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MERCURY CONTENT IN ORGANS OF COMMERCIAL FISH (POLAND) – A SHORT REPORT

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Key words: total mercury, marine fish, freshwater fish, muscles, liver, gills

The concentration of mercury in selected organs (muscles, liver and gills) of five fish species was measured by flameless cold vapor atomic absorption spectrometry (CV AAS). The fish species examined: freshwater (pike, *Esox lucius* (L.), roach, *Rutilus rutilus* (L.) and bream, *Abramis brama* (L.)) and marine (mackerel, *Scomber scombrus* and flounder, *Platichthys flesus*), were bought from supermarkets of Olsztyn (north-eastern Poland) over the period from November to December 2006. Differences in the total mercury content were found both between species and organs. The concentration of mercury turned out to be higher in muscles of freshwater fish than in other organs ($p \leq 0.05$). Muscles of flounder had also more mercury than gills and liver, but differences were statistically significant only between muscles and gills ($p \leq 0.05$). The content of mercury in the liver of mackerel was higher than in gills ($p \leq 0.05$) and muscles, although did not differ statistically ($p > 0.05$). The higher levels of mercury (0.226 mg/kg and 0.084 mg/kg, respectively) were determined in muscles ($p \leq 0.05$) and liver ($p \leq 0.05$) of pike as compared to the other fish studied (with the exception of mackerel), because the concentration of Hg in liver of these fish was not statistically significant ($p > 0.05$). A significantly higher mercury content (0.034 mg/kg) was recorded in gills of mackerel than in those of bream ($p \leq 0.05$). The muscle tissue of freshwater fish contained a higher concentration of mercury (0.135 mg/kg) than that of marine fish (0.052 mg/kg), ($p \leq 0.05$). In turn, the content of mercury (0.033 mg/kg) in gills of marine fish was higher than in the freshwater fish (0.019 mg/kg), ($p \leq 0.05$), whereas the content of mercury in liver of freshwater fish was close to that of the marine fish (0.051 mg/kg and 0.053 mg/kg, respectively) ($p > 0.05$).

INTRODUCTION

Mercury is a particularly dangerous food contaminant. It is known that on the one hand fish are a source of n-3 and n-6 polyenoic fatty acids, but on the other – they possess ability to accumulate this metal. A high concentration of mercury in fatty tissue of fish may diminish the beneficial effects of its n-3 fatty acids [Guallar *et al*., 2002]. Levenson & Axelrad [2006] referring to US FDA and EPA [US Food and Drug Administration & US Environmental Protection Agency, 2006] advised not to eat shark, swordfish, king mackerel and tilefish, for they contain some quantities of this toxic metal. According to Jezierska & Witeska [2001], the fish absorb metals from both aquatic and food organisms and the content of these metals in various aquatic organisms belonging to trophic levels of the aquatic environment chain determines the amount of metal absorbed by fish. It is known that the accumulation of mercury is dependent on the length of the food chain. The results published by Łuczyńska & Brucka-Jastrzębska [2006] showed that the predatory fish belonging to the higher trophic levels contained more mercury than the bentho- and planktonophagous species. Generally, the highest values of mercury in muscles of piscivorous species, and the lowest ones in muscle tissue of fish feeding invertebrate were observed by Amundsen *et al.* [1997]. Therefore, the literature data indicate that the muscles of fish accumulate more mercury than other organs [Voigt, 2000].

The aim of this work was to determine the effect of species on mercury concentration in the selected organs (muscles, liver and gills) of freshwater and marine fish and to evaluate differences between the content of this metal in organs of the same fish.

MATERIALS AND METHODS

The freshwater (pike, *Esox lucius* (L.), roach, *Rutilus rutilus* (L.) and bream, *Abramis brama* (L.)) and marine fish (mackerel, *Scomber scombrus* (L.) and flounder, *Platichthys flesus* (L.)) were bought from supermarkets of Olsztyn from November to December 2006. The body weight and the fork length of each fish were measured (Table 1). The liver, gills and dorsal part of muscles from each fish were taken. The samples were kept in polypropylene bags at 248 K (-25°C) until analysis.

TABLE 1. Body weight and total length of five fish species studied.

Species	Number of fish	Body weight (g)		Total length (cm)	
		Range	Mean±SD	Range	Mean±SD
Bream	6	424–634	518±87	32–37	34±2
Roach	17	130–314	207±60	22–28	25±2
Pike	6	714–1060	880±112	47–56	51±3
Flounder	12	204–314	268±43	26–30	27±1
Mackerel	12	278–468	343±55	33–37	34±1

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The samples of muscles, liver and gills were wet-digested using a mixture of nitric and sulphuric acids: HNO_3:H_2SO_4 (2:1) (v/v) at 373-383 K (100-110°C) (MERCK, max. 0.0000005% Hg). Organic compounds were ultimately oxidized by the addition of a 6% w/v solution of $KMnO_4$ (MERCK, max. 0.000005% Hg). An excess of $KMnO_4$ was reduced with hydroxylammonium hydrochloride (20% w/v) (MERCK, max. 0.000001% Hg) until the sample was discoloured. The samples were then treated with 2 mL of a stannous chloride solution. The total mercury was analysed by the flameless cold vapor atomic absorption spectrometry [Hatch & Ott, 1968] using UNICAM 939 SOLAR. The absorption wavelength was 253.7 nm. All samples were processed in duplicate. Two blanks were analysed with each batch of samples. The method was validated by measuring the total mercury in reference material: CRM 422 – muscles of cod (*Gadus morhua* L.). The certified concentration of Hg was 0.559±0.016 mg/kg and the obtained one was 0.560±0.018 mg/kg. The percent recovery rate was 100.2%, n=4, whereas the variability coefficient V(%) was 3.27 [Quevauviller *et al.,* 1993]. The standard reference materials were analysed with each batch of samples. The contents of mercury in muscles, liver and gills of fish are expressed in mg/kg wet weight (wet wt.). The one-way analysis of variance ANOVA (Duncan's test) was used to test significant interspecific differences in the content of mercury both between species and organs of the same species. The Student's t-test was used for the evaluation of significant differences in the concentration of this metal between groups of freshwater and marine fish. In both cases, the significance levels of $p \leq 0.05$ was used.

RESULTS AND DISCUSSION

The concentration of mercury in muscles of fish varied between some species (Figure 1). As shown in Table 2 and Figure 1, the highest mean content of mercury was observed in muscles of pike (0.226 mg/kg), ($p \leq 0.05$). In the muscle tissue of other freshwater fish belonging to the non-predatory fish (bream and roach), the content of mercury was lower (0.077 mg/kg and 0.101 mg/kg, respectively). The interspecific differences in Hg level in muscle tissue of these fish were not statistically significant ($p > 0.05$). These differences may be due to different feeding type and aquatic environment. Significant differences in the content of mercury in muscles of whitefish (*C. lavaretus lavaretus* L. and *C. lavaretus pidschian* L.), perch (*Perca fluviatilis* L.), pike, brown trout (*Salmo trutta m. fario*), burbot (*Lota lota* L.) and vendace from the border region between Norway and Russia were observed by Amundsen *et al*. [1997]. According to these authors, mercury was the only metal for which species differences were possibly related to biomagnification. The mean contents of mercury in fish varied from 0.16 to 0.89 mg/kg and decreased as follows: burbot > perch > brown trout ≈ pike > vendace ≈ densely rakered whitefish ≈ sparsely rakered whitefish. The differences in the levels of mercury in muscles between predatory and non-predatory fish were found by Łuczyńska & Brucka-Jastrzębska [2006], too. Similar observation was made by Jewett *et al*. [2003] for pike and Arctic grayling (*Thymallus arcticus* L.) from Yukon and Kuskokwim rivers. The mean concentrations of Hg

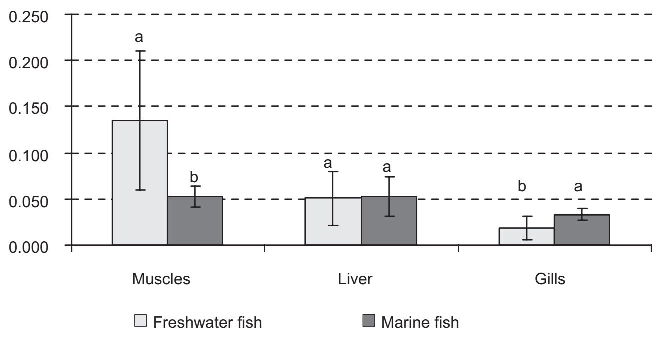

FIGURE 1. Mercury content (mean±standard deviation) in muscle tissue, liver and gills of freshwater and marine fish (mg/kg wet weight). n=18 in the case of freshwater fish, n=12 in the case of marine fish. The different letters indicate the significant differences between the organs of freshwater and marine fish ($p \leq 0.05$).

TABLE 2. Differences in the content of mercury between the organs of the same fish studied and between species.

Species	Mercury content (mg/kg wet weight)		
	muscles	liver	gills
Bream	0.077±0.006 [a B] (0.069–0.084)	0.027±0.005 [b C] (0.019–0.033)	0.005±0.005 [c B] (0.001–0.01)
Roach	0.101±0.040 [a B] (0.057–0.165)	0.040±0.010 [b B] (0.03–0.059)	0.029±0.005 [b A] (0.023–0.036)
Pike	0.226±0.049 [a A] (0.182–0.307)	0.084±0.026 [b A] (0.062–0.129)	0.023±0.013 [c A] (0.007–0.032)
Flounder	0.052±0.013 [a C] (0.032–0.067)	0.041±0.007 [ab B] (0.032–0.049)	0.032±0.007 [b A] (0.026–0.044)
Mackerel	0.052±0.011 [ab C]. (0.039–0.068)	0.065±0.025 [a A] (0.046–0.111)	0.034±0.006 [b A] (0.026–0.04)

n=6 in the case of all fish species; a, b, c – significant differences between the organs of the same species ($p \leq 0.05$) (in rows); A, B, C – significant differences between species ($p \leq 0.05$) (in columns). The same letter indicates the absence of significant differences.

in pike and grayling from Yukon River were 1.506 mg/kg and 0.264 mg/kg, respectively, while the mean values of this metal in these species from Kuskokwim River were 0.628 mg/kg and 0.078 mg/kg, respectively. Similarly, the content of mercury (0.48 mg/kg) measured by Richard *et al*. [2000] for carnivorous fish (South America) was higher than for the non-carnivorous fish (0.05 mg/kg). Literature data showed that mercury content in roach of all 78 circumneutral lakes ranged between 0.02 and 0.54 mg/kg (mean 0.13 mg/kg) [Sonesten, 2001]. The mean value was similar to the content of mercury in the same species in the present study (Table 2). Whereas in a study reported by Žlábek *et al*. [2005] for bream, the concentration of Hg was higher than in the muscles of bream examined in our study (Table 2) and varied between 0.172 and 0.852 mg/kg.

In the present study, the freshwater fish (pike, roach and bream) were characterised by a higher content of mercury than the marine fish (flounder and mackerel), ($p \leq 0.05$). Flounder feeding on snails, molluscs and insect larvae contained the lowest concentration of Hg (0.052 mg/kg) (Table 2 and Figure 1). These results are consistent with those of Falandysz *et al.* [2000] for bream, perch, roach and flounder. Significant differences in mercury contents between species (tuna, *Thunnus albacaras*, bluefish, *Pomatomus saltatrix* and flounder) were found by Burger *et al*. [2005]. The content of mercury in muscles of the examined flounder was lower than in the same species (0.12 mg/kg) from the Finnish and Estonian parts of the Gulf of Finland [Voigt, 2003]. Whereas, the present findings confirmed results of investigations by Burger & Gochfeld [2005] for flounder bought from markets in New Jersey (USA). The muscles of mackerel studied contained lower values of mercury than mackerel examined by Plessi *et al*. [2001] and Jureša & Blanuša [2003]. The contents of mercury measured by these authors were 0.126 mg/kg and 0.153 mg/kg, respectively.

When assayed in liver, the highest values of mercury (0.084 and 0.064 mg/kg, respectively) were found in pike and mackerel ($p \leq 0.05$), (Table 2). The contents of mercury in liver of fish examined were in the following order: pike ≈ mackerel > flounder ≈ roach > bream ($p \leq 0.05$). According to this sequence, the lowest concentration of mercury (0.027 mg/kg) was found in the liver of bream. An opposite regularity was observed by Amundsen *et al*. [1997]. These authors noticed that the concentrations of mercury in liver of fish decreased in the order: brown trout > vendace > perch > densely rakered whitefish ≈ sparsely rakered whitefish > pike. Whereas, Jewett *et al*. [2003] obtained in liver of pike as a representative predatory fish, higher values of mercury (0.471 mg/kg) than in whitefish from Kuskokwim (0.057 mg/kg). The mean content of mercury (0.053 mg/kg) in liver of marine fish was close ($p > 0.05$) to the values of this metal (0.051 mg/kg) in the freshwater fish (Figure 1).

The concentrations of mercury in gills of selected fish were as follows: 0.005 mg/kg (bream), 0.023 mg/kg (pike), 0.029 mg/kg (roach), 0.032 mg/kg (flounder) and 0.034 mg/kg (mackerel) (Table 2). The gills of bream had significantly the lowest value of mercury than other fish species ($p \leq 0.05$). In the case of gills, the marine fish (0.033 mg/kg) contained more amount of mercury ($p \leq 0.05$) than the freshwater fish (0.019 mg/kg) (Figure 1). The content of mercury in freshwater and marine fish varied between selected organs (muscles, liver and gills) (Table 2). Generally, the highest concentrations of this metal were found in muscles, followed by liver and gills, except with mackerel. In the case of mackerel, the content of Hg gave rise to the following sequence: liver ≈ muscles > gills ($p \leq 0.05$). Whereas, the mean concentration of Hg in the muscles of flounder was significant higher than that in gills ($p \leq 0.05$). The muscles of most fish species from the Finnish and Estonian parts of the Gulf of Finland contained higher values of mercury than liver and gonads [Voigt, 2003]. Altindag & Yigit [2005] found that as opposed to chub, higher contents of mercury were measured in muscles of other fish species (carp, *Cyprinus carpio* (L.), zander, *Zander lucioperca* (L.), and tench, *Tinca tinca* (L.)) (Turkey) than in gills.

CONCLUSIONS

The differences in the content of total mercury both between species and organs were found in the study. The muscles of all freshwater fish contained significantly higher values of this metal than liver and gills. There was no regularity in the case of marine fish. Contrary to gills, in the muscles of freshwater fish contents of mercury were higher than in those of marine fish, whereas the levels of this metal in liver of freshwater fish were close to those of the marine fish.

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