Contents of Vitamins, Mineral Elements, and Some Phenolic Compounds in Cultivated Mushrooms

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The aim of the study was to determine the contents of mineral elements (Ca, K, Mg, Na, P, Cu, Fe, Mn, Cd, Pb, and Se), vitamins (B_1, B_2, B_{12}, C, D, folates, and niacin), and certain phenolic compounds (flavonoids, lignans, and phenolic acids) in the cultivated mushrooms *Agaricus bisporus*/white, *Agaricus bisporus*/brown, *Lentinus edodes*, and *Pleurotus ostreatus.* Selenium, toxic heavy metals (Cd, Pb), and other mineral elements were analyzed by ETAAS, ICP−MS, and ICP methods, respectively; vitamins were detected by microbiological methods (folates, niacin, and vitamin B_{12}) or HPLC methods (other vitamins), and phenolic compounds were analyzed by HPLC (flavonoids) or GC−MS methods (lignans and phenolic acids). Cultivated mushrooms were found to be good sources of vitamin B_2, niacin, and folates, with contents varying in the ranges 1.8−5.1, 31−65, and 0.30−0.64 mg/100 g dry weight (dw), respectively. Compared with vegetables, mushrooms proved to be a good source of many mineral elements, e.g., the contents of K, P, Zn, and Cu varied in the ranges 26.7−47.3 g/kg, 8.7−13.9 g/kg, 47−92 mg/kg, and 5.2−35 mg/kg dw, respectively. *A. bisporus*/brown contained large amounts of Se (3.2 mg/kg dw) and the levels of Cd were quite high in *L. edodes* (1.2 mg/kg dw). No flavonoids or lignans were found in the mushrooms analyzed. In addition, the phenolic acid contents were very low.

Keywords: *Mushrooms; nutritional value; mineral elements; vitamins; flavonoids; lignans; phenolic acids*

INTRODUCTION

Mushrooms have been part of a normal human diet for thousands of years and, in recent times, amounts consumed have risen greatly, involving a larger number of species. In 1997, the annual world production of cultivated mushrooms was 6.34 million metric tons, compared with only 4.92 million metric tons in 1994 (*1*). In Finland, especially, people living in the countryside have been interested in mushroom cultivation as a secondary occupation along with agriculture, or after giving up animal husbandry, and many cowsheds have been rebuilt for mushroom growing (*2*). The 4 major cultivated mushrooms in Finland are 2 varieties of the button mushroom (*Agaricus bisporus*/white and *A. bisporus*/brown), shiitake (*Lentinus edodes*), and the oyster mushroom (*Pleurotus ostreatus*).

Because of increasing mushroom consumption, data on their nutritional value are needed. However, previously published data, especially those concerning vitamins, are dated because they were generated using methods that are now obsolete. In the case of mineral elements, the quality of the available information is better, but the data is still partly insufficient, e.g., information concerning mineral element contents of *A. bisporus*/brown and *L. edodes* is respectively missing or scant. Furthermore, few publications are available concerning the contents of flavonoids, lignans, and phenolic acids in *A. bisporus*; to our knowledge, there are no data on other cultivated mushrooms.

Contents of biologically active compounds may vary considerably in mushrooms. Biologically active compounds are affected by differences in strain, substrate, cultivation and fruiting conditions, the developmental stage of the mushroom, and the age of the fresh mushroom sample (*3*, *4*). In addition, the water contents of mushrooms naturally affect their nutrient contents when the results are calculated on a fresh weight (fw) basis. Water contents of mushrooms may vary depending on the cropping and watering conditions during cultivation (*5*). Furthermore, there is a significant difference in the nutrient contents of pileus versus stalks (*6*−*10*). Because of developments in cultivation techniques, which in turn affect the nutrient contents in mushrooms, new data are needed. The aim of the present study was to determine the contents of mineral elements, vitamins, and some phenolic compounds in the major mushroom cultivars in Finland.

MATERIALS AND METHODS

Samples. Samples of *P. ostreatus*, *A. bisporus*/brown, *A. bisporus*/white, and *L. edodes* were donated by major mushroom producers in Finland. Developmental stages of the sample mushrooms paralleled those of normal commercial products. Similarly, only pilei with very short stalks were taken as samples. Samples of each species (1.5 kg) were cut into 1-cm^3 cubes, mixed, packed into 300-ml plastic containers

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(50−70 g per container), freeze-dried, and stored at −18 °C. Acid-washed containers were used for those samples meant for mineral element analysis. Before every analysis the contents of 1−2 containers were homogenized. Analyses of mineral elements, phenolic compounds, thiamin, riboflavin, niacin, vitamin B_{12}, and folates were performed from the freeze-dried samples (phenolic acids and lignans were analyzed only from *A. bisporus*/brown, *A. bisporus*/white, and *L. edodes*). In the cases of vitamin D and vitamin C, determinations were performed from the homogenized fresh or frozen samples, respectively. All the nutrients were analyzed in duplicate or triplicate.

Vitamin D Analysis. The vitamin D_2 (ergocalciferol) contents of the samples were determined using modified methods (*11*, *12*). The fresh mushroom sample (10 g) was saponified (no internal standard was added), extracted with a mixture of petroleum and diethyl ether, and after evaporation was diluted in 2 mL of *n*-hexane. An aliquot of 500 μL of *n*-hexane extract was purified using isocratic normal-phase semipreparative HPLC (Perkin-Elmer series 200, Wellesley, MA). After semipreparative purification, the collected fraction was evaporated and dissolved in 150 μL of water/methanol (7:93, v/v). A 100-μL amount was then injected into the analytical reversed-phase HPLC system (Perkin-Elmer series 200). Final quantification was based on an external standard method with recovery corrections; recoveries were 80 ± 0.6%. The coefficient of variation of the triplicated made samples was <10%.

Thiamin and Riboflavin Analysis. The thiamin and riboflavin contents of the mushrooms were determined according to Hägg (*13*). This method employs the same extraction and sample preparation for both vitamins, but separate HPLC determinations. After acid and enzyme hydrolysis, thiamin was oxidized to thiochrome, and the oxidized fraction was purified and concentrated with solid-phase extraction (SPE). Thiochrome and riboflavin were analyzed separately, using a reversed-phase column and a fluorescence detector. Quantification was based on the external standard method. The method employed has been accredited, and the laboratory follows the standards SFS-EN 45001 and ISO Guide 25. The uncertainty of the thiamin and riboflavin methods was 10−15%.

Vitamin C Analysis. Vitamin C was determined according to Speek et al. (*14*) with minor modifications (*15*). In this method, total vitamin C is determined as dehydroascorbic acid. Ascorbic acid was oxidized enzymatically to dehydroascorbic acid using ascorbate oxidase. Then, dehydroascorbic acid was reacted with O-phenylenediamide giving a fluorescent derivative. Quantification of total vitamin C was performed with HPLC, using a fluorescence detector. The sample size was 10 g. The method employed has been accredited, and the laboratory follows the standards SFS-EN 45001 and ISO Guide 25. The uncertainty of the method was 10−15%.

Analysis of Folates. Milled samples (1−2 g) were extracted with 35 mL of extraction buffer (50 mmol Ches, 50 mmol Hepes, containing 2% ascorbate, and 10 mmol 2-mercaptoethanol, pH 7.85) under nitrogen. Capped tubes were placed in a boiling water bath for 10 min, cooled on ice, and homogenized for 30 s at 13500 rpm using an Ultra Turrax T25 homogenizer (IKA, Staufen). Trienzyme treatment was performed according to Pfeiffer et al. (*16*) with minor modifications. Samples were deconjugated at pH 4.9 with 2 mL of hog kidney conjugase prepared according to Gregory et al. (*17*). At the same time, 1 mL of α-amylase (20 mg/mL; EC 3.2.1.1, A-6211 Sigma, St. Louis, MO) was added, and the samples were incubated for 3 h at 37 °C. The pH was then brought to 7.0 with KOH and the samples were incubated with 2 mL of protease (2 mg/mL; EC 3.4.24.31, P-5147, Sigma) for 1 h at 37 °C. The samples were boiled for 10 min to inactivate the enzymes, cooled on ice, and filled to exact volume with extraction buffer. The samples were analyzed for total folates using a microbiological method on 96-well microtiter plates (tissue culture-treated; Costar Corporation, Cambridge, MA) using chloramphenicol-resistant, cryoprotected *Lactobacillus rhamnosus* (NCIB 10463) as described by Molloy and Scott (*18*). The optical density of the wells was measured with a microplate reader (iEMS Reader MF; Labsystems, Helsinki, Finland) at 595 nm after mixing for 10 s at 1150 rpm. The coefficient of variation of the triplicated made samples was <10%.

Niacin and Vitamin B_{12} Analysis. Niacin and vitamin B_{12} determinations were conducted by the National Food Administration (Box 622, 75126 Uppsala, Sweden). The mushroom samples were analyzed using *Lactobacillus plantarum* (ATCC 8014, niacin) and *Lactobacillus delbrueckii* (CCUG 19776, vitamin B_{12}).

Analysis for Flavonoids. Contents of myricetin, eriodictyol, quercetin, naringenin, luteolin, hesperetin, isorhamnetin, apigenin, rhamnetin, galangin, tangeretin, and kaempferol were determined using a method developed by Mattila et al. (*19*), a modification of the method of Hertog et al. (*20*). This method included acid hydrolysis and reversed-phase HPLC quantification using diode array detection.

Hydrolysis of catechins ((−)-epicatechin, (+)-catechin, (−)-epicatechin gallate, (−)-epigallocatechin, and (−)-epigallocatechin gallate)) was performed using milder conditions than those used for other flavonoids: 0.1 mol HCl was used instead of 6 mol HCl with hydrolysis for 16 h at room temperature. Catechins were quantified according to the method of Mattila et al. (*19*).

Phenolic Acids and Lignans Analyses. Contents of phenolic acids and lignans (*tr*-cinnamic acid, *p*-hydroxybenzoic acid, vanillinic acid, gentisic acid, *tr*-*o*-coumaric acid, protocatechuic acid, *tr*-*m*-coumaric acid, syringic acid, *tr*-*p*-coumaric acid, gallic acid, ferulic acid, caffeic acid, sinapic acid, nordihydroguaiaretic acid, anhydrosecoisolariciresinol, secoisolariciresinol, matairesinol, and chlorogenic acid) were determined using a method developed by Mazur et al. (*21*) in which base hydrolysis was employed (*22*). This method included enzymatic-, base-, and acid hydrolysis and gas chromatography−mass spectrometry selected ion monitoring (GC-MS SIM) quantification using an HP 1 column.

Mineral and Trace Elements Determinations. For determination of mineral elements (Ca, K, Mg, Na, and P), trace elements (Cu, Fe, Mn, and Zn), and toxic heavy metals (Cd and Pb), dried mushroom samples were digested in concentrated HNO_3. Then, toxic heavy metals were quantified by inductively coupled plasma mass spectrometry (ICP−MS, Perkin-Elmer Elan 6000), and the other elements were quantified by plasma atomic emission spectrometry (ICP−AES, Thermo Jarrel Ash IRIS Advantage).

Selenium was determined with 2 different electrothermal atomic absorption (ETAAS) methods. For the determination of low Se concentrations (<0.050 mg/kg) the dried samples were digested in a mixture of concentrated HNO_3, $HClO_4$, and H_2SO_4, reduced to Se(IV), chelated with ammonium pyrrolidine dithiocarbamate, extracted into methyl isobutyl ketone, and measured with AAS (Varian SpectrAA 400; *23*). Higher Se concentrations (> 0.050 mg/kg) were analyzed without solvent extraction (*24*). The samples were digested in concentrated HNO_3, and Se was measured using ETAAS with platinum as matrix modifier.

All the employed methods have been accredited and the laboratory follows the standards SFS-EN 45001 and ISO Guide 25. Uncertainty of the methods varied 5−17%, depending on the mineral element.

Moisture Analysis. To obtain moisture contents, samples of the mushrooms were weighed before and after freeze-drying. The residual moisture was determined by drying at 105 °C overnight.

RESULTS AND DISCUSSION

Vitamins. Cultivated mushrooms were good sources of several vitamins (Table 1), particularly riboflavin, niacin, and folates. However, vitamin contents were species dependent. The riboflavin contents in mushrooms were higher than those generally found in vegetables, and in *A. bisporus* varieties the contents were as high as those found in eggs and cheese. *L.*

Table 1. Vitamin Contents of Analyzed Cultivated Mushrooms (mg or μg/100 g)[a]

	mushroom							
	Agaricus bisporus/white		Agaricus bisporus/brown		Lentinus edodes		Pleurotus ostreatus	
vitamin	fw	dw	fw	dw	fw	dw	fw	dw
vitamin C, mg	1.3	17	1.6	21	2.1	25	1.6	20
vitamin B_1, mg	0.05	0.6	0.05	0.6	0.05	0.6	0.07	0.9
vitamin B_2, mg	0.39	5.1	0.33	4.2	0.15	1.8	0.20	2.5
folates, μg	35	450	46	590	25	300	51	640
niacin, mg	3.3	43	4.1	53	2.6	31	5.2	65
vitamin B_{12}, μg	0.06	0.8	0.05	0.6	0.07	0.8	0.05	0.6
vitamin D, μg	<0.02		<0.02		0.1	1	0.02	0.3
dry matter, %	7.7		7.8		8.4		8.0	

[a] fw, fresh weight; dw, dry weight.

edodes and *P. ostreatus* contained somewhat lower amounts of riboflavin than *A. bisporus* varieties. In *P. ostreatus*, our results were identical (2.5 mg/100 g dry weight (dw)) to those previously reported (2.27−8.97 mg/100 g dw) for *Pleurotus* (*3*, *25*−*28*). In addition, the results for *A. bisporus* (5.1 mg/100 g dw) agreed with previous reviews (3.7−5.0 mg/100 g dw). Conversely, the riboflavin result for *L. edodes* (1.8 mg/100 g dw) was somewhat higher than that obtained by Bano and Rajarathnam (*25*, *26*; 0.9 mg/100 g dw) and lower than reported in data compiled by Crisan and Sands (*27*) and Miles and Chang (*3*; 4.9 mg/100 g dw).

All the mushrooms analyzed were rich in niacin. *P. ostreatus* contained higher levels of niacin (65 mg/100 g dw) than other cultivars. The lowest levels were found in *L. edodes* (31 mg/100 g). Results obtained for niacin correlated with previous reports: *L. edodes* 11.9−98.5, *A. bisporus* 36.19−57.0, and *Pleurotus* mushrooms 33.75−108.7 mg/100 g dw (*25*−*27*, *29*).

Mushrooms contained moderately high amounts of folates and the contents were of the same magnitude as that generally found in vegetables. In addition, the bioavailability of mushroom folates appears to be as good as that for folic acid, unlike the bioavailability of folates from some vegetables, such as peas and spinach (*30*). The contents of folates were highest in *P. ostreatus* (640 μg/100 g dw) and *A. bisporus*/brown (590 μg/100 g dw), whereas the lowest levels were found in *L. edodes* (300 μg/100 g dw). Higher contents of folates have previously been reported in *P. ostreatus* (1222−1412 μg/100 g dw) and *A. bisporus* (933 μg/100 g dw, *25*, *26*). Walker (*31*), however, noted that variation in folate contents in *A. bisporus* can be high: from 20 to 135 μg/100 g fw.

In addition to riboflavin, niacin, and folates, cultivated mushrooms contained small amounts of vitamins C and B_1, as well as traces of vitamins B_{12} and D_2. The vitamin C contents in the mushrooms analyzed were similar, varying from 17 (*A. bisporus*/white) to 25 mg/100 g dw (*L. edodes*). According to published reviews, there is high variation in the vitamin C contents in mushrooms; e.g., *A. bisporus* has been reported to contain 1.44−8.6 mg/100 g fw of vitamin C (*32*, *33*). In addition, contradictory results have been received for *P. ostreatus* and *L. edodes*; according to some reviews they do not contain any vitamin C (*27*) but according to others, the contents are rather high (*Pleurotus*, 36.4−144 mg/100 g dw and *L. edodes*, 40.4−59.9 mg/100 g dw; *25*, *26*, *34*).

The contents of thiamin were quite low in the mushrooms analyzed and did not vary much (0.6−0.9 mg/100 g dw). These levels, however, were of the same magnitude as those generally found in vegetables. Only traces of vitamin B_{12} were found in the mushrooms studied (0.6−0.8 μg/100 g dw). The vitamin B_{12} in mushrooms probably derives from surface microorganisms. There have been sporadic reports of B_{12} in mushrooms, with both trace and high levels (0−140 μg/100 g fw; *35*).

In addition to vitamin B_{12}, vitamin D was also almost absent in the mushrooms analyzed. Cultivation, and especially illumination, affects vitamin D_2 contents in mushrooms because most fungi produce ergosterol, a precursor to vitamin D_2, under sunlight or UV irradiation. According to Mattila et al. (*12*), wild mushrooms contained much higher amounts of vitamin D_2 (2.91−29.82 μg/100 g fw) than dark-cultivated *A. bisporus* (0.21 μg/100 g fw). In addition, *L. edodes* cultivated under natural climatic conditions contained high amounts of vitamin D_2 ranging from 22 to 110 μg/100 g dw (*36*T).

Mineral and Trace Elements. As compared with vegetables, mushrooms proved to be good sources of many mineral elements (Table 2). The bioavailability of the mineral and trace elements from mushrooms is, however, questionable. It is evident from Table 2 that K and P are the main constituents in the ash. The contents of K were especially high in comparison to Na, which is considered to be an advantage from the nutritional point of view. The contents of K and P were lower in *L. edodes* than in other mushrooms, and the Na contents were higher in *Agaricus* varieties than in *L. Edodes* and *P. ostreatus*. These findings were generally in accordance with original findings by Shah et al. (*37*), Verma et al. (*38*), and Vetter (*8*, *9*, *39*), as well as data compiled by Bano and Rajarathnam (*26*), Beelman and Edwards (*32*), Crisan and Sands (*27*), and Kurzman (*33*). The Na contents were, however, lower in the present study than in previous studies.

Calcium was not significantly present in the mushrooms analyzed. However, *Agaricus* varieties, especially *A. bisporus*/white, contained higher amounts of it than other species. According to Kurzman (*33*) ordinary *Agaricus* compost contains large quantities of Ca, hence, it was no surprise that analysis of *Agaricus* showed higher amounts of Ca than other mushroom species. It is, however, rather surprising that the levels of Ca remained quite low. The Ca levels obtained in the present study were generally lower than those obtained previously. However, large variation in the Ca contents has been reported. For example, results of 0.05−0.066 g/kg fw (*32*), 0.015−0.093 g/kg fw (*33*), 0.23−4.36 g/kg dw (*27*), 15.2 g/kg dw (*38*), and 2.83 g/kg dw (*39*) were obtained for *A. bisporus*.

Magnesium represented the third major mineral element (after K and P) found in fungal fruiting bodies. Mg levels were similar in all the mushrooms analyzed, and were of levels similar to those generally found in

Table 2. Mineral Contents of Analyzed Cultivated Mushrooms (g, mg, or μg/kg)[a]

	mushroom							
	Agaricus bisporus/white		Agaricus bisporus/brown		Pleurotus ostreatus		Lentinus edodes	
	fw	dw	fw	dw	fw	dw	fw	dw
Ca, g	0.019	0.25	0.01	0.13	0.001	0.01	0.004	0.05
K, g	3.64	47.3	3.59	46.0	2.98	37.3	2.24	26.7
Mg, g	0.10	1.30	0.11	1.41	0.16	2.0	0.13	1.55
P, g	0.980	12.7	1.01	12.9	1.11	13.9	0.73	8.7
Na, g	0.032	0.42	0.034	0.44	0.01	0.13	0.011	0.13
Cu, mg	2.2	29	2.7	35	0.67	8.4	0.44	5.2
Fe, mg	3.7	48	2.2	28	4.3	54	2.8	33
Mn, mg	0.42	5.5	0.40	5.1	0.89	11	1.74	21
Zn, mg	5.1	66	3.7	47	6.6	83	7.7	92
Se, ug	110	1400	250	3200	12	150	3.3	39
Pb, μg	14	180	2.7	35	1.6	20	3.1	37
Cd, μg	2.8	36	7.5	96	30	380	100	1200
dry matter	7.7		7.8		8.0		8.4	

[a] fw, fresh weight; dw, dry weight.

Table 3. Contents of Phenolic Acids in *A. Bisporus* (white), *A. Bisporus* (brown), and *L. Edodes* (μg/100 g)

	mushroom					
	Agaricus bisporus/white		Agaricus bisporus/brown		Lentinus edodes	
phenolic acid	fresh weight	dry weight	fresh weight	dry weight	fresh weight	dry weight
tr-cinnamic acid	20.7	269	11.5	147	13.4	160
p-hydroxy-benzoic acid	3.9	51	50.3	645	66.4	790
protocatechuic acid	<2.3	<30	8.3	106	11.7	139
caffeic acid	6.3	82	5.5	71	<4.2	<50
dry matter/%	7.7		7.8		8.4	

vegetables. The Mg contents obtained in this study were generally in accordance with previous publications (*8*, *9*, *26*, *39*, *40*, *45*, *47*).

As in vegetables, Fe was present in low concentrations in all the mushrooms. In addition, the bioavailability of Fe from mushrooms is questionable because, according to the data compiled by Bano and Rajarathnam (*26*), contradictory results have been obtained. Previous data concerning Fe vary widely: e.g., *A. bisporus* has been reported to contain levels of this element in the range of 2−1280 mg/kg dw (*27*).

The mushrooms investigated were quite good sources of Zn and Cu, whereas Mn contents were low. In all the mushrooms, Zn was found to be the major trace element, but the levels of this element were higher in *P. ostreatus* and *L. edodes* than in *Agaricus* varieties. On the other hand, Cu contents were clearly higher in *Agaricus* varieties than in the other mushrooms analyzed. According to previously published data, *A. bisporus* also contains higher contents of Cu than *L. edodes* and *Pleurotus spp* (*8*, *9*, *26*, *38*, *39*). The levels of Zn and Mn paralleled previous data (*8*, *9*, *26*, *39*).

Perhaps the most important question regarding minor elements concerns the amounts of the toxic trace elements, Cd and Pb, whose dietary excess may be injurious to health. If mushrooms are produced in substrates in which these elements are present, accumulation may occur. The Cd contents in the mushrooms studied varied widely according to the species, and especially *L. edodes* proved to be the most efficient Cd accumulator. The contents of this element in *L. edodes* attained the national limit set for Cd in vegetables (0.1 mg/kg). FAO/WHO has defined the limit for weekly intake of Cd to be 7 μg/kg body weight (*48*), hence, a person whose weight is 60 kg should not eat more than 4.2 kg of *L. edodes* fruiting bodies per week. This amount is quite large, however, and thus overdosing is virtually improbable. The Pb contents of all the mushrooms studied were quite low; the Cd and Pb levels in the mushrooms analyzed were generally the same as or lower than those found earlier (*8*, *9*, *26*, *39*, *40*−*46*).

The selenium contents in *Agaricus* varieties were extremely high (brown, 3.2; white, 1.4 mg/kg dw), whereas *P. ostreatus* contained about 20 times less and *L. edodes* 80 times less than the richer *Agaricus* variety. Recommended daily allowances for women and men are 55 and 70 μg, respectively (*49*), hence, eating 100 g of *A. bisporus*/brown will fulfill 46−58% of the recommended amount. However, according to Mutanen (*50*), using the criteria of plasma Se level or plasma and platelet GSH−Px activity, the bioavailability of mushroom Se is reasonably low. The Se levels obtained in the present study were generally in accordance with the values reported by Piepponen et al. (*51*) for *A. bisporus* and *L. edodes* (0.45−1.2 and 0.02 mg/kg dw, respectively). Haldimann et al. (*43*) also obtained higher Se results for *A. bisporus* (1.3−5.7 mg/kg dw) than for *L. edodes* (0.54−0.93 mg/kg dw) and *P. ostreatus* (0.35−1.05 mg/kg dw). The Se levels obtained for the last 2 mushroom species were, however, higher than those obtained in the present study.

Phenolic Compounds. Phenolic compounds were absent or their levels were very low in the mushrooms analyzed. The contents of flavonoids and lignans determined were under their limits of detection (0.08−5 and 0.1 mg/100 g dw, respectively). On the other hand, mushrooms contained low amounts of some phenolic acids (Table 3), whereas the contents of the other compounds were under the limit of detection (10−200 μg/100 g dw, depending on the compound). *A. bisporus*/white contained lower levels of phenolic acids than the other mushrooms analyzed. With regard to *A. bisporus*, the results of Herrman (*52*) and Hertog et al. (*20*) were very similar to ours; according to these studies *A. bisporus* did not contain any phenolic acids or flavonoids. To our knowledge, there is no previous information available concerning lignans in mushrooms or

concerning flavonoids, lignans, and phenolic acids in cultivated mushrooms, other than *A. bisporus*.

CONCLUSION

Cultivated mushrooms were a good source of vitamin B_2, niacin, and folates. As compared with vegetables, mushrooms also proved to be good sources of many mineral elements, e.g., the contents of K, P, Zn, and Cu were considerable. In addition, *A. bisporus*/brown contained large amounts of Se, and the levels of Cd were quite high in *L. edodes*. No flavonoids or lignans were found in the mushrooms analyzed, and the contents of phenolic acids were very low.

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