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Hazelnut husk as a substrate for the cultivation of shiitake mushroom (*Lentinula edodes*)

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Abstract

The possibility of using hazelnut husk (HH) as a new basal ingredient for substrate preparation in *Lentinula edodes* cultivation was investigated. Some chemical properties of the substrates prepared by HH alone and its mixtures with wheat straw (WS), beech wood-chip (BWC) and wheat bran (WB) in different ratios were compared, and their effects on spawn run time, days to first harvest (earliness), yield and biological efficiency (BE) were determined. The N content of the substrate prepared from HH alone was very high (0.82%), and thus the C:N ratio of substrates decreased with an increase in the rate of HH in the mixtures. Yield and BE in the HH alone substrate was considerably low compared with the controls (80BWC:10WS:10M and 60BWC:20WS:20WB), and decreased with an increase in the rate of HH in the mixtures. However, when the HH content in the mixtures was kept below 50%, the yield was relatively high (50HH:50WS and 50HH:50BWC). Even when the HH content increased to 75% in the mixture, the comparable yield and BE to the controls could be obtained by adding 10% of WB as nutrients (75HH:15WS:10WB and 75HH:15BWC:10WB). The results revealed that HH could be used as a new basal ingredient for substrate preparation in *L. edodes* cultivation.

Keywords: *Lentinula edodes*; Hazelnut husk; Substrate; Chemical properties; Yield; Biological efficiency; Correlation

1. Introduction

Lentinula (*Lentinus*) *edodes* (Berk.) Pegler (shiitake) is the second most popular edible mushroom in the world because of its flavor, taste and quality (Jong and Birmingham, 1993). In addition, shiitake is one of the best known and the best characterized mushrooms used for medicinal purposes (Royse, 1996; Ooi, 2000).

Shiitake can be grown on synthetic logs as well as natural logs. Sawdust is the most popular basal ingredient used in synthetic formulations of substrate for producing *L. edodes*. Different substrate formulas have been developed in different countries, depending on their readily available raw material. Growers typically select the best and the least expensive, locally available substrate materials. Agricultural wastes such as oak, hornbean, sweetgum, poplar, alder, ironwood, beech, willow, pine, maple and birch sawdust, cereal straw, corn cobs, sugarcane bagasse, tea waste, sunflower seed hulls, peanut shells, cotton straw and seed hulls can be used alone or in combination with other wastes in shiitake cultivation (Diehle and Royse, 1986; Miles and Chang, 1989; Salmones et al., 1999; Morais et al., 2000; Zhao et al., 2001; Pire et al., 2001; Zervakis et al., 2001; Curvetto et al., 2002; Philippoussis et al., 2003; Rossi et al., 2003). Starch based supplements such as wheat and rice bran, sugarcane molasses, millet, rye, maize, and corn flour are added to the mix (İlbay, 1994; Royse, 1996; Royse, 1997; Fomina et al., 1999; Kalberer, 2000; Rossi et al., 2003).

A widely used "standard" substrate formula is 80% hardwood sawdust and 20% supplements on a dry weight basis (Royse, 1985; Miller and Jong, 1987). Some formulations, with all ingredients based on oven dry substrate weight, consisting of 80% sawdust and 20% bran in Asia

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(Lizuka and Takeuchi, 1978); 80% sawdust, 10% bran and 10% wheat or millet in the USA (Royse, 1985; Miller and Jong, 1987); and 84% sawdust, 5% rice bran, 5% wheat bran, 3% soybean and 3% lime in Taiwan (Kalberer, 1987) are commonly used for *L. edodes* cultivation as standard substrates. Swiss researchers reported that the mixture of 75% spruce sawdust, 24% wheat bran and 1% lime could be used for the successful cultivation of *L. edodes* (Kalberer, 1987).

Hazelnut is one of the major agricultural products of the Black Sea region in Turkey. The production of hazelnut in 2004 was about 425 Mt (FAO, 2005). Hazelnut processing produces large quantities of husk and shell waste. They are burnt in stoves for house heating, also causing pollution. It has been thought that these agricultural wastes could be used for *L. edodes* cultivation.

The objective of this study was to investigate the possibility of using hazelnut husk as a new basal ingredient for substrate preparation in *L. edodes* cultivation. Some characteristics of substrates prepared by hazelnut husk alone, and its mixtures with wheat straw, beech wood-chip and wheat bran in different ratios were compared, including their effects on spawn run time, days to first harvest (earliness), yield and biological efficiency.

2. Methods

Hazelnut husk (HH) was supplied by hazelnut growers in the vicinity of Samsun province in Turkey. Air-dried HH in 3.0–3.5 cm size was used to prepare substrates without chopping into pieces. Particle size of wheat straw (WS) was less than 10 cm and beech wood-chip (sawdust) (BWC) was 0.5–4.0 cm long. Homogeneous substrate mixtures were prepared by mixing component materials based on their dry weight (w/w) (Table 1).

The substrate mixtures were wetted for two days to raise their moisture content to 60–65%. The mixed substrate (1 kg wet wt) was put in unused heat resistant polypropylene bags (28×42 cm) and sterilized in an autoclave at 121 °C for 1.5 h. After sterilization, moisture, pH, ash, carbon (C) and total nitrogen (N) content of substrates were determined (Kacar, 1994) and C:N ratios were calculated. Mineral (K, P, Ca, Mg, Fe, Cu, Mn and Zn) contents of substrates were also determined in ash by atomic absorption spectrophotometer (Kacar, 1994). Spawn of *L. edodes* (Berk.) Pegler used in the experiment were supplied by Agromycel Company, Denizli, Turkey. The sterilized substrates were inoculated with 0.8% (w/w) spawn, and incubated at 22 ± 2 °C in darkness. After the mycelium colonization was completed, the bags were exposed to daylight for a 10 h photoperiod to promote mushroom formation at 18 ± 2 °C room temperature and 80–90% relative humidity in a controlled room. After each flush of mushrooms was harvested, synthetic logs were re-soaked to increase log weight to 0.9 kg. Spawn run time, earliness (days to first mushroom harvest) and total mushroom yield were also determined. Mushroom yields were obtained from two or three flushes in a harvest period of 120 days. The biological efficiency percentage (BE) was calculated using the substrate dry weights as follow: ([weight of fresh mushrooms harvested/substrate dry matter content] × 100) (Royse, 1985).

The experiments were designed in a Completely Randomized Plots with six replications. The data obtained from the experiment were subjected to analysis of variance and means showing statistical significance were compared by Duncan's multiple range tests using the MSTATC statistical computer program. Correlation analyses were carried out to determine the relationships among chemical constituents of the substrates. Correlation coefficients (R) between chemical constituents of the substrates and spawn run time, earliness, yield and BE were also computed.

3. Results

Moisture content, some chemical properties of substrates such as, pH, ash, C and N contents, and C:N ratios are given in Table 2. Substrates varied for moisture content and pH values ($P < 0.05$). The highest moisture content was determined in 60BWC:20WS:20WB, followed by 75HH:25WS. Significant differences ($P < 0.01$) were found among substrates regarding ash, C and N contents, and C:N ratio. In general, ash content of substrates prepared by the mixtures of HH with BWC was lower than the

Table 1
Materials used for substrate prepared and their mixing ratios

Substrates and mixing ratio	Symbol
Hazelnut husk	HH
25% hazelnut husk:75% wheat straw	25HH:75WS
50% hazelnut husk:50% wheat straw	50HH:50WS
75% hazelnut husk:25% wheat straw	75HH:25WS
75% hazelnut husk:15% wheat straw:10% wheat bran	75HH:15WS:10WB
25% hazelnut husk:75% beech wood-chip	25HH:75BWC
50% hazelnut husk:50% beech wood-chip	50HH:50BWC
75% hazelnut husk:25% beech wood-chip	75HH:25BWC
75% hazelnut husk:15% beech wood-chip:10% wheat bran	75HH:15BWC:10WB
80% beech wood-chip:10% wheat bran:10% millet (control-1)	80BWC:10WB:10M
60% beech wood-chip:20% wheat straw:20% wheat bran (control-2)	60BWC:20WS:20WB