Mercury, lead and cadmium content of fresh and canned fish collected from Austrian retail operations

Zum Quecksilber-, Blei- und Cadmiumgehalt in Frisch- und Dosenfisch aus dem österreichischen Einzelhandel

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Summary

Ninety-three samples of fresh and canned fish (edible part) collected from Lower Austria, Burgenland and from Viennese retail operations were analysed for mercury, lead and cadmium. The mercury contents ranged from <0,01 (limit of determination) to 0,89 mg/kg with a mean value of 0,14 mg/kg. The highest mercury contents were measured in Escolar (mean value of 0,63 mg/kg), followed by Swordfish (mean value of 0,42 mg/kg) and Halibut (mean value of 0,29 mg/kg). The lead contents ranged from <0,02 (limit of determination) to 1,0 mg/kg with a mean value of 0,033 mg/kg. The highest lead contents were measured in Anchovy (mean 0,15 mg/kg). The cadmium contents ranged from <0,01 (limit of determination) to 0,12 mg/kg with a mean value of 0,014 mg/kg. The highest cadmium contents were measured in Swordfish (mean value 0,046 mg/kg).

Key words
Mercury, Lead, Cadmium, Fish

Zusammenfassung

Es wurden insgesamt 93 Frischfische und Dosenfische aus dem Handel der Bundesländer Niederösterreich, Burgenland und Wien untersucht. Die Quecksilbergehalte erstreckten sich von <0,01 (Bestimmungsgrenze) bis 0,89 mg/kg (jeweils Frischmasse) mit einem Mittelwert von 0,14 mg/kg. Die höchsten Quecksilbergehalte wurden in Butterfisch (Mittelwert von 0,63 mg/kg), gefolgt von Schwertfisch (Mittelwert von 0,42 mg/kg) und Heilbutt (Mittelwert von 0,29 mg/kg) gemessen. Die Bleigehalte erstreckten sich von <0,02 (Bestimmungsgrenze) bis 1,0 mg/kg mit einem Mittelwert von 0,033 mg/kg. Die höchsten Bleigehalte wurden in Sardellen gemessen (Mittelwert von 0,15 mg/kg). Die Cadmiumgehalte erstreckten sich von <0,01 (Bestimmungsgrenze) bis 0,12 mg/kg mit einem Mittelwert von 0,014 mg/kg. Die höchsten Cadmiumgehalte wurden in Schwertfischen gemessen (Mittelwert von 0,046 mg/kg).

Kennwörter
Quecksilber, Blei, Cadmium, Fisch

Introduction

Toxicological and environmental studies have prompted interest in the determination of toxic elements in food. While mercury, cadmium and lead can be tolerated at extremely low levels, at certain concentrations they are exceptionally toxic to humans. Cadmium accumulates in the human body and may induce kidney disfunction, skeletal damage and reproductive deficiencies. Also, it cannot be excluded that it acts as a human carcinogen [1].

Methylmercury may induce alterations in the normal development of the brain of infants and at higher levels may induce neurological changes in adults. Mercury contaminates mostly fish and fishery products. To protect public health, maximum levels of mercury in fishery products are laid down by Commission Decision 93/351/EEC [2].
Lead absorption may constitute a serious risk to public health. Lead may induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular diseases in adults. Over the past decade the levels in food have decreased significantly owing to the awareness of lead as a health problem and source-related efforts to reduce the emission of lead. The EC concluded in its opinion of 19th June 1992, that whereas the mean level of lead in foodstuffs does not seem to be a cause for alarm, long-term action should follow with the objective of further lowering the mean levels of lead in foodstuffs. Therefore, the maximum levels should be as low as reasonably achievable [1].

The present study was carried out to determine the current levels of total mercury, lead and cadmium in the muscle tissue of fish samples, imported in Austria and caught in the Mediterranean Sea and the North Atlantic, with the purpose of ascertaining whether the concentrations would exceed the maximum level fixed by the European Commission decision [1].

Material and Methods

The heavy metal concentrations were obtained for canned tuna and 21 species of fresh fish, representing the species most commonly consumed in Austria: Sardines (*Sprattus sprattus*), Tuna (*Thunnus thynnus*), Atlantic herring (*Clupea harengus*), Anchovy (*Engraulis*), Gilthead Sea bream (*Sparus aurata*), Shark, Mackerel, Turbot (*Psetta maxima*), Pollack (*Pollachius pollachius*), Cod (*Gadus macrocephalus*), Atlantic halibut (*Hippoglossus hippoglossus*), Swordfish (*Xiphias gladius*), Ocean perch (*Sebastes marinus*), Pangasius, Red snapper (*Lutjanus malabaricus*), European Anchovy (*Engraulis encrasicolus)*, Escolar (*Lepidocybium flavobrunneum*), Polar cod (*Boreogadus saida*), European plaice (*Pleuronectes platessa*), Lemon sole (*Microstomus kitt*) and Beltfish. Tuna was recognised as a predator able to concentrate large amounts of heavy metals.

Samplepreparation

After opening each can, oil was drained off and the meat was homogenized thoroughly in a food blender with stainless steel cutters. Samples were then taken and digested promptly.

Hydrolysis and measurement

The fish samples were incinerated wetly in a microwave system under pressure with nitric acid and perhydrol. Water tests were acidified with nitric acid and stabilized with potassiumdichromat. Mercury compounds were reduced by sodium boron hydride and acid to elementary mercury, which was transported in steam form into a glass cell and measured by atomic absorption-spectrometry.
Mercury levels in fish were determined by cold vapour phase atomic absorption spectrometry (AAS), while cadmium and lead levels were determined by graphite furnace atomic absorption spectrometry (GFA-AAS) fixed by the Commission Decision 90/515 of 26 September 1990 laying down the reference methods for detecting residues of heavy metals and arsenic [3].

Results

A total of ninety-three fish samples were analysed for heavy metals and data have been released and are reported here. The limit of determination for mercury was 0,01 mg/kg, for cadmium 0,01 mg/kg and for lead 0,02 mg/kg. For statistical calculations, levels below the limit of determination were assigned a value of half the limit of determination. Of the fish samples 66,3 % were under the limit of determination of 0,02 mg/kg for lead; 60 % under the limit of determination of 0,01 mg/kg for cadmium and 1.6 % under the limit of determination of 0.01 mg/kg for mercury.
Summary statistics for mercury, lead and cadmium in each species are presented in *Table 1.*

	N	Lead	Cadmium	Mercury
Sardines (*Sprattus sprattus*)	6	0.041	0.012	0.014
Tuna (*Thunnus thynnus*)	12	0.013	0.014	0.19
Canned tuna (*Thunnus thynnus*)	37	0.014	0.016	0.11
Atlantic herring (*Clupea harengus*)	4	0.018	0.0067	0.15
Anchovy (*Engraulis*)	1	0.15	<0.01	0.05
Gilthead Sea bream (*Sparus aurata*)	1	<0.02	<0.01	0.041
Shark	5	0.034	0.018	0.26
Mackerel	3	0.02	0.009	0.036
Turbot (*Psetta maxima*)	1	<0.02	<0.01	0.026
Pollack (*Pollachius pollachius*)	2	<0.02	<0.01	0.033
Cod (*Gadus macrocephalus*)	2	<0.02	<0.01	0.038
Atlantic halibut (*Hippoglossus hippoglossus*)	2	0.02	0.012	0.29
Swordfish (*Xiphias gladius*)	3	0.015	0.046	0.42
Ocean perch (*Sebastes marinus*)	1	<0.02	<0.01	0.17
Pangasius	1	<0.02	<0.01	0.022
Red snapper (*Lutjanus malabaricus*)	1	<0.02	<0.01	0.47
European Anchovy (*Engraulis encrasicolus*)	2	0.02	0.018	0.057
Escolar (*Lepidocybium flavobrunneum*)	3	0.021	0.012	0.63
Polar cod (*Boreogadus saida*)	1	<0.02	<0.01	0.014
European plaice (*Pleuronectes platessa*)	3	0.05	<0.01	0.079
Lemon sole (*Microstomus kitt*)	1	<0.02	<0.01	0.03
Beltfish	1	0.021	<0.01	0.18

Tab. 1: Mean levels of lead, cadmium and mercury (mg/kg wet weight) by species, N (number of samples)

Pollack and Cod had the lowest lead concentration in muscle tissue, with mean concentrations of <0,02 wet weight; and Anchovy the highest, with 0,15 mg/kg. European plaice, Pollack and Cod had the lowest muscle cadmium concentrations, with mean tissue concentrations of <0,01 mg/kg wet weight; and

Swordfish the highest, with 0,046 mg/kg mean value. Sardines generally had the lowest muscle mercury concentrations, with mean tissue concentrations of 0,014 mg/kg wet weight; and Escolar the highest, with 0,63 mg/kg. Summary statistics for mercury, lead and cadmium of all fish samples are presented in *Table 2*.

in mg/kg	Lead (Pb)	Cadmium (Cd)	Mercury (Hg)
N	93	93	93
Min	<0.02	<0.01	<0.01
Max	1.0	0.12	0.89
Mean value	0.033	0.014	0.135
Standard Deviation	0.1017	0.017	0.175

Tab. 2: Heavy metal content in fish

The results indicate that the concentration of lead varied from <0,02 (limit of determination) to 1,0 with a mean of 0,033 mg/kg; for cadmium from <0,01 (limit of determination) to 0,12 with a mean of 0,014 mg/kg. The metal content in the samples, expressed in mg/kg wet weight, varied from <0,01 (limit of determination) to 0,89 with a mean value of 0,135 mg/kg for mercury. The results of mercury, lead and cadmium in this study indicate that the assayed fish samples had concentrations well below the permissible levels for these toxic metals which are for mercury 1,0 mg/kg; 0,2 mg/kg for lead; 0,05 mg/kg for cadmium muscle meat of fish (for *Thunnus species*: for lead 0,4 mg/kg; for cadmium 0,1 mg/kg). Their contribution to the body burden can therefore be considered negligible.

Discussion

Woidich and Pfannhauser [4] reported a concentration range of cadmium in tuna fish within which our values fell. During the period 1976-1977 freshwater fish were sampled and analysed for residues of cadmium, lead and mercury [5]. *Vos* et al. [6] reported low mean levels in some freshwater and marine fish. *Diaz* et al. [7] reported a mean lead level and cadmium level mg/kg in hake (*Merluccius gayi*). In one sample of hake (*Merluccius australis*) a swedish study [8] reports <0,005 mg Pb/kg and <0,001 mg Cd/kg. In detail: for Cod 0,014 mg/kg lead content and <0,001 mg/kg cadmium content; Atlantic mackerel <0,005 mg/kg lead content and 0,002 mg/kg cadmium content; Baltic herring 0,014 mg/kg lead content and 0,008 mg/kg cadmium content. From 1987 to 1992 the laboratory of the canton of Berne (Switzerland) analysed 153 samples of fish (edible part) collected in Bernese rivers and lakes for lead, cadmium and mercury. The concentrations of lead and cadmium were significantly lower than 0,5 and 0,1 mg/kg, respectively [9]. *Engman and Jorhem* [10] found in mackerel (*Scomber scombrus*) from the Nordic Sea lower lead and similar cadmium concentrations than in this current study. The results of the analysis of the study by *Voegborlo* [11] indicate that the concentration of cadmium of canned tuna fish varied from 0,09 to 0,32 with a mean of 0,18 mg/kg; for lead it ranged from 0,18 to 0,40 with a mean of 0,28 mg/kg. *Dykstra* et al. [12] reported mean value for cadmium and lead of 60 Pacific halibut sampled in Alaska in 2002. *Table 3 and 4* include an overview of the results for cadmium and lead in mg/kg of the mentioned references.

Fish species	Own results: mean values	Results in literature: range and mean values	Reference
Tuna	0.014	0.05-0.97	[4]
Freshwater fish	n.s.	0.01-1.04; 0.07	[5]
Freshwater and marine fish	n.s.	0.004	[6]
Hake	n.s.	0.08	[7]
Hake	n.s.	<0.001	[8]
Cod	<0.01	<0.001	[8]
Atlantic mackerel	0.009	0.002	[8]
Baltic herring	n.s.	0.008	[8]
Mackerel	0.009	0.0073	[10]
Canned tuna	0.016	0.09-0.32; 0.18	[11]
Halibut	0.012	0.0017	[12]
n.s.: not studied			

Tab. 3: Comparison of results for cadmium in mg/kg of various fish species

Fish species	Own results: mean values	Results in literature: range and mean values	Reference
Freshwater fish	n.s.	0.10-4.92; 0.32	[5]
Freshwater and marine fish	n.s.	0.07	[6]
Hake	n.s.	0.94	[7]
Hake	n.s.	<0.005	[8]
Cod	<0.02	0.0014	[8]
Atlantic herring	0.018	<0.005	[8]
Baltic herring	n.s.	0.008	[8]
Mackerel	0.02	0.006	[10]
Canned tuna	0.014	0.18-0.4; 0.28	[11]
Halibut	0.02	0.0307	[12]
n.s.: not studied			

Tab. 4: Comparison of results for lead in mg/kg of various fish species

In a recent study from *Hellou* et al. [13] the concentrations of Hg, Cd, and Pb in three tissues of Cod, *Gadus morhua*, from the Northwest Atlantic were well below levels permissible in food products. Mercury content in hake from the Mediterranean coast of Israel was reported by *Yannai* [14]. They found higher levels of mercury in larger (older) specimens. *Buzina* et al. [15] reported mercury content in Hake caught in an industrially polluted area in the Adriatic Sea and from different locations in the Adriatic Sea [16]. Highest contents of mercury were found in Northern pike (*Esox lucius*), Barbel (*Barbus barbus*) and Carp bream (*Abramis brama*) by a study from *Rieder* [9]. *Vukadin* et al. [17] found higher values for mercury in hake from Kastela Bay (a polluted area) than in hake caught in open sea. In a study by *Voegborlo* [11] the concentrations of mercury in tuna varied from 0,2 to 0,66 mg/kg. For Angler fish (*L. piscatorius*) and Black-bellied angler (*L. budegassa*) species, belonging to the family of Lophiidae, mean mercury concentrations found in muscle were reported by *Storelli* [18]. A study from Spain [19] describes mercury contents in mg/kg from Anchovies, from Cod, from canned tuna in oil and from Sardines. *Juresa and Blanusa* [20] reported the highest total mercury content in hake (*M. merluccius*).

Fish species	Own results: mean values	Results in literature: range and mean values	Reference
Freshwater fish	n.s.	0.01-0.84; 0.11	[5]
Hake	n.s.	0.09-0.88	[14]
Hake	n.s.	0.312	[15]
Hake	n.s.	0.10-0.38	[16]
Fish	n.s.	<0.005-0.8	[9]
Hake	n.s.	0.31 (polluted); 0.13 (open sea)	[17]
Tuna	0.19	0.2-0.66	[11]
Angler fish	n.s.	0.61-2.22; 1.26	[18]
Black-bellied angler	n.s.	0.22-1.62; 0.68	[18]
Anchovies	0.05	0.035	[19]
Cod	0.038	0.06	[19]
Canned tuna	0.11	0.22	[19]
Sardines	0.014	0.076	[19]
Hake	n.s.	0.037	[20]
n.s.: not studied			

Tab. 5: Comparison of results for mercury in mg/kg of various fish species

They also confirmed that mercury accumulates in hake to a larger degree if the fish is older because the total concentration in hake was directly correlated with the length of specimen (r=0.6471, $p < 0.05$). The average mercury contamination level collected from fish including Eel (*Anguilla anguilla*), Pike (*Esox lucius*), Perch (*Perca fluviatilis*), Dace (*Leuciscus leuciscus*), and Roach (*Rutilus rutilus*) caught in the River Thames is described by *Yamaguchi* et al. [21]. *Table 5* gives an overview of the results for mercury in mg/kg of the mentioned references.

Conclusions

In our study, we present data on the levels of trace metals in the muscle tissue of fish collected from retail operations in Lower Austria, Burgenland and Vienna. These fish samples are representative for the market by it´s variability but admittedly excluding tuna not in terms of volume. The Joint Food and Agriculture Organisation/World Health Organisation (FAO/WHO) Expert Committee on Food Additives [22] has suggested a provisional tolerable intake of 400-500 µg cadmium per week for man; for lead a weekly intake of 3 mg; the tolerable intake of mercury in human food is 0,3 mg per week [22], which is achieved by eating approximately 750g of swordfish (mean level of mercury: 0,42 mg/kg fresh weight) a week. Though estimates of the amount of toxic metals consumed in the diet are difficult to obtain and a discussion of heavy metal tolerances in the diet is beyond the scope of this paper, it can be concluded from the results so far obtained that mercury, lead and cadmium content of fish collected in Austria is unlikely to constitute a significant health hazard.

References

[1] Council Regulation (EC) No 466/2001 of 8 March 2001 setting maximum levels for certain contaminants in foodstuffs (*Official Journal L 313, 30/11/2001 P. 0060 - 0060*).

[2] Commission Decision No 93/351 of 19 May 1993 determining analysis methods, sampling plans and maximum limits for mercury in fishery products (*Official Journal L 144, 16/06/1993 P. 0023 – 0024).*

[3] Commission Decision No 90/515 of 26 September 1990 laying down the reference methods for detecting residues of heavy metals and arsenic (*Official Journal L 286, 18/10/1990 P. 0033 – 0039).*

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