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Trace elements in *Pleurotus sajor-caju* cultivated on chemithermomechanical pulp for bio-bleaching

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Abstract

Some trace elements were analyzed in *Pleurotus Sajor-caju* mushroom cultivated on chemithermomechanical pulp. In this experiment, phytohormones, such as 2.4-D and PS A6, were studied at concentrations of 10, 20 and 30 mg/100 ml, mixed into the pulp. Determination of mineral elements was done by flame atomic absorption spectrophotometry (Perkin Elmer model 1100 B). Sixteen mineral elements were determined in all samples. Cu, Mg, Pb, Na, Ag, Bi, Mn, Ni, Li, Co, Sb, Ca, Zn, Fe, Cr and Al contents of mushrooms, grown on treated pulp, were near control values. K was not present.

Keywords: Pleurotus sajor-caju; Cultivation; Chemithermomechanical pulp; Phytohormones

1. Introduction

Mushroom and toadstool are terms applied rather loosely to the fruit bodies of fleshy gill fungi and are commonly used to denote edible and poisonous species, respectively. They form a small part of the enormous range of organisms called fungi. Their essential characteristic is the lack of green pigment and this puts the fungi in a separate kingdom from other plants (Oderinde, Jiboku, Faniran, & Adelek, 1985; Pergler, 1981).

Structurally, the mushroom is like an umbrella, with a cap protecting the spore-producing surfaces from the rain. Edible mushrooms have a high nutritive value, almost twice that of any other vegetables or fruits. They are also rich in vitamins B and D. The edible species of mushroom include *Boletus*, Miller, the parasol mushroom and the *chanterelle*. Apart from the food value of mushroom, its medicinal value as an ideal food for diabetics and in cancer therapy has been emphasized (Geuders, 1974).

Various edible mushrooms are appreciated for their pleasant flavour and their biting texture. In general, their fruiting bodies, on a dry weight basis contain about 39.9% carbohydrate, 17.5% protein, and 29% fats, the remainder being minerals. Most cultivated mushrooms contain significant amounts of potassium and sodium, a smaller amount of calcium and very low amounts of iron and magnesium. These metals are most conveniently determined by either the flame emission (FE) or atomic absorption (AA) methods (Chang & Quimio, 1982).

There have been few reports on the elemental analysis of species of edible mushrooms. Among them are studies of heavy metal accumulator collectors, as in the species *Pleurotus sajor-caju* and *Pleurotus ostreatus* (Yasui, Tsutsumi, Arcos, & Pozo-Lora, 1988); the translocation of heavy metals in to the mushroom by altering the metal concentration in the substrate (Jain, Gujral, Jha, & Vasudevan, 1988), major and trace elements in some edible Thai and Norwegian mushroom (Surinrut, Julshamn, & Njaa, 1987); the effect of mineral supplement on the organic and mineral compositions of various mushroom types (Levai, 1988) and variation of trace mineral (Cr, Co, Ni, Zn) contents in three wild edible mushrooms (Alofe, 1991).

During the last 20 years, mushrooms, or rather higher fungi in general, have become notorious for their ability to accumulate trace elements, including several potentially toxic metals. Although the principal cultivated mushrooms of commerce, such as the champignon

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(*Agaricus bisporus*), shiitake (*Lentinus edodes*) and other mushrooms (*Pleurotus ostreatus*) have a reassuringly low heavy metal content, several wild-growing edible species in the markets of Europe have high mercury or cadmium concentrations. Consequently, public health authorities in Germany have published guidelines to limit their intake (Stijve & Bourgai, 1991).

Many investigations have dealt with the metal contents of mushrooms, especially edible ones (Jain et al., 1988; Surinrut et al., 1987; Yasui et al., 1988). The concentrations of lead and cadmium in the fruiting bodies of mycorrhizal and edible macrofungi (*Basidiomycetes*, *Agaricales*) were measured in the vicinity of a lead smelter (Lepsova, 1988).

Cd, Cu, Pb and Zn contents were determined in wild-growing mushrooms in polluted and unpolluted regions (Gast, Jansen, Bierling, & Haanstra, 1988). Some species of mushrooms, e.g. *Amanita muscaria,* are known to concentrate vanadium (Beinert & Palmer 1965; Kneifel, & Bayer, 1973). Stijve and Roschnik (1974) suggested that the members of the genus *Agaricus* could be used as indicator organisms in a study of mercury pollution (Stijve, & Roschnik, 1974). The highest content of mercury was found in samples of *Pleurotus campestris* (Zurera, Rincon, Arcos, & Pozo-Lora, 1986) coinciding with the findings of other studies (Kuusi, Laaksovirta, Liukkonen-Lilja, Lodenius, & Piepponen, 1981; Lodenius, Kuusi, Laaksovirta, & Piepponen, 1981; Quinche, Bolay, & Dvorak, 1976; Stijve & Besson 1976; Stijve & Roschnik 1974).

In another study,the average arsenic content was 1–6 ppm (Vetter, 1987) in 80 mushroom samples. But in certain taxonomic groups (e.g. the genus, *Agaricus* and the family Tricholomataceae), a significant bioaccumulation was shown (*Agaricus augustus*; 11.9 ppm; *Macrolepiota rhaodes*; 26.6 ppm; Vetter, 1990). Important lead contaminants were registered in some urban fungi samples from England (Thomas, 1992).

On the other hand, it has been reported that the mineral contents of the edible mushrooms were changed as follows; Fe levels 3.5–27; Cu: 0.4–26.6; Mn: 0.8–7.4; and Zn: 3.3–19.5 $\mu g\ g^{-1}$ (Breene, 1990).

The dry-ashing and wet-oxidation methods were compared after determination of Cu and Zn levels by flame atomic absorption spectrometry in mushroom samples (Özdemir, 1996). In addition, the effect of blanching (with and without addition of L-ascorbic acid) on the concentrations of elements and drained weight was examined in mushroom *Agaricus bisporus* (Coşkuner & Özdemir, 1997).

Contents of Hg, Pb, Cd, Fe, Cu, Mn, Zn, Co and As of fruiting bodies of two cultivated and 109 wild macrofungi, collected from the East Blacksea Region in Turkey, were determined spectrometrically (Sesli & Tüzen, 1999). Elemental contents of seven selected species of edible mushrooms have been determined by neutron activation analysis (Latif, Daran, & Mohamed, 1994).

2. Material and methods

Fruit bodies of *Pleurotus sajor-caju* cultivated on chemithermomechanical pulp, were grown in mushroom farm. During the cultivation period, both phytohormones 2.4-D and PS A6, were used at concentrations of 10, 20 and 30 mg/100 ml, respectively. Twenty samples were collected from each group of experiments. After collecting, the samples were cleaned, dried in a drying oven at 103 °C and homogenized by grinding. Each sample comprised all the edible parts of the mushroom. After pretreatment, the samples were stored in closed containers at room temperature, then 2 g samples were taken and placed in a small beaker. After addition of 20 ml concentrated HNO_3, the mixture was allowed to stand overnight. The mixture was heated carefully on a hot plate until the production of red NO_2 fumes ceased.

After cooling, 10 ml of 70% $HClO_4$ were added, and the mixture heated and allowed to evaporate to a small volume. Then, it was heated adding after 5 ml of HCl, for a short time, and transferred to a 100-ml flask and diluted to volume with distilled water. To overcome potential interferences when determining calcium and magnesium, 1% (w/w) of lanthanum was added to the final sample dilution. Contents of trace elements of mushrooms were determined by atomic absorption spectrophotometry.

3. Results and discussion

Metal accumulating ability of mushroom may have two origins:

1. bio-accumulation, supposing the presence of certain metal binding compounds (e.g. cadmium, vanadium)
2. a higher element content resulting from higher metal content in the environment (Vetter, 1993).

Trace element contents of mushroom *Pleurotus sajor-caju* cultivated on chemithermomechanical pulp with phytohormones PS A6 and 2.4-D are shown in Table 1.

Some trace element contents of the mushroom *Pleurotus sajor-caju* cultivated on chemithermomechanical pulp with phytohormones PS A6 and 2.4-D are shown in Fig. 1.

As can be seen from Fig. 1, the Cu level was 10.0 μg/g for control samples, whereas it increased from 10.5 to 12.0 μg/g in PS A6 samples. Maximum level was 14.0 μg/g for 2.4-D2. The Cu levels are in agreement with

Table 1
Trace element contents of the examined mushroom samples (μg/g, on dry weight basis)

Element	PS A6	PS A6	PS A6	2.4-D	2.4-D	2.4-D	Control
	1	2	3	1	2	3	
Cu	10.5	11.5	12.0	12.0	14.0	12.0	10.0
Mg	1750	1750	1700	1850	1950	1800	1650
Pb	16.5	28.5	27.5	28.5	22.5	33.5	27.5
Na	1550	1600	1400	1650	1800	1850	1650
Ag	4.0	4.5	4.0	5.5	5.0	5.0	4.0
K	–	–	–	–	–	–	–
Bi	453	44.0	438	41.0	443	36.5	44.0
Mn	15.0	16.5	16.0	19.0	18.5	17.0	17.5
Ni	16.0	16.0	16.5	17.5	18.0	16.0	17.5
Li	0.0	0.5	0.5	0.5	0.5	0.5	0.0
Co	10.5	11.5	11.0	12.0	10.5	11.0	12.5
Sb	134	108	111	112	129	111	106
Ca	915	865	695	1040	1025	1180	1250
Zn	115	110	105	130	135	120	110
Fe	126	135.5	114	130	155	154	137.5
Cr	7.0	8.5	11.0	9.5	8.0	9.0	8.5
Al	125	130	175	100	95	155	175

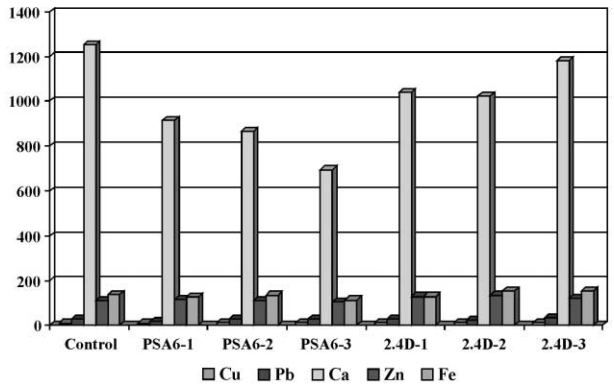

Fig.1. Cu, Pb, Ca, Zn and Fe elements of the examined mushroom samples (μg/g, on dry weight basis).

other literature findings (Chang & Quimio, 1982; Gujral, Jain, & Vasudevan, 1987). The highest Mg level was found as 1950 μg/g for 2.4-D2; the lowest Mg level was 1650 μg/g for control samples. Gujral and his coworkers determined the Mg value as 1051 mg/kg.(Gujral et al., 1987). The highest Pb level was 33.5 μg/g for 2.4-D3 and lowest value was 16.5 μg/g for PS A6–1. These results conform with the FAO/WHO (1976) standards for Pb and Cd as toxic metals. Maximum permissible dose for an adult is 3 mg Pb and 0.5 mg Cd per week, but the recommended doses are only one-fifth of those quantities.

The Na levels were between 1550 and 1850 μg/g in all groups. Ag levels were quite similar for all groups. K was not apparent in any sample. In the groups of PS A6, when the concentration of hormones was increased from 10 to 30 mg/100 ml, the levels of Bi decreased from 45.3 to 44.0 and 43.8 μg/g, respectively. In 2.4-D groups, Mn value decreased from 2.4D-1 to 2.4D-3 as 19, 18.5 and 17.0 μg/g, respectively. Mn levels accorded with the observations made by earlier workers (Latiff et al., 1994). The lowest Ni level was 16.0 μg/g in PS A6–1, PS A6–2 and 2.4-D3, the highest Ni level was 18.0 μg/g in 2.4-D2.

With Co levels, there was an opposite relationship between PS A6-1, 2, 3 (10.5, 11.5 and 11.0 μg/g, respectively) and 2.4-D1, 2, 3 (12.0, 10.5, and 11.0 μg/g, respectively). On the other hand, the Co results are in agreement with values given in the literature (Latif et al., 1994). As can be seen from Table 1, the levels of Sb in the samples of PS A6-1,2 and 3 ranged from 108 μg/g to 134 μg/g and for the samples of 2.4-D vary between 111 μg/g and 129 μg/g. Ca content of PS A6 (10, 20, 30 mg/100 ml) groups decreased from 915 μg/g to 695 μg/g with increasing concentrations of PS A6 hormones. Fig. 1 shows that the highest Ca content was determined in control samples (1250 μg/g).

The Zn levels were between 115 and 105 μg/g in PS A6 groups (10, 20 and 30 mg/100 ml) whereas they used 120 and 130 μg/g in 2.4-D (10, 20 and 30 mg/100 ml). The highest Fe level was found in 2.4-D2 (155 μg/g). The lowest Fe level was found in PS A6–3 (114 μg/g). Also the Fe levels in PS A6 groups were less than in 2.4-D groups. Fe and in Zn results were close to those found in the literature (Latift et al., 1996). The Cr levels are almost in agreement with 2.4-D values (7.0, 8.5, 11.0 μg/g and 9.5, 8.0 and 9.0 μg/g). The highest Al value was determined in the control sample as 175 μg/g, being equal to PS A6–3.

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