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Mercury Content in Mushroom Species in the Cordova Area

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Numerous investigations have established that fish is the food which shows the highest levels of mercury, thus being the most hazardous for humans. Recently much research has been carried out in several places of Europe on the high capacity of mushrooms to accumulate heavy metals. Stegnar et al. (1973) have reported the selective absorption and accumulation of mercury by mushrooms in an area of Yugoslavia contaminated by industrial wastes. These findings have been confirmed and enlarged on by later investigations (Stijve and Roschnik 1974; Stijve and Cardinale 1974; Pallotti et al. 1976; Quinche et al. 1976; Stijve and Besson 1976; Lodenius et al. 1981; Kuusi et al. 1981; Liukkonen-Lilja et al. 1983).

It has been noticed that the various species differ in their tendency to accumulate heavy metals. However, industry and road traffic may increase the amounts (Liukkonen-Lilja et al. 1983). Two genera in which mercury accumulation was very marked are Agaricus and Lycoperdon . High mercury-accumulating abilities are thus demonstrated in these fungi. It is suggested that members of the genus Agaricus could be used as indicator organisms in the study of mercury pollution (Stijve and Roschnik 1974).

The object of the present paper is to provide data on the levels of mercury contents in mushroom species collected in the Cordova area (Spain).

MATERIALS AND METHODS

A total of 124 mushroom samples were collected in the Sierra of Cordova. The bulk of the samples were collected in autumn 1.984; they were divided into two anatomicals groups: group 1 of caps and group 2 of stems. Each sample was dried overnight at 80ºC. For mercury analysis, about 0.5 g of the dried and homogenized samples was digested in closed vessels with sulphuric and nitric acids (4/1) at 60ºC (Kuusi et al. 1.981), and was oxidized with 6% w/v potassium permanganate solution. Excess permanganate was reduced with a sodium chloride-hidroxylamine sulphate solution (Hatch and Ott 1.968).

Table 1. Mercury concentrations (mg/kg) in mushroom cap samples at dry weight.

Species	n	moisture %	min.	max.	$\bar{X} \pm$ S.D.
Volvaria speciosa	14	93.24	0.209	1.509	0.538 ± 0.297
Psalliota bispora	23	92.14	0.045	0.682	0.262 ± 0.190
Psalliota compestris	25	90.16	3.182	50.909	12.323 ± 9.498
Lactarius deliciosus	13	89.30	0.182	1.754	0.591 ± 0.379
Lepiota procera	10	91.59	0.328	2.709	1.488 ± 0.675
Lepista nuda	14	91.85	1.455	9.454	4.355 ± 0.266
Amanita phalloides	10	93.07	0.773	1.482	0.926 ± 0.232
Amanita vaginata	5	89.09	0.163	1.336	0.456 ± 0.442
Boletus granulatus	10	94.62	0.145	0.673	0.334 ± 0.172
	124	90.54	0.045	50.909	1.693 ± 4.818

Table 2. Mercury concentrations (mg/kg) in mushroom stem samples at dry weight.

Species	n	moisture %	min.	max.	$\bar{X} \pm$ S.D.
Volvaria speciosa	14	94.59	0.218	0.945	0.450 ± 0.168
Psalliota bispora	23	89.77	0.036	0.509	0.202 ± 0.130
Psalliota compestris	25	92.06	3.963	49.090	9.828 ± 8.692
Lactarius deliciosus	13	88.66	0.190	1.540	0.555 ± 0.328
Lepiota procera	10	91.93	0.281	2.991	1.011 ± 0.725
Lepista nuda	14	93.22	1.146	4.865	2.550 ± 1.008
Amanita phalloides	10	95.27	0.309	0.764	0.506 ± 0.115
Amanita vaginata	5	91.92	0.109	0.673	0.287 ± 0.202
Boletus granulatus	10	93.00	0.045	0.500	0.177 ± 0.135
	124	91.14	0.036	49.090	1.282 ± 4.031

The determinations were carried out on a Perkin-Elmer Model 2380 atomic-absorption spectrophotometer equipped with a mercury hollow cathode lamp, operated at 253.7 nm and a Perkin-Elmer MHS-10 accessory for hydride generation, using 3% v/v NaOH and 1% w/v sodium borohydride mixture as the reducing agent.

The detection limit (3 SD) was 3.6 ng or 0.36 ug/kg for a 10 mL aliquot (relative detection limit) and the recovery was 96.4% at 100-200 ng levels and 98.7% at 4500-4600 ng levels (Psalliota campestris). The calibration graphs have a high degree of linearity from 0 to 300 ng of mercury and sensitivity was 2.3 ng or 0.23 ug/kg for a 10 mL aliquot (relative sensitivity).

RESULTS AND DISCUSSION

The mercury content in the samples of mushrooms analyzed is presented in Tables 1 and 2. The results obtained show that the mercury content differs according to the species and to the anatomical group examined. A two-factor analysis of variance was performed to determine the level of significance of the resulting difference between species and between anatomical groups. The results are presented in Table 3 and show that differences in mercury concentrations at dry weight between species were significant at the 0.001 % level ($F = 29.133$). On the contrary, the differences in mercury concentration at dry weight between anatomical groups does not greatly differ.

Table 3. Two-factor analysis of variance to determine the significant differences between species and between anatomical groups (mercury in mg/kg at dry weight).

Source of variance	Degrees of freedom	Variance or F ratio
Subgroups	17	
species	8	29.133***
anatomical groups	1	2.261 (n.s.)
interaction	8	0.409 (n.s.)
Error	230	
Total	247	

*** $P \leq 0.001$; n.s. = do not differ significantly.

Individual statistical evaluation of the results for species was made with Student's t-test and only showed that differences in mercury concentration between anatomical groups were significant at the 0.001% level in Amanita phalloides ($t = 4.866$) and Lepista nuda ($t = 6.242$).

The samples of Psalliota campestris showed maximun levels and samples of Boletus granulatus and cultivated Psalliota bispora were those with the lowest mercury content. The concentration obtained in the caps is 1.3 times higher than that obtained in the stems. This proportion is slightly lower than that reported by Quinche et al. (1976) and Seeger (1976).

As is shown in Tables 1 and 2, the highest content are found in the samples of P.campestris coinciding with the findings of Stijve and Roschnik (1974), Quinche et al. (1976), Sitve and Besson (1976), Lodenius et al. (1981) and Kuusi et al. (1981), that this species has the greatest ability to accumulate mercury in both cap and stem. Stijve and Roschnik (1974) suggest that P.campestris could be used as an indicator of mercury pollution since this species largely grows in areas affected by human activity and is usually found from November until May.

In contrast to the high content of mercury in P.campestris is the cultivated P.bispora whose mercury content is the lowest found in the present study (Tables 1 and 2). The concentrations obtained from the samples of this species were even lower than those reported by Stijve and Besson (1976).

According to Vigne and Gounelle de Pontanel (1978) the low content of mercury in the cultivated P.bispora is accounted for by the fact that the duration of the mycelium life of the mushroom is seldom longer than 12 weeks, at the end of which time the mycelium is renewed to assure a better harvest.

Although some species of edible mushrooms show a high mercury content, Stijve and Roschnik (1974) consider that their consumption makes a scant contribution to the intake of mercury in adults because of their infrequent occurrence in the average diet. Thus, for instance, in the case of P.campestris the average mercury content obtained in the cap and expressed as dry matter is 12.3 mg/kg which only represents a concentration at fresh weight of 1.2 mg/kg when we take into account an average moisture of 90%. On considering that the estimates of consumption in Europe of this mushroom do not exceed 500 g per inhabitant/yr, the intake of mercury would be 11 ug/wk. However, Beker (1975) has reported about 20 cases of poisoning after the intake of P.bispora picked in areas which had been treated with a weed-killer of the triazine family. This author deduced that the Psalliotas had accumulated this weed-killer, or one of its metabolites, during growth. Nevertheless, this has to be proved as yet by experimental essays.

Consequently, and bearing in mind that the loss of mercury which occurs during the preparation and cooking of the mushrooms amounts to 70% according to Wenning et al. (1978), it can be affirmed that any population whose diet contains a reasonable proportion of this foodstuff does not run any real risk of suffering poisoning through its contamination by mercury.

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