior to those of meat and soybean. Adjusted PER values have not been reported previously for any type of fungi, however, based on the content of amino acids Khana and Garcha (1986) calculated PER values (PERc) for various *Pleurotus* species, which are lower than those determined in this study.

Previous to this work, true digestibility has been only reported for two species of edible fungi, *Schizophillum commune* (53.2%) and *Lentinus edodes* (76.3%) (Longvah & Deosthale, 1998) whilst values obtained in this study for strains IE136, INI8 and PORO are around 98%. Similarly, NPR values for these strains (4.07–4.18) are greater than those reported for *S. commune* (0.7) and *L. edodes* (1.7) (Longvah & Deosthale, 1998) and even than those of common foods like meat (3.9), soybean (3.5), oats (3.2) and rice (2.9) (Hopkins & Steinke, 1978).

Biological value of casein is superior to those of proteins from fruit bodies from the three *Pleurotus* strains since casein contains all essential amino acids in adequate quantity and proportion to sustain a correct nitrogen balance. Crisan and Sands (1978) reported that proteins from *Pleurotus* fruit bodies present a low content of sulphur amino acids (methionine and cysteine), necessary for protein synthesis in humans. However, a biological value of 86–88% indicates that this type of proteins can sustain tissue integrity, allowing development and growth of mice.

Computed NPU values for the three *Pleurotus* strains evaluated in this study (84–87%) were greater than those previously reported for other type of edible fungi like *Agaricus bisporus* (72.4%) (FAO, 1970), *S. commune* (23.7%) and *L. edodes* (45.8%) (Longvah & Deosthale, 1998). They were also superior to those of common foods like wheat (60%), cow milk (81%) and rice (82%) (Hackler, 1977) and, remarkably, they were in the range of the NPU value reported for whole eggs (87%). As a remarkable conclusion, it has to be pointed out that fruit body proteins from the three *Pleurotus* strains tested in this study show a high physiological availability.

Acknowledgements

This research was sponsored by Grant IN208798 from the Dirección General de Asuntos del Personal Académico (DGAPA) of the National University of

Mexico (UNAM) and by material and logistical support provided by Hongos Leben.

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