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Chitin content of cultivated mushrooms *Agaricus bisporus*, *Pleurotus ostreatus* and *Lentinula edodes*

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Abstract

The chitin contents of pileus and stipes of fruit bodies of *Agaricus bisporus*, *Pleurotus ostreatus* and *Lentinula edodes* (shii take) were determined and compared. The fruit bodies of different, common varieties of the cultivated mushroom species were taken from Hungarian and German large-scale farming. The analytical procedure was carried out on the powder of cleaned, dried and milled pileus and stipes. The pileus of *A. bisporus* variety 'K-23' showed a significant decrease ($p < 0.05$) during the cultivation's flushes (breaks), 1–3, while the chitin level of stipes seemed to be constant. The other analysed *A. bisporus* varieties (var. '158', 'K-7', 'Sylvan A-15', 'Sylvan 608', and Le Lion C-9) had practically the same chitin levels. This indicates that the chitin content is a stable characteristic of the species and there are no significant differences between the different varieties. The chitin levels of pileus and stipes were not significantly different (for *A. bisporus*, 6.68 and 7.25) but showed significant differences for *P. ostreatus* ($p < 0.05$) and *L. edodes* ($p < 0.001$). In the case of the latter two species, the pileus had the higher and the stipe the lower chitin content. The presented data confirm that a mushroom saprotrophic (*A. bisporus*) had higher chitin level than had the wood-rotting ones (*P. ostreatus*, *L. edodes*).

Keywords: Chitin; Fruit body; Pileus; Stipe; *Agaricus bisporus*; *Pleurotus ostreatus*; *Lentinula edodes*

1. Introduction

The edible cultivated mushrooms have some valuable properties (remarkable quantity and high quality of proteins, low energy level, some important elements such as K and P, some odorous and taste materials) and valuable and important foods. The contents of these favourable components have been reported in different publications (Kasuga, Fujihara, & Aoyagi, 1999; Manzi, Gambelli, Marconi, Vivanti, & Pizzoferrato, 1999; Manzi, Aguzzi, & Pizzoferrato, 2001; Mattila, Lampi, Ronkainen, Toivo, & Piironen, 2002). The chemical composition of these mushrooms, however, shows other constituents, which can effect (limit) the digestibility or have other negative effects.

The main components of the fungal cell wall are the polysaccharides (80–90% of the dry mass). The N-containing chitin is one of the skeletal fungal polysaccharides responsible for the rigidity and shape of the cell wall. Chitin is a characteristic component of the taxonomical groups Zygo-, Asco-, Basidio- and Deuteromycetes, but it is absent in other groups (for e.g., Oomycetes). The fungi, according to many new fungal systems, are organisms with a chitin-containing cell wall. The other fungal or fungi-like organisms without such cell walls are ranked among the kingdoms Protista or Chromista.

The dietary fibre (total dietary fibre = TDF) is the sum of the intrinsic non-digestible carbohydrates and lignin (plants) and the sum of such carbohydrates (mainly of chitin) in mushrooms. The *Lentinula edodes* (shii take) contains about twice the TDF of the brown strain of *Agaricus bisporus* (Mattila et al., 2002).

Chitin molecules decrease the digestibility. However, they have a positive biological role as a component of

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dietary fibres (Bauer-Petrovska, Jordanoski, Stefov, & Kulevanova, 2001; Cheung, 1996).

We earlier analysed the chitin content of the most important wild-growing mushroom species (Vetter & Siller, 1991) and a difference of chitin content of between 2% and 8.5% (to DM) was established. The chitin level of three varieties of *Pleurotus ostreatus* varied between 2.16% and 3.31% of DM. According to data of Manzi et al. (2001) the cooking of *A. bisporus* increased the chitin content for normal, fresh mushrooms, for the deep frozen and for the canned variants, too (control, 6.0%; cooked 7.0%; deep frozen; 3.4%, cooked 5.2%; canned: 6.1%, cooked 7.4%). Unfortunately, the variety of the examined mushroom was unknown, the fruit bodies were whole (and not fractionated). The chitin content of the wild-growing *Boletus* group ranged from 0.5 to 3.3 g/100 g edible weight, and the effect of cooking was not significant (Manzi, Marconi, Aguzzi, & Pizzoferrato, 2004). The main drawback of previous literature was the small number of analysed samples and of species or of varieties, and the absence of data on chitin contents of two morphological parts of fruit body (pileus and stipe).

The aims of these investigations were: (a) to evaluate the changes of chitin content of *A. bisporus* during the cultivation process (are there differences in chitin content among the repeating 3–5 day cycles, i.e., flushes or breaks of cultivation?), (b) to compare the chitin contents of two parts of sporocarps (pileus and stipe) of the three cultivated species and to establish and compare the chitin contents of some common and frequently used varieties, such as the most important cultivated mushroom species (*A. bisporus*, *P. ostreatus*, *L. edodes*).

2. Materials and methods

The fruit bodies of the different varieties and species originated from large scale cultivation, i.e., mainly from the National Korona Mushroom Union (Kerecsend, Hungary), but some varieties were cultivated in Germany by GAMU (Krefeld, Germany). The samples of *A. bisporus* var. 'K-23' were taken from three flushes (or breaks) of four independent cultivations (two in 1999 and in 2000). The cultivations of other varieties (species) were done in 2000; the samples were taken from the first flush. The analysed species and varieties were:

(1) *A. bisporus* (Lange) Imbach, varieties 'K-23', 'K-7' '158', Sylvan A-15; 'Sylvan 608' Le Lion C-9; (2) *P. ostreatus* (Jacq. et Fr.) Kummer varieties G-32, G-24, H-7 357, Somycel HK-35; Amycel 3015; and (3) *L. edodes* (Berg.) Sing. varieties ST-66, ST-67. The fruit bodies were cleaned, separated into pileus and stipes, dried and milled. The chitin determinations were carried out from the mushroom powders. The hydrolysis of the samples (20–20 mg) was carried out in 6 N HCl solution (in 2.5 cm^3, at 106 °C, 24 h). The glucoasamine content of the hydrolysed and neutralized material was determined with 3-methyl-2-benzothiazolone-hydrazone-hydrochloride (MBTH) according to Smith and Gilkerson (1979). The determinations were done triplicate, and chitin contents were given as the arithmetical means (in percent of DM) with standard deviations (±SD). The statistical evaluation of the analytical data were performed by using the software 'Origin 4.0'.

3. Results and discussion

The chitin contents of different parts of fruit bodies of *A. bisporus* var. 'K-23' are given in Table 1.

The chitin concentrations of flushes 1–3 showed a decreasing tendency for pileus: 7.21% of DM; 7.16% of DM; 5.63% of DM and relatively constant level for stipes: 7.01; 7.29; and 6.94 (for flushes 1, 2 and 3, respectively). Comparing the data of flushes for pileus, between flushes 1 and 3 there was a significant difference ($p < 0.05$), but among the other consecutive flushes (1–2; 2–3) there were no significant differences. No significant differences were demonstrated between the flushes for stipes. This fact seems to be a stable characteristic because the mushroom samples for this evaluation were taken from independent cultivation cycles (from the years 1999 and 2000).

The chitin contents of other varieties of *A. bisporus* are summarized in Table 2. The analysed varieties ('158'; 'K-7', 'Sylvan A-15', 'Sylvan 608', 'Le Lion C-9') all have practically the same level of chitin in fruit bodies, because the differences are not significant. This stability of chitin

Table 1
Chitin contents of different flushes (breaks) of *Agaricus bisporus* var. 'K-23'

Part of fruit body	Year and number of examination	Flushes	Chitin content (% DM) ± SD	Mean of all samples (±SD)	Pileus chitin/stipe chitin
Pileus (cap)	1999/1	No. 1	7.25 ± 0.09	7.21 ± 0.51	0.93
	1999/2		7.48 ± 0.17		
	2000/1		7.64 ± 0.15		
	2000/2		6.47 ± 0.06		
Stipe	1999/1	No. 1	8.35 ± 0.08	7.61 ± 0.90	
	1999/2		8.70 ± 0.14		
	2000/1		7.54 ± 0.12		
	2000/2		6.81 ± 0.12		
Pileus (cap)	1999/1	No. 2	8.31 ± 0.08	7.16 ± 1.0	0.98
	1999/2		7.73 ± 0.23		
	2000/1		6.26 ± 0.10		
	2000/2		6.37± 0.09		
Stipe	1999/1	No. 2	8.74 ± 0.27	7.29 ± 1.34	
	1999/2		8.13 ± 0.34		
	2000/1		5.97 ± 0.19		
	2000/2		6.34 ± 0.10		
Pileus (cap)	1999/1	No. 3	5.64 ± 0.22	5.63 ± 1.02	0.81
	1999/2		6.85 ± 0.16		
	2000/1		5.70 ± 0.15		
	2000/2		4.35 ± 0.18		
Stipe	1999/1	No. 3	7.47 ± 0.27	6.94 ± 2.23	
	1999/2		9.66 ± 0.21		
	2000/1		6.34 ± 0.11		
	2000/2		4.31 ± 0.18		

Table 2
Chitin contents of other varieties of cultivated *Agaricus bisporus*

Variety and part of fruit body	Chitin content (% DM) ± SD	Pileus chitin/ stipe chitin
Var. ‘158’, pileus (Exp. No. 1)	6.72 ± 0.23	0.87
Var. ‘158’, stipe (Exp. No. 1)	7.74 ± 0.16	
Var. ‘158’, pileus (Exp. No. 2)	7.23 ± 0.21	0.92
Var. ‘158’, stipe (Exp. No. 2)	7.84 ± 0.21	
Var. ‘K-7’, pileus	6.17 ± 0.13	
Var. ‘Sylvan A-15’ whole fruit body	8.68 ± 0.34	
Var. ‘Sylvan 608’	8.16 ± 0.21	
Var. ‘Le Lion C-9’	8.88 ± 0.14	
Var. ‘Le Lion C-9’ open	8.47 ± 0.28	

concentration indicates that the cell wall structure is practically independent of the varieties.

The average data of all pileus samples of *A. bisporus* are always lower than those of stipes (their rate: 0.91) but the difference is not significant. The calculated means of all data are: 6.67% DM (±1.04) and 7.31% DM (±1.43) for pileus and for stipes, respectively.

Table 3 contains the chitin concentration of *P. ostreatus* fruit bodies (and, for the sake of comparison, the results of six data groups from our earlier work (Vetter & Siller, 1991)). The averages of the data for *P. ostreatus* varieties are: 3.78% DM (±0.97) and 2.8% DM (±0.75) for pileus and for stipes, respectively. The difference of chitin levels of pileus and stipes is significant ($p < 0.05$); their ratio is (1.35). The same data for *L. edodes* (Table 4) show, that the pileus has a significantly higher amount of chitin (8.07% DM) than the stipes (6.55); their ratio is 1.20.

Our previous results on wild-growing mushroom species (Vetter & Siller, 1991) demonstrated the role of fungal nutrition type in the regulation of chitin level, i.e., the saprotrophic groups had a higher, and the wood-destroying one a significantly lower content. The consequences of the presented studies are similar: the cultivated saprotrophic *Agaricus* species had higher, and the wood-rotting *L. edodes*, and mainly the *P. ostreatus*, the lower levels. The

Table 3
Chitin concentration of different varieties of *Pleurous ostreatus*

Variety and part of fruit body	Chitin content (% DM) ± SD	Pileus chitin/ stipe chitin
Var. ‘G-32’, pileus[a]	3.31 ± 0.41	1.37
Var. ‘G-32’, stipe[a]	2.42 ± 0.40	
Var. ‘H-7’, pileus[a]	3.06 ± 0.44	1.30
Var. ‘H-7’, stipe[a]	2.36 ± 0.36	
Var. ‘G-24’, pileus[a]	2.93 ± 0.21	1.36
Var. ‘G-24’, stipe[a]	2.16 ± 0.37	
Var. ‘357’, pileus (Exp. No. 1)	5.05 ± 0.24	1.28
Var.‘357’, stipe (Exp. No. 1)	3.93 ± 0.19	
Var. ‘357’, pileus (Exp. No. 2)	4.87 ± 0.22	1.34
Var. ‘357’, stipe (Exp. No. 2)	3.63 ± 0.10	
Var. ‘357’, pileus (Exp. No. 3)	5.46 ± 0.17	1.43
Var. ‘357’ stipe (Exp. No. 3)	3.83 ± 0.16	
Var. unknown, pileus	3.87 ± 0.19	1.25
Var. unknown, stipe	3.09 ± 0.07	
Somycel ‘HK-35’ whole fruit body	4.77 ± 0.16	
Amycel ‘3015’, whole fruit body	4.95 ± 0.13	

[a] According to our earlier work (Vetter & Siller, 1991).

Table 4
Chitin contents of *Lentinula edodes* (shii take) varieties

Variety and part of fruit body	Chitin content (% DM) ± SD	Pileus chitin/ stipe chitin
Var. ‘ST-67’, stipe	8.07 ± 0.19	
Var. ‘ST-66’, pileus	6.55 ± 0.18	1.20
Var. ‘ST-66’, stipe	5.46 ± 0.17	
Var. unknown, whole fruit body	5.36 ± 0.23	

published data on chitin contents of our most important cultivated mushrooms were sporadic. Our present data are totally confirmed by the data of Manzi et al. (2001) for *A. bisporus* (whole fruit body) and for *P. ostreatus*.

The biological role of the TDF (glucan and of chitin) of mushrooms was recently evaluated. Five percent of chitin in the diet of Wistar rats (Zacour, Silva, Cecon, Bambirra, & Vieira, 1992) caused lower protein digestibility, but reduced levels of liver triacylglycerols and cholesterols and higher excretion of triglycerides in faeces. The cholesterol levels were significantly lower in other groups of Wistar rats (Mathew & Ramachandran-Nair, 1998) fed 0.5% chitin or partially hydrolysed chitin during 13 weeks.

Based on the experimental data the following conclusions were drawn:

1. Chitin content of the cultivated mushrooms is a characteristic of the species and seems to be independent of the cultivars (varieties).
2. Chitin level of the pileus (cap) is – in general – higher, than of stipes. These differences can be significant (for *A. bisporus*) or non-significant (for *P. ostreatus* and *L. edodes*).
3. The fruit bodies of the consecutive cultivation flushes (breaks) show a small decrease in chitin content of pileus or a practically constant level in stipes for the variety ‘K-23’ of *A. bisporus*.
4. The chitin level of the cultivated mushrooms – like the wild growing ones – is also regulated by nutrition type of the species.
5. The chitin of our cultivated mushrooms is not only a stable chemical component of the fungal cell wall, but has an important role in the nutritional value of mushrooms.

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