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Mineral elements in the important cultivated mushrooms *Agaricus bisporus* and *Pleurotus ostreatus*

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The mineral elements of *Agaricus bisporus* and *Pleurotus ostreatus* (separately in the caps and stipes of the fruit body) were analysed. The main conclusions are:

1. The classical (conventional) and the new cultivation methods produce different mineral compositions in champignon. The new method (on pure wheat straw) produced lower B, Ca, Cu, Na, Zn and higher K, Fe, Mg, Ni, P and Ti concentrations.
2. The caps of fruit bodies have, in general, greater concentrations of mineral elements than the stipes in both *A. bisporus* and *P. ostreatus*. The exceptions are Ba, Cd, Cr, Li and Sr, whose concentrations are approximately identical in caps and stipes).
3. *A. bisporus* has higher P, K, Ca but lower trace element concentrations than *P. ostreatus*, which has higher Mg, B, Cd, Fe and Mn concentrations.
4. Accumulation of heavy metals was not found in the samples examined.

INTRODUCTION

Worldwide production of cultivated edible mushrooms currently amounts to approximately 3 700 000 tons. About 38% of this is accounted for by *Agaricus bisporus*, followed by the oyster mushroom, *Pleurotus ostreatus* (24·2%; Schmidt, 1993). Because of increasing mushroom cultivation, these fungi now have a more important role in human nutrition. In the literature there is little information about the mineral components of cultivated mushrooms (Gergely *et al.*, 1986; Lelley, 1991). Previous work has analysed the mineral composition of different edible, but not cultivated, higher fungi (Vetter, 1990; 1993*a*, 1993*b*). Accumulation of certain elements (primarily heavy metals: Cd, Pb, Hg, Cs, etc) by the higher fungi has been reported in other works (Tyler, 1982; Horyna & Randa, 1988; Lepsova & Mejstrik, 1988; Turnau & Kozlowska, 1991). The aim of this work was first a comparison of mineral compositions in the caps and stipes of *Agaricus bisporus* and *Pleurotus oxtreatus*, respectively, and second to determine whether there are any differences in the mineral composition of *Agaricus bisporus*, when the mushrooms are cultivated by classical and new cultivations's methods.

MATERIALS AND METHODS

The cultivation of *Agaricus bisporus* was achieved both by the classical method on compost, and by a new method on wheat straw (Balázs & Gyenes, 1989). The cultivation of oyster mushroom (*Pleurotus ostreatus*) was achieved on wheat straw, by the conventional method (Lelley, 1991). After cleaning, the fruit bodies were separated into caps and stipes; these were sliced, dried under mild conditions and milled to flour fineness. The samples were then macerated with HNO_3–H_2O_2 in special teflon vessels under $1{\cdot}56 \times 10^5$ Pa pressure for 30 min (200 mg sample, 2 cm^3 HNO_3, 2 cm^3 H_2O_2). The macerated substance was filtered and diluted to 10 cm^3, with twice-distilled water. The concentrations of the mineral elements were determined by plasmagenerated spectroscopy, using an ICAP 9000-type apparatus. All determinations were carried out in three replicates. Tables 1 and 2 contain the arithmetic means (ppm on dry-matter basis) and the standard deviations.

RESULTS AND DISCUSSION

Comparison of *Agaricus* fruit bodies originating from the two cultivation methods

The fruit bodies (caps and stipes) produced by the new cultivation method have identical concentrations of certain elements. Decreased concentrations were found for boron, calcium, copper, sodium and zinc; increased concentrations were found for potassium, iron, nickel, magnesium, phosphorus and titanium; concentrations

Table 1. Mineral composition in caps and stipes of cultivated champignon (*Agaricus bisporus*) (ppm on dry-matter basis)

Element	*Agaricus bisporus*			
	Classical cultivation		Cultivation on straw	
	Cap	Stipe	Cap	Stipe
Al	70·0 ± 15	40·1 + 2·0	74·0 ± 1·1	46·6 ± 3·72
As	0	0	0	0
B	25·2 ± 1·2	17·8 ± 0·3	2·5 ± 0·15	2·65 ± 0·31
Ba	2·3 ± 0·3	2·39 ± 0·19	2·67 ± 0·22	1·89 ± 0·27
Ca	2 829 ± 702	2 372 ± 230	2 377 ± 30	1 228 ± 231
Cd	0·2 ± 0·01	0·24 ± 0·03	0·22 ± 0·05	0·26 ± 0·12
Co	0	0·09 ± 0·06	0	0
Cr	1·11 ± 0·14	1·04 ± 0·10	1·39 ± 0·09	1·13 ± 0·14
Cu	61·5 ± 4·6	41·5 ± 0·61	37·46 ± 0·27	25·67 ± 0·25
Fe	78·5 ± 4·6	75·8 ± 2·57	128 ± 4·32	100·2 ± 8·55
Ga	0	0	0	0
K	41 132 ± 2 376	35 534 ± 274	47 370 ± 654	45 657 ± 252
Li	0·15 ± 0·02	0·21 ± 0·03	0·19 ± 0·01	0·19 ± 0·02
Mg	1 236 ± 53·1	906 ± 10·2	1 446 ± 37·6	1 064 ± 61
Mn	8·24 ± 0·64	6·35 ± 0·28	8·44 ± 0·21	6·09 ± 0·49
Mo	0·34 ± 0·11	0·05 ± 0·03	0·47 ± 0·06	0·53 ± 0·17
Na	762 ± 29·8	859 ± 51·65	597 ± 4·14	678 ± 45·7
Ni	1·42 ± 0·29	1·35 ± 0·09	1·70 ± 0·07	1·34 ± 0·19
P	14 311 ± 949	9 694 ± 296	18 810 ± 585	12 782 ± 210
Sr	9·82 ± 0·94	9·37 ± 1·37	9·67 ± 0·97	7·90 ± 1·29
Ti	0·35 ± 0·03	0·22 ± 0·01	0·69 ± 0·03	0·46 ± 0·05
V	0	0·08 ± 0·04	0·11 ± 0·04	0·03 ± 0·04
Zn	93·0 ± 21·7	81·4 ± 4·8	70·1 ± 9·1	50·1 ± 11·0

Table 2. Mineral composition in caps and stipes of oyster mushroom (*Pleurotus ostreatus*) (ppm on dry-matter basis)

Element	*Pleurotus ostreatus*	
	Caps	Stipes
Al	37·6 ± 12	45·5 ± 6·59
As	0	0
B	5·56 ± 0·40	6·88 ± 0·34
Ba	1·74 ± 0·28	2·08 ± 0·20
Ca	890 ± 238	1 056 ± 112
Cd	0·56 ± 0·24	0·23 ± 0·09
Co	0	0
Cr	0·90 ± 0·47	0·71 ± 0·27
Cu	21·9 ± 0·56	16·2 ± 0·55
Fe	151 ± 20·0	137 ± 11·1
Ga	0	0
K	39 883 ± 917	27 217 ± 403
Li	0	0·14 ± 0·02
Mg	1 901 ± 83	1 238 ± 14·4
Mn	11·3 ± 0·75	7·06 ± 0·20
Mo	0	0
Na	544 ± 85·8	438 ± 13·1
Ni	2·25 ± 0·75	3·6 ± 2·9
P	11 977 ± 314	6 176 ± 104
Sr	6·88 ± 1·41	8·22 ± 0·66
Ti	1·41 ± 0·28	0·66 ± 0·60
V	0·10 ± 0·06	0·10 ± 0·06
Zn	80·2 ± 2·19	48·9 ± 1·55

were identical or nearly identical for aluminium, cadmium, lithium, manganese and strontium; and levels of arsenic, cobalt and gallium were undetectable. Most noticeable among the macroelements were increased concentrations of potassium, magnesium and particularly phosphorus (in this case the increase is 31·4%), but lower concentrations of certain other elements (e.g. calcium, copper and zinc which are important from the point of view of human nutrition) were found. The greatest decrease was registered in the case of boron (classical method: 25·3 ppm; new method: 2·47 ppm).

Comparison of mineral contents in caps and stipes

The majority of measured mineral elements were found to be at higher concentrations in the caps than in the stipes. There are only a few exceptions; for barium, cadmium, chromium, iron, lithium and strontium the concentrations are roughly identical in the caps and stipes. Only one element (Na) occurs in higher concentration in stipe than in cap. This situation is characteristic of both classical and new cultivation methods; there are no differences between the actual occurrences of the minerals.

Comparison of mineral compositions of *Agaricus bisporus* and *Pleurotus ostreatus*

Comparison was made on the basis of cultivations on the same wheat straw (Tables 1 and 2). Phosphorus, potassium, calcium and a few trace elements (Al, Ba, Cr, Cu, Sr and Ti) have lower concentrations in *Pleurotus ostreatus*. In the case of magnesium, boron, cadmium, iron and manganese, the concentrations are higher in oyster mushroom. The concentrations of sodium and zinc are approximately identical in the two mushrooms. However, on the same substrate (wheat straw) *Agaricus bisporus* contains more calcium, potassium and particularly phosphorus and this fact is of importance from the point of view of human nutrition. On the other hand, the oyster mushroom has a higher magnesium level. The trace elements, in general, are of higher concentrations in *Agaricus* than in *Pleurotus* fruit bodies, but these differences are not great.

Fortunately, accumulation of certain heavy metals (known from our own and other data) was not found in the examined mushroom species.

Mushroom cultivation has developed very rapidly. The increasing quantities of protein-rich mushrooms produced, and the relative lack of reliable analytical data lend importance to the current work.

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