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Lodenius, M.

Finnish Zoological and Botanical Publishing Board
1981

Lodenius, M. et al. 1981. Lead, cadmium and mercury contents of Fungi in Mikkeli, SE Finland. Annales Botanici Fennici 18: 183-186.

http://hdl.handle.net/1975/289

Ann. Bot. Fennici 18: 183—186, 1981

Lead, cadmium and mercury contents of fungi in Mikkeli, SE Finland

MARTIN LODENIUS, TAINA KUUSI, KARI LAAKSOVIRTA, HELENA LIUKKONEN-LILJA and SULO PIEPPONEN

Lodenius, M., Kuusi, T., Laaksovirta, K., Liukkonen-Lilja, H. & Piepponen, S. 1981: Lead, cadmium and mercury contents of fungi in Mikkeli, SE Finland. — Ann. Bot. Fennici 18: 183-186. Helsinki ISSN 0003-3847.

Lead, cadmium and mercury contents of 59 samples of fruit-bodies of fungi (Agaricales) collected in a small town, Mikkeli, in southeast Finland were determined. The dry wt concentrations ranged <0.5-16 mg Pb/kg, <0.2-130 mg Cd/kg, <0.02-64 mg Hg/kg and were generally at the same level as reported earlier for unpolluted areas. High contents of cadmium (mean 32 mg/kg) and mercury (mean 11 mg/kg) were observed in *Agaricus* fungi. The mean lead content of *Agaricus* fungi was lower: 5.1 mg/kg. The uptake of cadmium and mercury in fungi is highly species-dependent. As it is very difficult to identify the species of this genus, the use of wild-growing *Agaricus* fungi for food should be limited. No correlation was found between the concentrations of these three metals.

Key words: heavy metals, fungi, alimentary hygiene, Finland.

M. Lodenius, Department of Environmental Science, University of Helsinki, SF-00710 Helsinki 71, Finland; T. Kuusi, H. Liukkonen-Lilja and S. Piepponen, Technical Research Centre of Finland, Food Research Laboratory, SF-02150 Espoo 15, Finland; K. Laaksovirta, Department of General Botany, University of Helsinki, SF-00710 Helsinki 71, Finland.

Edible fungi may contain high amounts of heavy metals such as lead, cadmium and mercury as compared with plants (cf. Varo et al. 1980). The highest contents of cadmium and mercury have been observed in lawn decomposer species belonging to Agaricaceae, Coprinaceae and Lycoperdaceae and in mycorrhizal fungi belonging to Boletaceae (Pallotti et al. 1976, Quinche 1976, Seeger 1976, Collet 1977, Meisch et al. 1977, Lorentz et al. 1978, Laaksovirta & Lodenius 1979). The cadmium content of some *Agaricus* species belonging to the section *Flavescentes* may be very high even if the cadmium content in the substrate is low (Stijve & Besson 1976, Laub et al. 1977, Seeger 1978, Mowitz 1980).

Lead is more uniformly distributed among different species than cadmium and mercury (Leh 1974, Seeger et al. 1976). The lead content may be affected by pollution from automobile exhausts (Laaksovirta & Alakuijala 1978) or other sources. As many of the species containing high amounts of heavy metals are popular edible fungi, it is important to study their contents of harmful elements and compounds. This study is part of a more extensive investigation, in which the heavy metal contents of fungi growing in different environments in Finland are determined.

MATERIAL AND METHODS

Fifty-nine samples of fungi belonging to different species were collected in September, 1979, from Mikkeli, a small town (population 28 000) in southeast Finland (Fig. 1). The only industry emitting substantial amounts of heavy metals is a zinc galvanization plant 3 km W of the centre.

The *Agaricus* samples were not determined to the species, but only divided into the sections *Flavescentes* and *Rubescentes*. From the small species several fruit-bodies growing close to each other were collected to one sample. From bigger species the cap and the stalk or part of them were used for element assays. Loose particles of

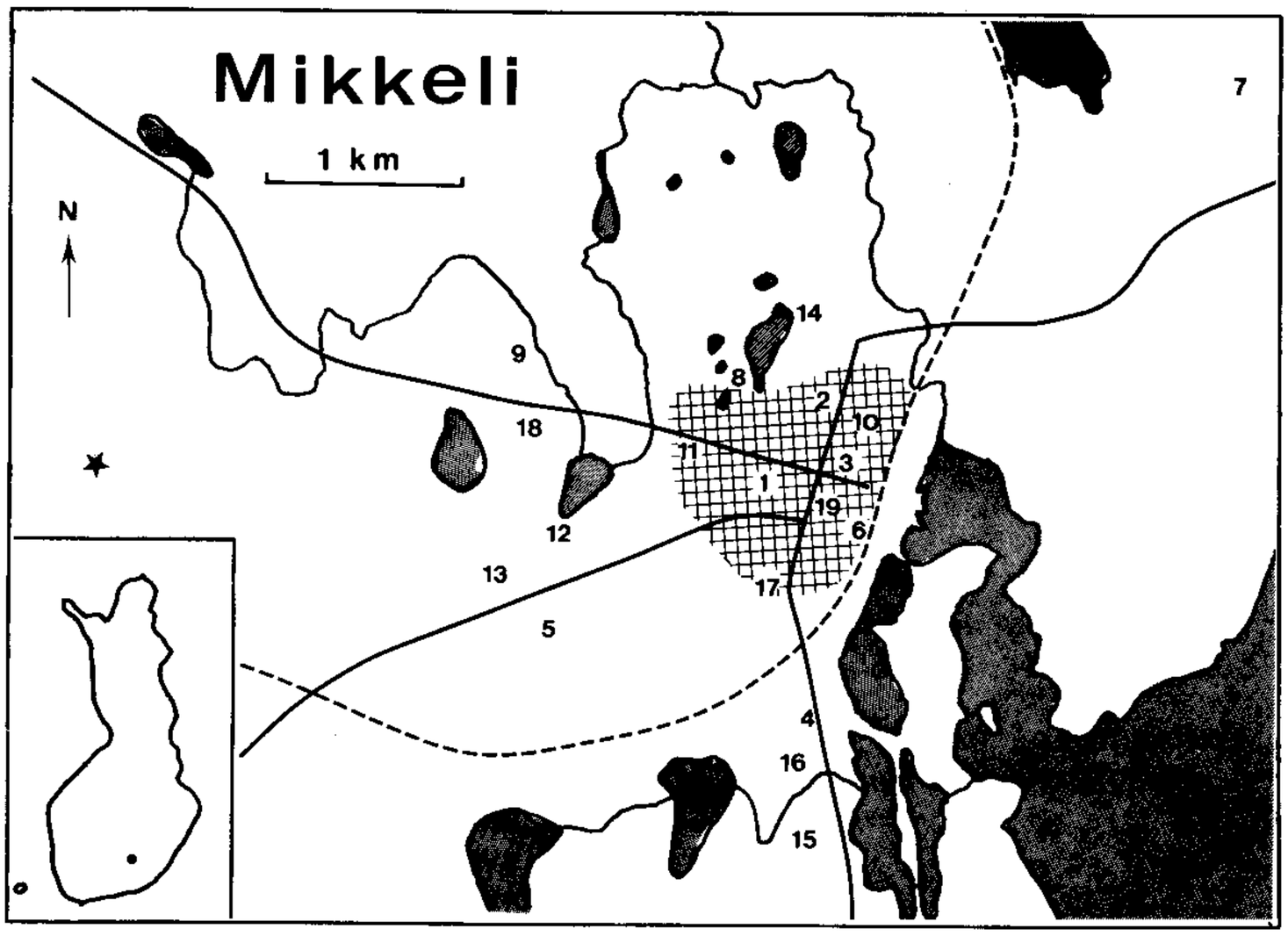

Fig. 1. The study area and the sampling sites (figures) in Mikkeli. Main roads (solid lines), railway (broken line), the zinc-galvanization plant (asterisk) and the centre of the town (checked) are marked.

rubbish and the mouldy base of the stalk were removed, but the samples were not washed. They were dried at 50° C for 24 hours, and homogenized before analysis. Almost all samples were run in duplicate.

For lead and cadmium analysis about 0.5 g of the sample was digested by an SLP-INFERNO aluminium hot block with sulphuric and nitric acids followed by hydrogen peroxide. The digestion residue was transferred into a beaker and the pH was adjusted to 2—3 with ammonium hydroxide. The solution was extracted twice with 10 ml of APDC/$CHCl_3$ (0.1 % ammonium pyrrolidine dithiocarbamate in chloroform). The chloroform solutions were evaporated and digested with 2 ml of nitric acid and the residue was dissolved into 5 ml of 0.5 M hydrochloric acid. The lead and cadmium concentrations were measured with a Perkin-Elmer 603 atomic absorbtion spectrometer using an air acetylene flame.

For mercury analysis the samples were digested with 10 ml of sulphuric and nitric acids (4:1) in a 60° C water bath for 4 hours. The mercury contents were measured using cold vapour atomic absorption spectrometry (Coleman MAS-50).

RESULTS AND DISCUSSION

The lead and mercury contents were about 6 times higher in lawn decomposing fungi than in mycorrhizal ones (Table 1). However, for cadmium the difference between these two groups of fungi was almost 25-fold due to the high cadmium content of the *Agaricus* samples.

In the *Agaricus* samples collected in Mikkeli the heavy metal contents were at the same level as reported in the literature (Quinche 1976, Seeger et al. 1976, Seeger & Nützel 1977, Alsen et al. 1977, Collet 1977, Meisch et al. 1977, Laaksovirta & Lodenius 1979). There was no difference in the lead and mercury contents between the sections *Flavescentes* and *Rubescentes*. However, a considerable difference in the cadmium contents could be noticed: mean 52 (range 4—130) mg/kg in the section *Flavescentes* and 7.3 (<0.2-27) mg/kg in the section *Rubescentes*. Even for all *Agaricus* samples the mean was very high: 32 mg/kg. As high cadmium concentrations were found only in the *Agaricus* samples they are probably not caused by pollution but by species-dependent factors. Tyler (1980) also found no correlation between the cadmium contents of fungi and that of the soil or substrate. The cadmium contents in the genus *Agaricus* are reported to be highly species-dependent (Laub et al. 1977, Mowitz 1980) and very high concentrations (max. 170 mg/kg) have been found in *A. silvicola* (Vitt.) Sacc. and *A. macrosporus* (Møll. & Schaeff.) Pilat, which belong to the section *Flavescentes* (Meisch et al. 1977).

Quinche (1980) found a very significant positive correlation between the contents of lead and cadmium in *Agaricus campester* Fr., but in this investigation we found no correlation between contents of the three metals in our *Agaricus* samples: $r_{Pb/Cd} = 0.09$, $r_{Pb/Hg} = 0.14$, $r_{Cd/Hg} = -0.02$.

The heavy metal contents of the other lawn

Table 1. The lead, cadmium and mercury content in mg/kg dry weight of fungi in Mikkeli

	Collection site*	Pb	Cd	Hg
Lawn decomposer fungi				
Lyophyllum connatum (Fr.) Sing.	*9*	0.5	0.2	0.86
»	*13*	<0.5	<0.2	5.6
»	*8*	1.6	1.1	1.4
Marasmius oreades (Fr.) Fr.	*1*	4.7	1.3	4.1
»	*3*			4.6
»	*10*			1.7
»	*11*	5.0	1.0	1.1
»	*12*	2.7	0.6	1.6
»	*13*	5.0		3.7
»	*6*	1.1	1.6	0.98
»	*14*	10	1.5	2.6
»	*15*			3.3
»	*5*			7.3
»	*11*			2.1
»	*16*	15	1.1	1.5
mean		**6.21**	**1.18**	**2.88**
Agaricus sp.	*1*		1.3	64
»	*6*	2.1	22	4.1
»	*9*	1.2	0.8	0.12
Agaricus sp. (sectio *Flavescentes*)	*2*	7.0	36	2.5
»	*1*	8.2	52	7.8
»	*1*	1.3	51	10
»	*1*	5.7	55	7.0
»	*1*	1.7	62	4.8
»	*4*	5.5	57	7.9
»	*5*	7.3	130	19
»	*7*	4.5	18	1.5
»	*8*	9.3	4	4.1
Agaricus sp. (sectio *Rubescentes*)	*1*		<0.2	7.7
»	*1*	4.8	27	11
»	*3*	10	1.4	7.6
»	*4*	2.2	0.8	13
mean for all *Agarius* samples		**5.06**	**32.4**	**10.8**
Coprinus comatus (Fr.) S. F. Gray	*7*	0.9	1.0	3.6
»	*17*	1.6	1.6	1.4
»	*6*	1.3	4.9	2.7
»	*9*	0.8	0.9	1.6
»	*8*	12	4.2	4.4
»	*3*	1.9	3.5	3.0
»	*5*	2.5	2.4	10
mean		**3.00**	**2.64**	**3.81**

	Collection site*	Pb	Cd	Hg
Wood decomposer fungi				
Armillariella mellea (Fr.) Karst.	*3*	1.2	1.4	0.52
»	*19*	1.2	5.4	1.6
Mycorrhizal fungi				
Coprinus atramentarius (Fr.) Fr.	*3*	<0.5	0.6	0.15
Russula paludosa Britz.	*2*	<0.5	0.6	0.08
»	*15*	<0.5	0.7	0.02
Russula sp.	*9*	0.8	0.7	<0.02
»	*18*	<0.5	0.7	<0.02
Lactarius necator (Fr.) Karst.	*15*	1.9	0.3	0.10
»	*5*	2.8	0.6	1.5
»	*9*	<0.5	0.7	0.02
»	*18*	0.7	0.6	0.02
Amanita muscaria (Fr.) Hook.	*5*			0.88
»	*11*			1.3
»	*2*			0.93
»	*8*			12
»	*5*			0.96
A. rubescens (Fr.) S. F. Gray	*18*			0.64
Leccinum scabrum (Fr.) S. F. Gray	*3*	0.9	1.4	0.45
Paxillus involutus (Fr.) Fr.	*12*			0.03
»	*3*			0.07

*The numbers refer to Fig. 1.

decomposer fungi were usually lower than those of the *Agaricus* samples, but considerably higher than in the mycorrhizal fungi. In the mycorrhizal species the heavy metal contents were generally at the level reported for unpolluted areas. However, high mercury contents were found in one

sample of *Amanita muscaria* (12 mg/kg) and in one sample of *Lactarius necator* (1.5 mg/kg), both collected in the centre of Mikkeli. In a sample of the wood decomposer species, *Armillariella mellea*, collected from a tree growing near the bus station, quite high concentrations of cadmium (5.4 mg/kg) and mercury (1.6 mg/kg) were found. No significant difference between the centre and the suburbs was observed, nor could any clear influence of the zinc-galvanization plant or the traffic be detected.

According to Finnish norms (Elinkeinohallitus 1979), the contents of mercury and lead should not exceed 0.8 and 0.1 mg/kg fresh weight respectively. In accordance with our dry weight determinations, these values correspond to 9.1 and 11 mg/kg dry weight. Seven of our samples exceeded the safety limit for mercury and two for that of lead. According to the FAO/WHO (1976) recommendations, adults should not consume more than 0.5 mg cadmium per week. This would allow about 50 g of a fresh fungus containing 11 mg Cd/kg (130 mg/kg dry wt) to be eaten, provided there is no other source of cadmium.

In general, the heavy metal contents of the fungi in Mikkeli were quite low. However, in relation to the norms, many of the *Agaricus* samples contained too much cadmium and mercury. Although the resorption of cadmium from fungi may be rather low (Schellmann et al. 1980) the gathering of wild-growing *Agaricus* fungi for food should be limited because of their high heavy metal content.

ACKNOWLEDGEMENTS

This investigation was supported by the Finnish Board of Trade and Consumer Interests and the Academy of Finland.

REFERENCES

Alsen, C., Braatz, G. & Kruse, H. 1977: Schwermetallgehalt in essbaren Pilzen. Zink, Cadmium, Quecksilber und Blei. — Öff. Gesundh.-Wesen 39: 780—789.

Collet, P. 1977: Die Bestimmung von Schwermetallspuren in Lebensmitteln mit Hilfe der Inverspolarographie. II Über den Gehalt von Blei, Cadmium und Kupfer in Speisepilzen. — Deutsche Lebensm. Rundschau 73: 75—82.

Elinkeinohallitus 1979: Elintarvikkeiden sisältämät vieraat aineet (National Board of Trade and Consumer Interests: Contaminants in foods). — Päärös (Decision) 3050/51/79. Helsinki.

FAO/WHO 1976: List of maximum levels recommended for contaminants by the Joint FAO/WHO Codex Alimentarius Commission. Second Series. — CAC/FAL 3, 1976: 1—8. Rome.

Laaksovirta, K. & Alakuijala, P. 1978: Lead, cadmium and zinc contents of fungi in the parks of Helsinki. — Ann. Bot. Fennici 15: 253—257.

Laaksovirta, K. & Lodenius, M. 1979: Mercury content of fungi in Helsinki. — Ann. Bot. Fennici 16: 208—212.

Laub, E., Waligorski, F. & Woller, R. 1977: Über die Cadmiumanreicherung in Champignons. — Z. Lebensm. Unters.-Forsch. 164:267—271.

Leh, H.-O. 1975: Bleigehalte in Pilzen. — Z. Lebensm. Unters.-Forsch. 157: 141—142.

Lorenz, H., Kossen, M.-T. & Käferstein, F. 1978: Blei-, Cadmium-, und Quecksilbergehalte in Speisepilzen. — Bundesgesundheitsblatt 21: 202—204.

Meisch, H.-U., Schmitt, A. & Reinle, W. 1977: Schwermetalle in höheren Pilzen. Cadmium, Zink und Kupfer. — Z. Naturforsch. 32(c): 172—181.

Mowitz, J. 1980: Höga halter kadmium i vildväxande, svenska champinjoner. — Vår Föda 32: 270—278.

Pallotti, G., Bencivenga, B. & Vegliante, A. 1976: Contenuto in mercurio totale di funghi selvatici e coltivati. — Industrie Alimentari Dic. 1976.

Quinche, J.-P. 1976: La pollution mercurielle de diverses espèces de champignons. — Rev. Suisse Agric. 8: 143—148.

-»- 1980: Teneurs en quelques éléments traces de l'Agaricus campester. — Bull. Romand Mycol. 2: 20.

Seeger, R. 1976: Quecksilbergehalt der Pilze. — Z. Lebensm. Unters.-Forsch. 160: 303—312.

-»- 1978: Cadmium in Pilzen. — Z. Lebensm. Unters.-Forsch. 166: 23—24.

Seeger, R., Meyer, E. Schönhut, S. 1976: Blei in Pilzen. — Z. Lebensm. Unters.-Forsch. 162: 7—10.

Seeger, R., & Nützel, R. 1977: Quecksilber in jungen und alten Pilzen und in Pilzsporen. — Deutsche Lebensm. Rundschau 73: 160—162.

Schellmann, B., Hilz, M.-J. & Opitz, O. 1980: Cadmium- und Kupferausscheidung nach aufnahme von Champignon-Mahlzeiten. — Z. Lebensm. Unters.-Forsch. 171: 189—192.

Stijve, T. & Besson, R. 1976: Mercury, cadmium, lead and selenium content of mushroom species belonging to the genus Agaricus. — Chemosphere 51: 151—158.

Tyler, G. 1980: Metals in sporophores of Basiodiomycetes. — Trans. Br. mycol. Soc. 74: 41—49.

Varo, P., Lähelmä, O., Nuurtamo, M., Saari, E. & Koivistoinen, P. 1980: Mineral element composition of Finnish foods. VII. Potato, vegetables, fruits, berries, nuts and mushrooms. — Acta. agr. Scand. suppl. 22: 89—113.

Received 9.III.1981