

Comments on "Determination of Mercury, Cadmium, Lead, Zinc, Selenium and Iron by ICP-OES in Mushroom Samples from Around Thermal Power Plant in Muğla, Turkey". doi:10.1007/s00128-011-0357-1

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**Bulletin of Environmental
Contamination and Toxicology**

ISSN 0007-4861

Bull Environ Contam Toxicol
DOI 10.1007/s00128-012-0566-2

**Bulletin of Environmental
Contamination
and Toxicology**

Volume 70 Number 1 January 2003

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Comments on “Determination of Mercury, Cadmium, Lead, Zinc, Selenium and Iron by ICP-OES in Mushroom Samples from Around Thermal Power Plant in Muğla, Turkey”.

doi:10.1007/s00128-011-0357-1

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Received: 21 January 2012 / Accepted: 7 February 2012
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Abstract In several articles on trace elements in mushrooms erroneous data were published on minerals sequestered in fruiting bodies. The biased analytical data published gave a false picture on the composition and nutritional value of mushrooms with respect to minerals. Wild mushrooms are relatively rich in trace elements and some species can hyperaccumulate certain metals. Selenium as reported in the referenced article is discussed in light of typical Se concentrations determined using validated methods as reported by other authors.

Keywords Fungi · Mushrooms · ICP-OES · Selenium · Trace metals · Wild foods

I read the article on contents of mercury, cadmium, lead, zinc, selenium and iron in mushrooms from an area affected by a thermal power plant fueled with hard coal. I came to this report with a particular interest with respect to Se concentrations. Selenium is vital to human health and a good bio-available source of this element from foods is needed to maintain good health (Jarzyńska and Falandysz 2011a). Selenium is found in different chemical species, has a relatively narrow margin of safety between an adequate, inadequate and excess intake, is highly potent and has great health impact. Hence, accurate data on Se content of foods are essential both in research and applicable surveys to enable health risk assessments to be carried out.

Both cultivated and wild mushrooms can be important constituents of the market basket, especially to vegans and vegetarians who may otherwise lack certain nutrients from their diet. Consumption rates of mushrooms vary largely between the nations, ethnic groups and regions of the world (Zhang et al. 2010). Many mushrooms are rich in K, P, Rb, Cu, Mn and Zn and in addition some species are abundant in a specific element or elements e.g. Ag, Cd, Cu, Fe, Hg, Se, V (Borovička and Řanda 2007; Borovička et al. 2010; Costa-Silva et al. 2011; Falandysz et al. 2001, 2002, 2003, 2004, 2007a, b, c, d, 2008a, b, 2012; Gucia et al. 2012; Jarzyńska et al. 2011). All mushrooms contain Se in flesh but a few edible wild mushrooms are specifically rich in Se (>10 µg/g dry weight), while in many the content is <1.0 µg/g dw (Fig. 1; Falandysz 2008).

The cultivated mushrooms (*Agaricus bisporus*), Oyster Mushrooms (*Pleurotus ostreatus*) and Shitake (*Lentinus edodes*) are usually relatively poor in Se (Falandysz 2008). In the USA, the cultivated species: *A. bisporus* (the White Button Mushroom, Portabella and Baby Bella varieties), *L. edodes*, *P. ostreatus*, *P. erungii* (King Trumpet), *Hipsizyugus tessulatus* (Brown Beech or Brown Clamshell Mushroom), *Flammulina veluipes* (Enoki) and *Grifola fromulosa* (Maitake) contained Se in concentrations varying between 0.01 and 2.7 µg/g dw, and in a consignment of *A. bisporus* concentrations were 2.7 µg/g dw and in *P. ostreatus* 0.2 µg/g dw (Hong et al. 2011).

Some common cultivated mushrooms if developed in substratum fortified with added Se or substratum made of biomass collected from a seleniferous area or if prepared from Se-laden plants, can be enriched in Se (Bhatia et al. 2011; Falandysz 2008; Hong et al. 2011; Rodriguez-Estrada et al. 2009).

Kula et al. (2011) reported high concentrations of Se between 18.7 and 67.10 µg/g dw for all fifteen species of mushrooms examined. For some of these mushrooms, i.e.

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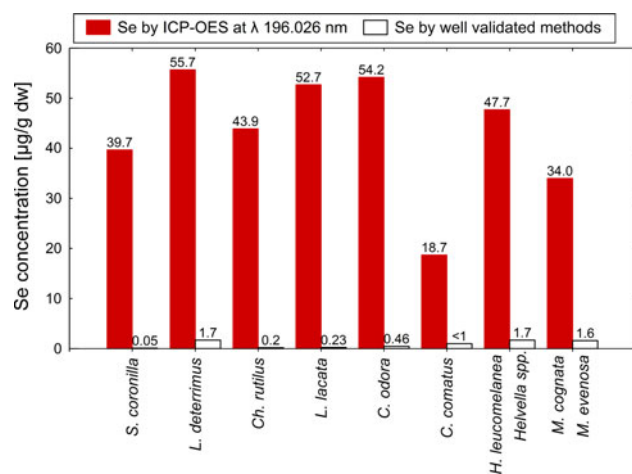


Fig. 1 The values of Se concentrations reported in certain mushrooms as determined using ICP-OES by Kula et al. (2011) (left bar) and by other researchers when using generally accepted methods (right bar; as cited after Falandysz (2008) and Mandić et al. (1991); the mushroom names are such as *Stropharia coronilla* (*S. coronilla*); *Lactarius deterrimus* (*L. deterrimus*); *Chroogomphus rutilus* (*Ch. rutilus*); *Laccaria lacata* (*L. lacata*); *Clitocybe odora* var. *alba* (*C. odora*); *Coprinus comatus* (*C. comatus*); *Helvella leucomelanea* (*H. leucomelanea*) (filled bar) and various *Helvella* spp. (empty bar); *Melanoleuca cognata* (*M. cognata*) (filled bar) and *M. evenosa* (empty bar) (color figure available online)

Stropharia coronilla, *Lactarius deterrimus*, *Chroogomphus rutilus*, *Laccaria lacata*, *Clitocybe odora* var. *alba*, *Coprinus comatus*, *Helvella leucomelanea*, *Melanoleuca cognata*, data on Se have been reported by other authors – see review by Falandysz (2008).

Kula et al. (2011) determined Se by inductively coupled plasma – optical emissions spectroscopy (ICP-OES; ICP-AES). Their data for eight mushrooms and “reference data” for the same species determined by other authors are given in Fig. 1. These “reference values” (Fig. 1) are valid and were obtained by widely accepted analytical methods such as hydride generation – atomic absorption spectroscopy (HG AAS), instrumental neutron activation analysis (INAA) and others. The discrepancies between erroneous Se data by ICP-OES and valid by other methods are evident (Fig. 1).

Good data on Se determined by graphite furnace AAS in mushrooms such as *Panellus stipticus*, *Tricholoma terreum*, *T. virgatum*, *Entoloma sinuatum*, *Boletus edulis*, *B. luridus*, *Suillus granulatus*, *Amanita muscaria*, *A. pantherina*, *Agaricus arvensis*, *A. porphyrizon*, *A. silvicola*, *Leucoagaricus leucothites*, *L. nymphaeum*, *Macrolepiota procera* and *Russula foetens* from Turkey have been reported by Tuzen et al. (2007). They imply on typical concentrations of Se in soils in Turkey and fit well with Se data for the same mushrooms but collected elsewhere in the world – as examined by several researchers, and reviewed by Falandysz (2008).

The matrix effects from biological samples due to presence of carbon but also sulfur, phosphorus and bromine can cause non-spectral interferences and it can lead to high Se concentrations as determined by ICP-AES – as discussed by several authors earlier (Grindla et al. 2007; Machat et al. 2002). Determination of Se as well as of Hg by ICP-AES even after efficient digestion/oxidation of biological material (mushrooms and plant) in closed PTFE vessels using concentrated nitric acid and with aid of microwave energy can lead to imprecise and frequently inaccurate results, when compared, respectively to HG-AAS and cold vapour – atomic absorption spectroscopy (CV-AAS) (Jarzyńska et al. 2012; Jarzyńska and Falandysz 2011b).

In the analytical quality control guidelines for the publication of analytical results of chemical analysis in food-stuffs by Jorhem et al. (2011) is stated that “suspicious of poor analytical quality of published elemental results have been mounting over the years”. To help the researchers, authors and reviewers, the check-list for the description of quality control criteria was created by these authors and the QC-guidelines are given for an open distribution (Jorhem et al. 2011). In the “Analytical parameter” part of these QC-guidelines in the sampling, methodology and certified reference materials sections, the primarily points are: (i) sampling representativity, appropriate choice of method and relevance of the certified material matrix, respectively (Jorhem et al. 2011).

In reports on minerals in mushrooms information on the number of samples (single or pooled, and number of fruiting bodies – mushrooms, if pooled sample were examined) collected and examined is often lacking detail or no such information at all is provided. It is left for the reader to guess that only a single specimen (fruiting body) was collected and examined and a value of standard deviation given refers to a single result and reflects only a variability of instrumental measurements of the same sample. Representative sample collection is important and should be made a priority, and to evaluate natural variability, the sample (specimen) number has to be no fewer than 15 in order to be satisfactory (Eckschlager 1974).

Borovička and Řanda (2007) discussed recently erroneously reported concentrations of iron (Fe) in mushrooms by some authors and the remarks there seem to apply also to data reported by Kula et al. (2011).

Acknowledgments This study has been supported by the Ministry of Science and Higher Education under grant no. DS-8130-4-0092-1.

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References

- Bhatia P, Prakash R, Cameotra SS, Aureli F, Cubadda F, D'Amato M, Nagaraja TP (2011) Fortification of edible mushrooms with selenium using naturally enriched substrates. In: 4th international IUPAC symposium for trace elements in foods (TEF-4). King's College, Aberdeen, Scotland, 19–22 June 2011. P/19/0040
- Borovička J, Řanda Z (2007) Distribution of iron, cobalt, zinc and selenium in macrofungi. *Mycology Prog* 6:249–259
- Borovička J, Kotrba P, Gryndler M, Mihaljevič M, Řanda Z, Rohovec J, Cajthaml T, Stijve T, Dunn CE (2010) Bioaccumulation of silver in ectomycorrhizal and saprobic macrofungi from pristine and polluted areas. *Sci Total Environ* 408:2733–2744
- Costa-Silva F, Marques G, Matos CC, Barros AIRNA, Nunes FM (2011) Selenium contents of Portuguese commercial and wild edible mushrooms. *Food Chem* 126:91–96
- Eckschlager K (1974) *Chyby chemických rozborů (Polish edition)*. Państwowe Wydawnictwo Naukowe, Warszawa
- Falandysz J (2008) Selenium in edible mushrooms. *J Environ Sci Health C* 26:256–299
- Falandysz J, Szymczyk K, Ichihashi H, Bielawski L, Gucia M, Frankowska A, Yamasaki S (2001) ICP/MS and ICP/AES elemental analysis (38 elements) of edible wild mushrooms growing in Poland. *Food Addit Contam* 18:503–513
- Falandysz J, Bielawski L, Kannan K, Gucia M, Lipka K, Brzostowski A (2002) Mercury in wild mushrooms and underlying soil substrate from the great lakes land in Poland. *J Environ Monit* 4:473–476
- Falandysz J, Gucia M, Brzostowski A, Kawano M, Bielawski L, Frankowska A, Wyrzykowska B (2003) Content and bioconcentration of mercury in mushrooms from northern Poland. *Food Addit Contam* 20:247–253
- Falandysz J, Jędrusiak A, Lipka K, Kannan K, Kawano M, Gucia M, Brzostowski A, Dadej M (2004) Mercury in wild mushrooms and underlying soil substrate from Koszalin, North-central Poland. *Chemosphere* 54:461–466
- Falandysz J, Gucia M, Mazur A (2007a) Content and bioconcentration factors of mercury by Parasol Mushroom *Macrolepiota procera*. *J Environ Sci Health B* 42:735–740
- Falandysz J, Kunito T, Kubota R, Bielawski L, Mazur A, Falandysz JJ, Tanabe S (2007b) Selected elements in Brown Birch Scaber Stalk *Leccinum scabrum*. *J Environ Sci Health A* 42:2081–2088
- Falandysz J, Kunito T, Kubota R, Lipka K, Mazur A, Falandysz JJ, Tanabe S (2007c) Selected elements in Fly Agaric *Amanita muscaria*. *J Environ Sci Health A* 42:1615–1623
- Falandysz J, Kunito T, Kubota R, Brzostowski A, Mazur A, Falandysz JJ, Tanabe S (2007d) Selected elements of Poison Pax *Paxillus involutus*. *J Environ Sci Health A* 42:1161–1168
- Falandysz J, Kunito T, Kubota R, Bielawski L, Frankowska A, Falandysz JJ, Tanabe S (2008a) Multivariate characterization of elements accumulated in King Bolete *Boletus edulis* mushroom at lowland and high mountain regions. *J Environ Sci Health A* 43:1692–1699
- Falandysz J, Kunito T, Kubota R, Gucia M, Mazur A, Falandysz JJ, Tanabe S (2008b) Some mineral constituents of Parasol Mushroom *Macrolepiota procera*. *J Environ Sci Health B* 43:187–192
- Falandysz J, Widzicka E, Kojta AK, Jarzyńska G, Drewnowska M, Danisiewicz-Czupryńska D, Dryżałowska A, Lenz E, Nnorom IC (2012) Mercury in Common Chanterelles mushrooms: *Cantharellus* spp. update. *Food Chem*. doi:10.1016/j.foodchem.2012.01.102
- Grindla G, Mora J, Gras L, de Loos-Vollebregt MTC (2007) Carbon-related matrix effects in ICP-AES. XIV EuroAnalysis, Antwerp, Belgium, 9–14 September 2007. <http://hdl.handle.net/10045/13406>
- Gucia M, Kojta AK, Jarzyńska G, Rafał E, Roszak M, Osiej I, Falandysz J (2012) Multivariate analysis of mineral constituents of edible Parasol Mushroom (*Macrolepiota procera*) and soils beneath fruiting bodies collected from Northern Poland. *Environ Sci Pollut Res* 19:416–431
- Hong J, Bañuelos GS, Fowler T, Lin Z-Q (2011) Use of selenium-laden plant materials from phytoremediation to produce selenium-biofortified edible mushrooms. In: ICOBTE 2011, 11th international conference on the biogeochemistry of trace elements. Conference proceedings Parte I, Congress Center, Florence, Italy, July 3–7, 2011, pp 349–350
- Jarzyńska G, Falandysz J (2011a) Selenium and 17 other largely essential and toxic metals in muscle and organ meats of Red Deer (*Cervus elaphus*)—Consequences to human health. *Environ Intern* 37:882–888
- Jarzyńska G, Falandysz J (2011b) The determination of mercury in mushrooms by CV-AAS and ICP-AES techniques. *J Environ Sci Health A* 46:569–573
- Jarzyńska G, Gucia M, Kojta AK, Rezulak K, Falandysz J (2011) Profile of trace elements in Parasol Mushroom (*Macrolepiota procera*) from Tucholskie Forests. *J Environ Sci Health B* 46:741–751
- Jarzyńska G, Kojta AK, Drewnowska M, Falandysz J (2012) Notes on selenium data in mushrooms determined by ICP-AES and HG-ASA techniques. *African J Agric Res* 7 (in press)
- Jorhem L, Engman J, Sundström B (2011) Analytical quality control—guidelines for the publication of analytical results of chemical analysis in foodstuffs. TEF-4 Protocol No 5 QC-guideline 2011-10-11.pdf (Objekt application/pdf)
- Kula İ, Solak MH, Uğurlu M, Işiloğlu M, Arslan Y (2011) Determination of mercury, cadmium, lead, zinc, selenium and iron by ICP-OES in mushroom samples from around thermal power plant in Muğla, Turkey. *Bull Environm Contam Toxicol* 87:276–280. doi:10.1007/s00128-011-0357-1
- Machat J, Otruba V, Kanicky V (2002) Spectral and non-spectral interferences in the determination of selenium by inductively coupled plasma atomic emission spectrometry. *J Anal At Spectrom* 17:1096–1102
- Mandić M, Grgić J, Grgić Z, Trstenjak-Petrović Ž (1991) The natural level of selenium in wildlife mushrooms in Eastern Croatia. *Prehrambeno Technol Biotechnol* 29:159–161
- Rodriguez-Estrada AE, Lee H-J, Beelman RB, Jimenez-Gasco M, Royse DJ (2009) Enhancement of the antioxidants ergothioneine and selenium in *Pleurotus eryngi* var. *eryngi* basidiomata through cultural practice. *World J Microbiol Biotechnol* 25:1597–1607
- Tuzen M, Sesli E, Soylak M (2007) Trace element levels of mushroom species from East Black Sea region of Turkey. *Food Control* 18:806–810
- Zhang D, Frankowska A, Jarzyńska G, Kojta AK, Drewnowska M, Wydmańska D, Bielawski L, Wang J, Falandysz J (2010) Metals of King Bolete (*Boletus edulis*) collected at the same site over two years. *African J Agric Res* 5:3050–3055