ELSEVIER

PII: S0308-8146(97)00066-6

Food Chemistry, Vol. 61, No. 1/2, pp. 127–130, 1998

0308-8146/98 $19.00 + 0.00

Studies on *Pleurotus ostreatus* (Jacq. ex Fr.) Kum. var. *salignus* (Pers. ex Fr.) Konr. et Maubl.: cultivation, proximate composition, organic and mineral composition of carpophores

A. Yildiz,[a]* M. Karakaplan[b] & F. Aydin[b]

[a]*Biology Department, Science Faculty, University of Dicle, Diyarbakir, Turkey*
[b]*Chemistry Department, Science Faculty, University of Dicle, Diyarbakir, Turkey*

(Received 3 February 1997; accepted 12 March 1997)

This study was conducted on the growth and cultivation of *Pleurotus ostreatus* var. *salignus* on local cellulosic wastes. The highest and lowest yields for 100 g material (70% moisture) were obtained with peanut straw (24.8 g) and with sorghum straw (11.3 g), respectively. Protein, pilus/stip, sporophore weight, % dry material, N and C in highest amounts were obtained with peanut straw. The lowest mushroom weight and pilus/stip ratio were obtained with sorghum, whereas the lowest protein, N and dry material weight were obtained with wheat straw. In all the *P. ostreatus* var. *salignus* cultivated on peanut and sorghum straw, the most abundant nutrients were protein, potassium and carbon. These results are discussed in relation to the prospect of cultivating *P. ostreatus* var. *salignus* in Diyarbakir, Turkey. © 1998 Published by Elsevier Science Ltd. All rights reserved

INTRODUCTION

Pleurotus species as a class of edible mushrooms are reputed to have a high saprophytic ability and to grow on a variety of cellulosic wastes (Jandik, 1974; Zadrazil, 1978; Chang, 1980; Garcha *et al*., 1984). Worldwide production of *Pleurotus spp*. mushrooms has increased at an accelerated rate in recent years. In 1986, *Pleurotus spp*. production accounted for approximately 7% of the total world production of edible mushrooms; by 1990, production of *Pleurotus spp*. reached one million metric tons and accounted for 24% of total edible mushroom production (Chang and Miles, 1991; Hayes, 1991; Royse, 1992).

Cultivation of *Pleurotus spp*. as edible mushrooms is becoming important throughout the world because of their ability to grow at temperatures of 10–35°C and on various lignocellulose-containing materials because of their shorter cultivation time compared with *Agaricus spp*. (Zadrazil, 1978).

There have been studies on the amino acid (Ginterova and Maxianova, 1975; Bano *et al*., 1983; Ginterova and Lazarova, 1987) and protein contents of fruit bodies of different *Pleurotus* species (Delmas and Mamoun, 1983; Ginterova and Lazarova, 1987; Yildiz and Saya, 1991; Fasidi and Ekuere, 1993). However there are no studies on the cultivation and nutritional content of *P. ostreatus* var. *salignus*.

Hence, an attempt was made to cultivate *P. ostreatus* var. *salignus* on local cellulosic wastes and to determine the yield, chemical composition and some physical properties of the cultivated mycelial.

MATERIALS AND METHODS

Inoculum preparation

This study was carried out in a disinfected mushroom culture laboratory. The cultured *P. ostreatus* var. *salignus* growing in Diyarbakir Hevsel Gardens was obtained from the main culture (Yildiz, 1994; Yildiz and Saya, 1996).

Conditions of cultivation

The carbon (C) and nitrogen (N) content of waste materials used as culture media is shown in Table 1. One kg of material from each trial was placed in plastic buckets, and kept for 48 h until the compost reached a

*To whom correspondence should be addressed.

Table 1. Carbon (C) and nitrogen (N) composition of different cellulosic wastes

Material	(C %)	(N %)	C/N
Sorghum straw	36.54	1.45	25.13
Peanut straw	27.04	0.76	35.20
Soybean straw	38.96	0.54	71.76
Wheat straw	42.16	0.52	81.08

humidity of 70–75%. In order to obtain the desired pH values (5.5–6.5), 35 g of lime ($CaCO_3$) and 35 g of gypsum ($CaSO_4$) were added to compost (Zadrazil, 1978; Laborde, 1987). The compost was sprayed with 1% formaldehyde (250 ml) containing 0.5 g of benlate so as to eliminate micro-organism (Yildiz, 1996). It was then mixed thoroughly. The compost was left in closed buckets for 24 h in the laboratory, emptied into plastic bowls, and then mixed until the formaldehyde was completely evaporated. The spawn grown on 100 g wheat was used for 1 kg dried material as inoculation material. Four hundred grams of inoculated compost was placed in a 1 litre glass jar.

The inoculation was performed in a room (2.10 × 2.60 × 3.00 cm) at 25 ± 1°C and later, the temperature was reduced to about 15 ± 1°C, with an air conditioning system. One air cooler was used for an hour a day to provide aeration to avoid the accumulation of CO_2. In order to supply a homogeneous condition in the incubation room, a ventilator was used for 1 h a day.

The culture room was subjected to light for 12 h a day with a light intensity of 200 lux (Delmas and Mamoun, 1983) after mycelium had developed on the compost. The culture room was constantly bathed to maintain the relative humidity (75–90%). As a shock procedure (Wood and Smith, 1987), the culture was kept at 5°C for 48 h after the compost had been invaded by mycelium.

In the present study, the yield, some physical properties and the nutritional content of *P. ostreatus* var. *salignus* were investigated for different cellulosic wastes used as culture medium.

Organic elements

Carbon (C), hydrogen (H) and nitrogen (N) were analysed via a Carlo Erba Element Analysis instrument (model EA 1108). The technique used for the determination of C, H and N is based on the quantitative dynamic flash combustion that converts all organic and inorganic substances into combustion products. The resulting combustion gases pass through a reduction furnace and are swept into the chromatographic column by the carrier gas (helium) where they are separated and detected by a thermal conductivity detector (TCD) which gives an output signal proportional to the concentration of the individual components of the mixture.

Minerals

Samples was roasted in an oven at 400°C to determine K, Ca, Mn, Fe, Cu, and Zn. After roasting, samples were placed in a beaker and 5 ml of HCl added. Then the solution was dried and 5 ml of HNO_3 was again added. After evaporation, the samples were diluted to 50 ml with water. The Na and Ca contents were determined by flame photometer, and Cu, Zn, Mn, and Fe by Unicam 929 Atomic Absorption Spectrophotometer.

Proximate composition

The moisture content of each sample was determined by drying in an oven at 100°C and crude fibre was determined according to the standard method of A.O.A.C. (Association of Official Agricultural Chemists, 1950).

Statistical analysis

The data obtained were analysed by ANOVA and tests of significance were carried out using Duncan's multiple range tests.

RESULTS AND DISCUSSION

It is well known that *Pleurotus* species as a class of edible mushroom have a high saprophytic ability and grow on a variety of cellulosic wastes (Jandik, 1974; Chang, 1980; Garcha *et al*., 1984; Klibansky *et al*., 1987; Laborde, 1987). Among the edible commercialized macromycetes in occidental countries, only two genera, namely *Agaricus* and *Pleurotus* produce carpophores in controlled culture conditions (Manachére, 1980). For

Table 2. Yield (g), weight of sporophore (dry and fresh weight) and protein composition of *P. ostreatus* var. *salignus* cultivated on cellulosic wastes[a]

Material	Yield/100 g waste (70% moisture)	Sporophore (fresh weight)	Sporophore (dry weight %)	Pilus/stip (fresh weight)	Protein (NX6.25) (dry weight %)
	$\overline{X} \pm SD$	$\overline{X} \pm SD$	$\overline{X} \pm SD$	$\overline{X} \pm SD$	$\overline{X} \pm SD$
Sorghum straw	11.4 ± 0.8^{c}	6.7 ± 1.8^{a}	10.1 ± 1.9^{a}	2.6 ± 0.7^{a}	32.7 ± 2.72^{a}
Peanut straw	24.8 ± 2.5^{a}	9.6 ± 2.3^{a}	10.6 ± 0.1^{a}	3.9 ± 0.7^{a}	34.6 ± 4.28^{a}
Soybean straw	21.9 ± 1.9^{a}	8.7 ± 2.1^{a}	10.0 ± 1.2^{a}	3.0 ± 0.2^{a}	$29.6 \pm 4.60^{a,b}$
Wheat straw	17.5 ± 1.0^{b}	7.4 ± 1.6^{a}	9.6 ± 0.6^{a}	2.8 ± 0.4^{a}	23.5 ± 2.76^{b}
Natural (*Salix spp*.)					28.9 ± 1.11^{a}

[a]Means having the same superscript letter(s) are not significantly different ($p > 0.05$) by Duncan's multiple range test.

Table 3. Organic composition of sporophore *P. ostreatus* var. *salignus* (data are calculated as % dry weight)[a]

Material	N	C	H	S
	$\overline{X} \pm SD$	$\overline{X} \pm SD$	$\overline{X} \pm SD$	—
Sorghum straw	5.23 ± 0.43^{a}	40.60 ± 0.28^{a}	6.33 ± 0.06^{a}	—
Peaunt straw	5.54 ± 0.68^{a}	42.10 ± 0.40^{a}	6.13 ± 0.06^{a}	—
Soybean straw	$4.73 \pm 0.74^{a,b}$	41.73 ± 0.30^{a}	6.13 ± 0.07^{a}	—
Wheat straw	3.75 ± 0.44^{a}	41.32 ± 0.33^{a}	6.19 ± 0.14^{a}	—
Natural (*Salix sp.*)	4.63 ± 0.18^{b}	41.39 ± 0.54^{a}	6.08 ± 0.02^{a}	—

[a]Means having the same superscript letter(s) are not significantly different ($p > 0.05$) by Duncan's multiple range test.

Table 4. Inorganic composition of sporophore *P. ostreatus* var. *salignus* (data are calculated as % dry weight)

Material	Major elements		Minor elements			
	K	Ca	Cu	Zn	Mn	Fe
Sorghum straw	4.50	0.020	0.005	0.011	0.002	0.012
Peaunt straw	4.06	0.001	0.004	0.013	0.003	0.013
Soybean straw	4.00	0.010	0.030	0.010	0.004	0.001
Wheat straw	3.44	0.010	0.003	0.011	0.002	0.019
Natural (*Salix sp.*)	4.34	0.020	0.003	0.110	0.030	0.042

cultivation of *Pleurotus ostreatus*, in addition, carbon/nitrogen ratios must be taken into consideration (Manachére, 1980).

P. ostreatus var. *salignus* was cultivated on four different materials, namely peanut, soybean, sorghum and wheat straw; among these, peanut straw produced the highest yield (24.8%), whereas sorghum straw produced the lowest (11.4%), as shown in Table 2. These yields are comparable with those recorded for other *Pleurotus* (Zadrazil, 1978; Rajarathnam *et al*., 1986; Royse, 1992; Fasidi and Ekuere, 1993). There were, however, no significant differences between the yields for *P. ostreatus* var. *salignus* grown on peanut straw and soybean straw. These results indicate that peanut straw and soybean straw can be good materials for cultivation of *P. ostreatus* var. *salignus*. Table 2 also shows that protein was the most abundant nutrient in the cultivated *P. ostreatus* var. *salignus*, and its value ranged from 23.5% for wheat straw to 34.6% for peanut straw. This result agrees with the earlier work conducted on sporophores of *P. ostreatus* (Delmas and Mamoun, 1983; Manu-Tawiah and Martin, 1986), *P. tuber-regium* (Kadiri and Fasidi, 1990; Fasidi and Ekuere, 1993) and *P. florida* (Yildiz and Saya, 1991). Mushroom proteins are generally higher in value than those of green vegetables (Chan, 1981).

Table 3 shows that sulfur (S) was not detected in the sporophores of *P. ostreatus* var. *salignus*, which is only found in structures of poisonous mushrooms.

Potassium was the most abundant mineral element in the cultivated *P. ostreatus* var. *salignus* (Table 4). This result is similar to those obtained in previous studies (Parent and Thoen, 1977; Khanna and Garcha, 1982; Delmas and Mamoun, 1983; Fasidi and Kadiri, 1990; Kadiri and Fasidi, 1990; Fasidi and Ekuere, 1993). As shown in Table 4, the preponderance of potassium in the sporophore tissue may be due to absorption accumulation of this element from the substrate.

In this study, *P. ostreatus* var. *salignus* production commenced 24 days after spawning and continued until 58 days, harvesting four times during this period. The implication of this result is that cultivated *P. ostreatus* var. *salignus* can be eaten and can be evaluated as a cultivated mushroom.

REFERENCES

Association of Official Agricultural Chemists (AOAC) (1950). *The Official Methods of Analysis*. AOAC, Washington DC, pp. 152–155.

Bano, Z., Srinivasan, K. S. & Srivastava, H. C. (1983). Amino acid composition of protein in *Pleurotus sp*. *Appl. Microbial.*, **11**, 184–187.

Chan, H. K. M. (1981). Consumption of edible mushroom in Hong Kong. *Mushroom Newslett. Tropics*, **1**(4), 5–10.

Chang, S. T. (1980). Mushroom production in South East Asia. *Mushroom Newslett. Tropics*, **1**(2), 18–22.

Chang, S. T. & Miles P. G., (1991). World production of edible mushrooms. *Mushroom Journal*, **504**, 15–18.

Delmas, J. & Mamoun, M. (1983). Le Pleurote en corne d'abondance un champignon aujourd'hui cultivable en France. *P. H. M.- Revue Horticóule*, **240**, 39–46.

Fasidi, I. O. & Ekuere, U. U. (1993). Studies of *Pleurotus tuber-regium* (Fries) Singer: cultivation, proximate composition and mineral contents of sclerotia. *Food Chemistry*, **48**, 255–258.

Fasidi, I. D. & Kadiri, M. (1990). Changes in nutrient contents of two Nigerian mushrooms, *Termitomyces robustus* (Beeli) Heim and *Lentinus Subnudus* Berk. during sporophore development. *Nahrung*, **34**, 415–420.

Garcha, H. S., Dhanda, S. & Khanna, P. (1984). Evaluation of various organic residues for the cultivation of *Pleurotus spp*. *Mushroom Newslett. Tropics*, **5**(1), 13–16.

Ginterova, A. & Lazarova, A. (1987). Amino acid composition of wood-rotting fungi (*Pleurotus*) and total amino acid balance of the cultivating system. *Food Chemistry*, **23**, 35–41.

Ginterova, A. & Maxianova, A. (1975). The balance of nitrogen and composition of protein in *Pleurotus ostreatus* grown on natural substrates. *Folia Microbial.*, **20**, 246–250.

Hayes, W. A. (1991). Worldwide cultivation of exotic or specialty mushrooms. In *Proceeding of the 9th Irish Mushroom Conference* (5 Sept 1991), Dublin, Ireland, pp. 25–29, Kinsealy Research and Development Centre, Dublin.

Jandik, C. L. (1974). Artificial cultivation of *Pleurotus sajor-caju*. *Mushroom Journal*, **22**, 440–445.

Kadiri, F. & Fasidi, I. O. (1990). Variations in chemical composition of *Chlorophylum molybditis* (Mayerex. Fr.) masses and *Pleurotus tuber-regium* (Fries) during fruitbody development. *Nigerian J. Sci.*, **24**, 695–699.

Khanna, P. & Garcha, H. S. (1982). Utilisation of paddy straw for the cultivation of *Pleurotus spp.*. *Mushroom Newslett. Tropics*, **2**(3), 5–9.

Klibansky, M. M., Mansur, M., Gutierrez, I. & Gonzales, L. (1987). Production of *Pleurotus ostreatus* mushrooms on sugar cane agrowastes. *Acta Biotechnol.*, **13**(1), 71–78.

Laborde, J. (1987). Proposition pour une amelioration de la culture Pleurote. *P. H. M.- Revue Horticole*, **278**, 13–21.

Manachére, G. (1980). Conditions essential for controlled fruiting of *Macromycetes*-A Review. *Trans. Br. Mycol. Soc.*, **75**(2), 255–270.

Manu-Tawiah, W. & Martin, A. M. (1986). Cultivation of *Pleurotus ostreatus* mushroom in peat. *Journal of the Science of Food and Agriculture*, **37**, 833–838.

Parent, G. & Thoen, D. (1977). Food value from upper Shoba region. *Econ. Bot.*, **31**, 436–445.

Rajarathnam, S., Zakia, B. & Patwardhan, M. V. (1986). Nutrition of the *Pleurotus flabellatus* during its growth on paddy straw substrate. *J. Horticul. Sci.*, **61**(2), 223–232.

Royse, D. U. (1992). Recycling of spent shiitake substrate for production of the oyster mushroom, *Pleurotus sajor-caju*. *Appl. Microbial. Biotechnol.*, **38**, 179–182.

Yildiz, A. (1994). *Pleurotus florida* Fovose misellerinin buğday ve arpa taneleri üzerinde üretilmesi. XII. *Ulusal Biyoloji Kongresi* (6–8 Temmuz) Bildiri Kitapçiği, Cilt **1**, pp. 330–334, Edirne-Türkiye.

Yildiz, A. (1996). *Pleurotus florida* Fovose'nin gelişim evreleri ve verimi üzerine dezenfektan olarak kullanilan benlatenin bazi tozlarinin etkileri. XIII. *Ulusal Biyoloji Kongresi*, 17–20 Eylül, 1996- Istanbul, Turkey.

Yildiz, A. & Saya, Ö. (1991). The effects of some additional substances on nutritional content of *Pleurotus florida*. *The 1st International Biophysics Congress and Biotechnol. at GAP*, 13–15 May 1991, Diyarbakir, Turkey.

Yildiz, A. & Saya, Ö. (1996). Identification and cultivation of *Pleurotus* species grown naturally in Diyarbakir province and surroundings. *Trans. J. Biol.*, **20**, 65–71.

Wood, D. A. & Smith, J. F. (1987). The cultivation of *Pleurotus sp.* In *Essays in Agricultural and Microbiology*, eds J. R. Norris & G. I. Pettipher. John Willey, Chichester, pp. 309–343.

Zadrazil, F. (1978). Cultivation of *Pleurotus*. In *The Biology and Cultivation of Edible Mushrooms*, eds S. T. Chang & W. A. Hayes. Academic Press, New York, pp. 521–558.