African Journal of Biotechnology Vol. 7 (19), pp. 3497-3501, 6 October, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

Full Length Research Paper

Yield performances and nutritional contents of three oyster mushroom species cultivated on wheat stalk

Abdurrahman Dundar[1]*, Hilal Acay[1] and Abdunnasir Yildiz[2]

[1]Department of Biology, Science Institute of Dicle University, TR 21280, Diyarbakır, Turkey.
[2]Department of Biology, Faculty of Science and Arts, Dicle University, TR 21280, Diyarbakır, Turkey.

Accepted 18 August, 2008

This study was conducted to determine nutritive value and yield performance of the three types of oyster mushroom; *Pleurotus eryngii* (Dc. Ex Fr.) quel), *Pleurotus ostreatus* (Jacq.: Fr.) Kumm.) and *Pleurotus sajor-caju* (Fr.) Singer, cultivated on wheat stalk. The total fresh mushroom yields obtained with 100 g material (70% misture) after the three harvests and the total harvest time were calculated. *P. sajor-caju* gave the highest yield as 20.2 g. The yield of *P. ostreatus* was 17.9 g and the lowest yield was *P. eryngii*, 4.5 g. Total harvest time of mushrooms were determined. As the *P. sajor-caju* was harvested in 67.46 days, *P. ostreatus* was harvested in 82.64 days and *P. eryngii* was harvested in 85.27 days. For chemical composition analysis the fruiting bodies of mushrooms were collected after the first productive flow and dried in an oven at 60°C at a constant weight and kept under refrigeration at 4°C. Energy, protein, fat, carbohydrate, dietary fibre, moisture, ash (g in 100 g dried matter) and amino acids (mg in 1 g dried matter) of mushrooms were analysed. In *P. eryngii* and *P. sajor-caju* the highest amount of amino acid was from aspartic acid and the lowest was from methionine. The highest and the lowest amino acid amount in *P. ostreatus* were from glutamic acid and methionine, respectively. The histidine amino acid was just detected in *P. eryngii* but hydroxy-L-proline was not detected in mushrooms. The energy (kcal/100 g dried matter), fat, protein, carbohydrate, dietary fibre, moisture and ash (g/100 g dried matter) values of *P. eryngii* were 276.33, 11.95, 7.50, 39.85, 28.45, 7.23 and 4.89, respevtively. These values for *P. ostreatus* were 243.66, 17.12, 2.60, 37.87, 30.25, 7.39 and 4.78, respectively. The values for *P. sajor-caju* were 229.22, 16.75, 1.15, 37.72, 30.67, 7.42 and 5.84, respectively.

Key words: Oyster mushroom, Pleurotus species, yield performance, nutritional value.

INTRODUCTION

Mushrooms represent one of the world's greatest untapped resources of nutritious food. Cultivation of saprophytic edible mushrooms may be the only currently economical biotechnology for lignocellulose organic waste recycling that combines the production of protein rich food with the reduction of environmental pollution (Obodai et al., 2003). Mushrooms are rich in protein, minerals, and vitamins, and they contain an abundance of essential amino acids (Sadler, 2003). Therefore, mushrooms can be a good supplement to cereals (Chang and Buswell, 1996). However, many people are apprehensive about mushrooms as a food source. Ignorance has led many to become sceptical about whether food of fungal origin can hold any great nutritional promise. It seems much education is needed before full advantage can be taken of this readily available, nutritionally rich food source (Crisan and Sands, 1978; Chang and Mshigeni, 2001). There is a very high incidence of malnutrition, especially of protein deficiency in developing countries. The problem of protein shortage in developing

*Corresponding author. E-mail: adundar@dicle.edu.tr. Tel:+90 412 248 85 50. Fax: +90 412 248 8039.

countries including Turkey is an existing reality and will continue for the foreseeable future. Protein malnutrition will become even more acute since the supply of protein for the diet has not kept pace with population growth (FAO, 1996). In order to meet the deficit most developing countries tend to import essential protein sources of food from abroad, spending large sums of their meagre foreign exchange earnings. Such a situation has forced planners and nutritionists to think about unconventional alternative sources of protein such as mushrooms (Chang and Mshigeni, 2001).

A detailed account of the compositional analyses of cultivated and wild species of edible mushrooms has been reported elsewhere (Crisan and Sands, 1978). Also mushrooms have been used as human food for centuries, being valued particularly for the variety of flavours and textures they can provide (Sadler, 2003). However, they have nutritional value and can be useful food supplements, although species vary in their nutritional value (Crisan and Sands, 1978). Protein tends to be present in an easily digested form and on a dry weight basis. Mushroom normally ranges between 20 and 40% protein which is better than many legume sources like soybeans and peanuts, and protein-yielding vegetable foods (Chang and Buswell, 1996; Chang and Mshigeni, 2001). Moreover, mushroom proteins contain all the essential amino acids needed in the human diet and are especially rich in lysine and leucine which are lacking in most staple cereal foods (Chang and Buswell, 1996; Sadler, 2003). Mushrooms are low in total fat content and have a high proportion of polyunsaturated fatty acids (72 to 85%) relative to total fat content, mainly due to linoleic acid. The high content of linoleic acids is one of the reasons why mushrooms are considered a health food (Chang and Mshigeni, 2001; Sadler, 2003). Furthermore, they contain significant amounts of carbo-hydrates and fibres (Crisan and Sands, 1978; Chang and Buswell, 1996). In Turkey, there have been important studies and development strategies done on mushroom productions at the universities and in the developed private companies. Not only the quantity and the numbers of cultivated mushroom species, but also scientific researches about cultivation techniques of edible wild mushrooms which have nutritional and medicinal aspects are increasing (Aksu, 2001). Increasing consumption of mushroom is good for preventing malnutrition, although mushrooms cannot be an alternative protein source for of meat, fish, and egg (Çağlarirmak et al., 2002).

The objective of this study was to determine and compare the yield performance, total harvest time, proximate and nutritive value of three oyster mushroom species cultivated on wheat stalk, that are usually burned or left in the field to rot in South –East Anatolia region of Turkey.

MATERIALS AND METHODS

Inoculum preparation

The main culture of Pleurotus eryngii, *Pleurotus sajor-caju* and *Pleurotus ostreatus* were obtained from Microbiology laboratory of Science and Arts Faculty of Dicle University. For the propagation of the main culture, 2.0% Malt-Extract Agar (MEA) was used. MEA plates (90-mm diameter) were inoculated with a mycelium/agar plug (6-mm-diam.) of a young, actively growing margin of the colony. Prior to its use as an inoculum for grain spawn, a mycelium/agar plug was inoculated at the center of the plate and incubated at 25°C in the dark for seven days.

Spawn preparation

One kg wheat grain was used for spawn production. The grain was cooked for 40 min and washed in tap-water. Grain was drained and supplemented with 2 g lime and 8 g gypsum and mixed manually. Then, 120 g grain, cooked and supplemented, was placed in erlenmayer flask (250 ml), closed and steriliazed in autoclave at 121ºC for 15 min. After cooling, each erlenmayer was inoculated with two agar disks of 6 mm diam., containing mycelium (actively growing mycelial growth on MEA plates), and incubated at 25ºC in full darkness for two weeks.

Conditions of cultivation

Wheat stalk was used as a main material in this study for cultivation of oyster mushrooms are agricultural lignocellulosic wastes that are usually burned or left in the field to rot in our region and were obtained from Dicle University campus area. Wheat stalk was placed in plastic buckets and kept for 48 h until compost reached a humidity of 70-75%. The compost was emptied into plastic bowls, then in order to obtain the desired pH values (5.5 - 6.5), for one kg material, 35 g of lime and 35 g of gypsum was added to compost (Zadrazil, 1978; Yildiz et al., 1998; Yildiz and Karakaplan, 2003). Each compost medium was mixed manually. Then, 360 g of compost was placed in a 2 L glass jar, and closed and sterilized in autoclave at 121ºC for 15 min. After cooling the substrates to room temperature, they were inoculated by spreading spawn on the surface of the substrate with a weight percentage of about 4% of the wet weight of compost and incubated at 25±1°C in the dark for 2 to 3 weeks or until the mycelium had completely colonized the substrate.

For the fruit body formation, *P. eryngii*, *P. sajor-caju* and *P. ostreatus* compost mediums placed in different incubation rooms due to each mushroom species needs different incubation temperatures. *P. eryngii* was incubated at 17±1°C, *P. sajor-caju* was incubated at 27±1°C and *P. ostreatus* was incubated at 23±1°C for the optimum yield performances. For all the mushroom spices, an air cooler was used for 4 to 5 h each day to provide aeration to avoid the accumulation of CO_2. In order to supply a homogenous condition in the incubation rooms, ventilators were used for 4 to 5 h each day. The cultivation rooms were illuminated for 12 h a day with a light (fluorescent bulbs) with an intensity of 200 lux (Delmas and Mamuon, 1983). The culture rooms were constantly damped to maintain the required relative humidity (80 - 85%) and humidified by spraying the top of compost with water once or twice a day. After mycelium had been developed on the compost, the harvesting periods of the mushrooms were determined after three harvests.

Table 1. Yield performance (100 g material with 70% moisture), total harvest time (day) and chemical composition (g in 100 g dried matter) of three oyster mushroom*.

Parameter	*P. eryngii*	*P. ostreatus*	*P. sajor-caju*
Harvest time (day)	85.27±1.47^{c}	82.64±1.05^{b}	67.46 ±2.02^{a}
Total yield (g)	4.5±0.60^{b}	17.9±6.30^{a}	20.2±2.70^{a}
Energy (kcal/100g)	276.33±1.50^{a}	243.66±2.08^{b}	229.42±1.02^{c}
Protein (g/100g)	11.95±0.93^{b}	17.12±0.62^{a}	16.75±1.02^{a}
Fat (g/100g)	7.50±0.08^{a}	2.60±0.22^{b}	1.15±0.18^{c}
Carbohydrate (g/100g)	39.85±0.21^{a}	37.87±0.46^{b}	37.72±0.24^{b}
Dietary fibre (g/100g)	28.45±0.09^{c}	30.25±0.12^{b}	30.67±0.12^{a}
Moisture (g/100g)	7.23±0.18^{a}	7.39±0.09^{a}	7.42±0.04^{a}
Ash (g/100g)	4.89±0.06^{b}	4.78±0.04^{b}	5.84±0.09^{a}

*Values are mean of 3 replicates. Means with different letters in the same row are significantly different ($P < 0.05$).

The fruiting bodies of mushrooms were collected after the first productive flow and dried in an oven at 60°C to constant weight and kept under refrigeration at 4°C. Samples of mushrooms were analysed for chemical composition. Moisture, diatery fibre and ash contents were determined with the AOAC procedures (1995). Protein was determined following method of Leco Manuel. "Thermal conductivity" by the Kjeldahl. The nitrogen factor used for protein calculation was N x 4.17. Energy, fat and carbohydrate were determined by the method of Watt and Merill (1975), amino acid components of muhrooms were determined by using the Phenomenex EZ Faast GC-FID Hydrolized Amino Acid Analysis Kit, Varian GC, CP-3800GC. These analyses were performed by the TUBITAK (The Scientific and Technical Research Council of Turkey) Food Institute of Marmara Research Centre. The data obtained were analysed by ANOVA and tests of significance were caried out using Duncan's multiple range tests.

RESULTS

Harvesting periods of three mushroom spices were determined and shown in Table 1. The longest harvesting periods after three harvests were 85.27 days for *P. eryngii*, 82.64 days for *P. ostreatus* and the shortest was 67.46 days for P. sajor-caju. Total fresh mushroom yield obtained with 100 g material (70% moisture) after the three harvests were determined and shown in Table 1. *P. sajor-caju* gave the highest yield as 20.2 g, *P. ostreatus* was 17.9 g and the lowest yield was obtained from *P. eryngii* as 4.5 g. Table 1 also shows the energy, protein, fat, carbohydrate, dietary fibre, moisture and ash contents of the mushrooms. The energy(kcal/100 g dried matter) values of mushrooms are 229.22, 243.66 and 276.33 for *P. sajor-caju*, *P. ostreatus* and *P. eryngii*, respectively. While the highest energy value was obtained from *P. eryngii*, the lowest was obtained from *P. sajor-caju*. The fat content values are 1.15, 2.60 and 7.50 g for *P. sajor-caju*, *P. ostreatus* and *P. eryngii*, respectively. The carbohydrate values are 37.72, 37.87 and 39.85 (g/100 g dried matter) in *P. sajor-caju*, *P. ostreatus* and *P. eryngii*, respectively. Dietary fibre values are 28.45, 30.25 and 30.67 (g/100 g dried matter) in *P. eryngii*, *P. ostreatus* and *P. sajor-caju*, respectively. Bonatti et al. (2004) found 5.58 and 6.13 g of ash in *P. ostreatus* cultivated in banana straw and rice straw, respectively. In this study, we found the ash content values as 4.78, 4.89 and 5.84 in *P. ostreatus*, *P. eryngii*, and *P. sajor-caju*, respectively. The moisture contents are 7.23 in *P. eryngii*, 7.39 in *P. ostreatus* and 7.42 in *P. sajor-caju*.

As shown in Table 2, cultivating different mushroom species affects amino acid content significantly ($P < 0.05$). Each amino acid content generally changes due to mushroom species. Hydroxy-L-proline was not detec-ted in the mushrooms and histidine was found only in *P. eryngii*. In *P. eryngii* and *P. sajor-caju* the highest amount of amino acid was from aspartic acid and the lowest was from methionine. The highest and the lowest amino acid amounts in *P. ostreatus* were from glutamic acid and methionine, respectively.

DISCUSSION

In this study, different yields were observed from different oyster mushroom species. As stated by other authors (Laborde et al.,1993; Sangwan and Saini, 1995), these yield differences are depended on the genotype of the cultured mushroom. Except *P. eryngii*, the yield of the other mushrooms are in accordance with previous literature (Klinbasky et al., 1993; Laborde et al., 1993). According to other workers (Breene, 1990; Çoşkuner and Özdemir, 2000), protein contents of mushrooms range from 19 to 39 g in 100 g dried matter. In our study we found the protein values (g/100 g dried matter) as 11.95 g in *P. eryngii*, 16.75 g in *P. sajor-caju* and 17.12 g in *P. ostreatus*. Shah et al. (1997) reported the fat value as 2.0 g in 100 g dry matter. Except for *P. eryngii*, the other

Table 2. Amino acid composition of three oyster mushroom* (mg in 1 g dried matter).

Amino acid (mg/g)	*P. eryngii*	*P. ostreatus*	*P. sajor-caju*
Alanine	8.92±0.09[c]	12.53±0.20[a]	11.24±0.20[b]
Glycine	7.48±0.11[c]	10.43±0.80[a]	9.37±0.20[b]
Valine[d]	7.40±0.80[c]	10.51±0.05[a]	10.04±0.30[b]
Leucine[d]	10.77±0.08[c]	16.36±0.09[a]	14.61±0.10[a]
Isoleucine[d]	7.27±0.01[c]	9.88±0.40[b]	11.20±0.10[b]
Threonine[d]	6.78±0.02[c]	9.43±0.02[a]	8.95±0.07[b]
Serine	5.96±0.02[c]	7.91±0.02[a]	7.65±0.10[b]
Proline	5.86±0.10[c]	8.15±0.06[a]	7.91±0.02[b]
Aspartic acid	19.55±0.40[c]	22.53±0.44[a]	20.12±0.15[b]
Methionine[d]	1.66±0.00[b]	2.69±0.31[a]	2.72±0.11[a]
Hydroxy-L-proline	ND	ND	ND
Glutamic acid	18.48±0.09[b]	25.31±0.26[a]	15.56±0.12[c]
Phenylalanine[d]	7.16±0.03[c]	11.09±0.09[a]	9.24±0.09[b]
Lysine[d]	7.31±0.32[b]	11.28±0.06[a]	5.75±0.18[c]
Histidine	2.50±0.12[a]	ND	ND
Tyrosine[d]	4.88±0.14[c]	6.94±0.04[a]	5.96±0.17[b]

*Values are mean of 3 replicates. Means with different letters in the same row are significantly different ($P < 0.05$). [d]Essential amino acids. ND: Not Detected.

mushrooms' fat values are in conformity with Shah et al. (1997) study. 34.8% dietary fibre value was found in *P. ostreatus* cultivated in wheat straw by Justo et al. (1999), which is higher than the values we obtained in our study. Watanabe et al. (1994) found the carbohydrate value as 47.9 g in 100 g dry matter. Our carbohydrate values are lower than the study made by Watanabe et al. (1994).

As shown in Table 2, cultivating different mushroom species affects amino acid content significantly ($P < 0.05$). Each amino acid content generally changes due to the different mushroom species. Except histidine that was found only in *P. eryngii*, the amino acid profiles of oyster mushrooms are the same. This result may be due to the same substrate materials used for the cultivation and genetic properties of oyster mushrooms. In this study, oyster mushroom species have valine, leucine, isoleucine, threonine, methionine, phenylalanine, lysine and tyrosine essential amino acids. Apart from essential amino acids, considerable amounts of alanine, glycine, serine, proline, aspartic acid and glutamic acid can be also found in these mushrooms.

In conclusion, as also mentioned by other authors (Shah et al., 1997; Manzi et al., 2001), the chemical composition of edible mushrooms determines their nutritional value and sensory properties. They differ according to species but this difference also depends on the substratum, atmospheric conditions, age and part of the fructification. We found different nutritional values in the different cultivated mushroom species. This differences may have arisen from the genetical structure of the mushrooms. These results also indicate that the studied mushrooms have good nutritive value for humans. Additionaly, the agricultural lignocellulosic wastes that are usually burned or left in the field to rot in our region can effectively be used for oyster mushroom production and this will provide an economical gain to this region if cultivation of oyster mushroom is made a profession by producers.

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