Mercury concentrations in captive Atlantic bluefin tuna (*Thunnus thynnus*) farmed in the Adriatic Sea

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ABSTRACT: Levels of total mercury in the muscle (29 samples) and liver tissue (15 samples) of bluefin tuna (*Thunnus thynnus*) weighing 100–300 kg were determined by cold vapour atomic absorption (AA) spectroscopy. Tunas were previously captured in the waters of Malta, towed to the farm in the Adriatic Sea and fattened with defrosted herring and sardine for the period of 6 to 7 months. The purpose of the investigation was to determine the magnitude of mercury contamination and to ascertain whether the concentrations in muscle tissue exceeded the maximum level defined by the European Commission Decision (1 μg/g wet weight). Total mercury concentrations in the muscle tissue of tunas ranged from 0.49 to 1.809 (median 0.899 μg/g wet weight) while in the liver tissue it was from 0.324 to 3.248 (median 1.165 μg/g wet weight). Total mercury concentrations in six samples of sardine ranged from 0.050 to 0.072 μg/g wet weight while two samples of herring contained 0.020 and 0.053 μg/g wet weight. Twelve out of 29 (41%) muscle samples of tuna contained mercury above the maximum level defined by the European Commission Decision. It is generally believed that mercury levels in Mediterranean fish are higher than those of the other seas or oceans due to numerous deposits of mercury ores and metallic mercury in surrounding countries.

Keywords: mercury; tuna; contamination; legislation

Among the wide range of toxic substances contaminating the aquatic environment, a major concern has been focused on mercury whose toxicity is widely investigated since the first major incidents of human poisoning in Japan (at Minamata). High toxicity of mercury is a consequence of biomethylation and biomagnification of the element in the aquatic environment. Large predators such as tuna are at the top of aquatic food chains, and hence they can accumulate a significant amount of mercury mostly in the form of methyl-mercury through their diet. Tuna is a valuable source of protein for many people throughout the world and provide omega-3 fatty acids that reduce cholesterol levels and the incidence of heart disease, stroke and preterm delivery (Daviglus et al., 2002; Paterson, 2002). However, the levels of methyl-mercury are so high in some tuna that they exert adverse effects on human health (counteract cardioprotective effects, damage developing foetuses and young children) in people consuming large quantities of tuna for a longer period (Burger et al., 2005). There is even evidence that one meal of fish with a very high mercury content (> 2.0 μg/g) might have an adverse impact on a developing foetus at a critical developmental period (Ginsberg and Toal, 2000). The purpose of the investigation was to determine the magnitude of mercury contamination and to ascertain whether the concentrations in muscle tissue exceeded the maximum level laid down by the European Commission Decision (1 μg/g wet weight), which is also HTA (highest tolerable amount) set by the Croatian legislation.

MATERIAL AND METHODS

Atlantic bluefin tuna (*Thunnus thynnus*) were farmed in cages 50 m in diameter and 32 m or 38 m in depth, located in the mid-Adriatic Sea. Every cage contained approximately 1 000 specimens. Wild tuna were originally captured by seine net in April in the waters of Malta and Libya, towed, and transferred to the farm in the Adriatic Sea. Tuna were fed defrosted herring *Clupea harengens*, and sardine *Sardinops melanosticus* according to their size during the 6–7 months period. In November 2003 and 2004 the fish (weight 100–300 kg) for this study were sacrificed and samples of muscle (n = 29) and liver (n = 15) tissue were collected and frozen until total mercury determination was done.

Total mercury was determined by cold vapour AAS and concentrations were expressed as µg Hg/g of wet weight tissue according to the method by Stanley and Elliot (1976) using a Coleman Mercury Analyser MAS 50, Perkin Elmer. The accuracy of the method was confirmed by a simultaneous neutron activation analysis with recovery over 90%. Verification of the analysis was carried out using the certified standard reference material (oyster tissue SRM–1566a).

RESULTS AND DISCUSSION

Total mercury concentrations in the muscle tissue of tunas ranged from 0.490 to 1.809 (median 0.899 µg/g wet weight) while in the liver tissue it was from 0.324 to 3.248 (median 1.165 µg/g wet weight) (Figure 1). Total mercury concentrations in 6 samples of sardine ranged from 0.050 to 0.072 µg/g wet weight while two samples of herring contained 0.020 and 0.053 µg/g wet weight. In two samples of the standard reference material (certified concentration 0.0642 ± 0.0067 µg/g) concentrations of 0.063 and 0.062 µg/g were recovered.

There are several factors, both biotic (species, sex, age, diet, metabolism) and abiotic (contamination gradients and physicochemical parameters of the aquatic environment) ones, that may affect metal accumulation in marine organisms (Storelli et al., 2005). It has been accepted that a major route of metal accumulation in fish, especially predator fish, is via diet. Bluefin tuna are mostly piscivorous, so their food in wilderness as well in captivity is small fish which contain a considerable amount of mercury according to our results. Considering that tuna is high performance fish with a very high metabolic rate and consequently their rate of food intake is elevated, a property which contributes notably to the accumulation of mercury, and the fact that tuna is relatively long living fish it can be assumed that tuna can accumulate a considerable amount of mercury. Of the abiotic factors it is the contamination gradient for the Mediterranean Sea, which is generally believed to contain higher concentrations of mercury than the other seas or oceans due to numerous deposits of mercury ores and metallic mercury in surrounding countries. All these circumstances can lead to the accumulation of mercury in edible tissue to such an amount that can be toxic to the consumer. In our investigation 41% of the muscle samples of tuna contained mercury above the maximum level laid down by the European Commission Decision and Croatian legislation. Similar and even higher concentrations

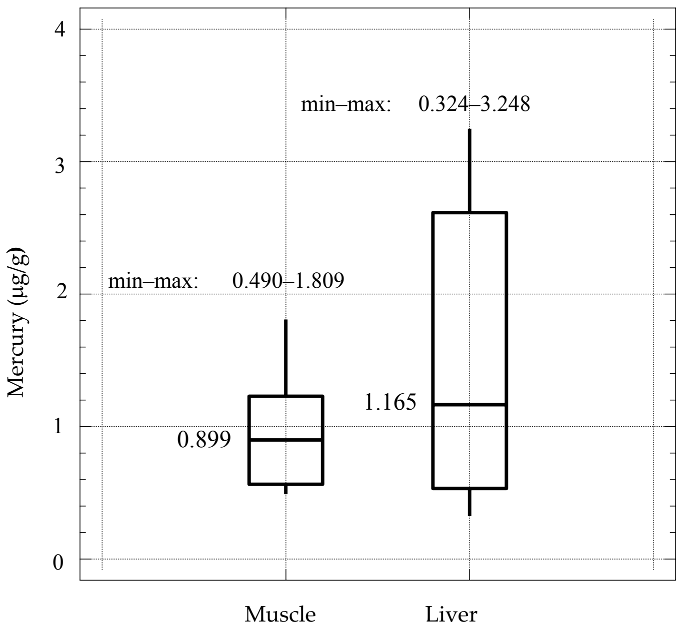

Figure 1. Median values of total mercury concentrations in muscle and liver tissues of bluefin tuna

of mercury were estimated by Licata et al. (2005), who investigated metal concentrations in tuna from the Straits of Messina in Italy. In 14 samples of the muscle tissue of tuna weighing 50–190 kg they found 2.45–4.21μg/g, and in the liver tissue 1.32–3.02 μg/g. In another investigation done by Storelli et al. (2005) in the Ionian Sea concentrations of mercury in muscle tissue (0.13–0.35 μg/g) and liver tissue (0.27–0.60 μg/g) of 73 bluefin tuna weighing 2.85–4.36 kg were much lower, like were in the investigation done by Hernandez-Hernandez et al. (1990), who found 0.081–0.306 μg/g of mercury in 12 samples of the muscle tissue of tuna from the Castellon coast (Spain) weighing 0.7–1.085 kg. The reason for this is that fish were much smaller (younger), which clearly demonstrates that mercury builds up with ageing. All the mentioned comparisons refer to one species – bluefin tuna. If we compare our results with results of other tuna species, we will see that some other species are less contaminated by mercury. Besada et al. (2006) determined total mercury in the muscle tissue of three different species of adult tuna and found the following results: *Thunnus alalunga* (n = 24) median was 0.190 μg/g (0.118–0.564), in *Thunnus albacares* (n = 13) 0.327 μg/g (0.166–0.531) and in *Thunnus obesus* (n = 30) 0.761 μg/g (0.344–1.29). All these three species mostly live in tropical and subtropical waters of the Atlantic, Pacific and Indian Ocean, and do not usually enter the Mediterranean Sea, which is generally believed to be more contaminated by mercury than the other seas and oceans.

In terms of food safety the concentration of mercury in muscle tissue is an important parameter although there is a big discrepancy in legislative regulations between the countries, so that in the EU and USA the maximum permitted level of mercury in fish is 1.0 μg/g (Burger and Gochfeld, 2004) while in Japan it is 0.4 μg/g (Yamashita et al., 2005). In terms of ecotoxicology the age (correspondingly weight) is an important parameter in evaluating mercury hazard.

REFERENCES

Besada V., Gozales J.J., Schultz F. (2006): Mercury, cadmium, lead, arsenic, copper and zinc concentration in albacore, yellowfin tuna and bigeye tuna from the Atlantic Ocean. Ciencias Marinas, 32, 439–445.

Burger J., Gochfeld M. (2004): Mercury in canned tuna: white versus light and temporal variation. Environmental Research, 96, 239–249.

Burger J., Stern A.H., Gochfeld M. (2005): Mercury in commercial fish. Optimizing individual choices to reduce risk. Environmental Health Perspective. 113, 266–271.

Daviglus M., Sheeshka J., Murkin E. (2002): Health benefits from eating fish. Comments on Toxicology, 8, 345–374.

Ginsberg G.L., Toal B.F. (2000): Development of a single-meal fish consumption advisory for methyl mercury. Risk Analysis, 20, 41–47.

Hernandez-Hernandez F., Medina J., Ansuategui J., Conesa M. (1990): Heavy metal concentrations in some marine organisms from the Mediterranean Sea (Castellon, Spain): Metal accumulation in different tissues. Scientia Marina, 54, 113–129.

Licata P., Drombetta D., Cristani M., Naccari C., Martino D., Calo M., Naccari F. (2005): Heavy metals in liver and muscle of bluefin tuna (*Thunnus thynnus*) caught in the Straits of Messina (Sicily, Italy). Environmental Monitoring and Assessment, 107, 239–248.

Paterson J. (2002): Introduction-comparative dietary risk: balance the risk and benefits of fish consumption. Comments on Toxicology, 8, 337–344.

Stanley P.I., Elliot G.R. (1976): An assessment based on residues in owls of environmental contamination arising from the use of mercury compounds in British agriculture. Agroecosystems, 2, 223–234.

Storelli M.M., Giacominelli-Stuffler R., Storelli A., Marcotrigiano G.O. (2005): Accumulation of mercury, cadmium, lead and arsenic in swordfish and bluefin tuna from the Mediterranean Sea: A comparative study. Marine Pollution Bulletin, 50, 1004–1007.

Yamashita Y., Omura Y., Okazaki E. (2005): Total mercury and methylmercury levels in commercially important fishes in Japan. Fisheries Science, 71, 1029–1035.

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