Sri Lanka J. Aquat. Sci. **15** (2010): 39-43

Mercury, Cadmium and Lead Levels in Three Commercially Important Marine Fish Species of in Sri Lanka

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Abstract

Most heavy metals which bio-accumulate in fishes, especially predatory species do not have any biological significance or beneficial use, but due to the presence of heavy metal fish can pose a health risk to consumers. The objective of this research is to determine mercury (Hg), cadmium (Cd), and lead (Pb) levels in samples of yellowfin tuna, *Thunnus albacores* (n=25), swordfish, *Xiphias gladius* (n=35), and red snapper, *Lutjanus* sp (n=12). Samples were prepared by dividing edible parts into small pieces and homogenizing. Total Hg was measured by cold vapor atomic absorption spectrometry whereas the Pb and Cd were analysed by graphite furnace atomic absorption spectrometry after microwave-assisted digestion. Swordfish contains highest mercury and cadmium concentrations while yellowfin tuna contained the highest lead concentrations. The mean concentrations of heavy metals in fish muscles were found to be 1.24± 0.72 mg/kg (Hg), 0.13±0.83 mg/kg (Cd) and 0.03±0.04 mg/kg (Pb) in swordfish and 0.39± 0.19 mg/kg (Hg), 0.02±0.02 mg/kg (Cd) and 0.06±0.06 mg/kg (Pb) in yellowfin tuna. In red snapper concentrations were 0.17± 0.06 mg/kg (Hg), 0.02±0.01 mg/kg (Cd) and 0.04±0.05 mg/kg (Pb).

Introduction

Fishes are an essential food items providing high nutritional value and are important sources of high quality protein, low saturated fat, omega-3 fatty acids, iodine and some vitamins (Gamal and Shamery 2010). Medical Research Institute of Sri Lanka recommends the increase of per capita consumption of fish to 21 kg per year (NARA 2007). Tuna and swordfish are commercial important varieties, which have a vast demand in both local as well as the export markets.

Due to the pollution of the aquatic environment, fishes accumulate a significant amount of heavy metals. Some metal like copper (Cu), iron (Fe) and zinc

(Zn) are essential for fish metabolism while other metals like mercury (Hg), lead (Pb) and cadmium (Cd) have no known biological role, but known to be extremely toxic at even low concentrations (Mwashote 2003). The pollution of marine ecosystems is a worldwide problem, and the situation is aggravated by the ability of these ecosystems to concentrate and accumulate some metals within food chains (Mwashote 2003). Especially predatory fish species bio-accumulates substantial concentration of lead, cadmium and mercury in their tissues and thus can represent a major dietary source of these elements to the humans (Voegborlo and Akagi 2007). When such trace metals are present in fish they can pose a serious threat to the health of consumers. Chronic exposure to mercury can cause problems in the central nervous system (CNS) and the areas mainly affected are those associated with the sensory, visual and auditory functions (WHO, 1976) while exposure to lead are manifest in three organ systems; the haematological system, the central nervous system (CNS) and the renal system (Hutton 1987). The kidney is the critical organ of intoxication after long-term exposure to cadmium (Hutton 1987).

Due to the presence of these trace metals in fish exceeding the levels allowed by legislations, fishes are subjected to rejection within the local market as well as the export market. As such, it is becoming a growing concern among consumers on the consequences of trace metal poisoning and the routes of poisoning (Liyanage 2009). Therefore, the objectives of the study were to determine mercury, cadmium, and lead levels in samples of three commercially important fish species in the local market of Sri Lanka.

Materials and methods

Samples of yellowfin tuna, *Thunnus albacores* (n=25), swordfish, *Xiphias gladius* (n=35) and red snapper, *Lutjanus* sp (n=12) were collected from the local fish market during the period of August to October 2009. Length and weight of each fish were measured. Samples were preserved in ice and transported to the analytical chemistry laboratory, Institute of Post Harvest Technology (IPHT), National Aquatic Research and Development Agency (NARA). In the laboratory, approximately 500 g of edible portion of the belly area was obtained from each fish and placed in separate vacuum-packed bags.

A CEM/MARS XP-1500+ microwave oven was used for the microwave assisted digestion of fish samples. The program has a working pressure 800 psi and can operate at temperatures up to 200°C. For microwave digestion, 1 g of homogenized sample was accurately weighed and transferred directly into the microwave vessels. For each sample, 10 ml of Conc. HNO_3 (AR-Sigma) were added. The analytical reagent blanks were also prepared and these contained only the acids. All blank and spiked samples were taken in duplicate. The vessels were sealed and placed into the rotor of microwave system. After the digestion process, the digested liquids were transferred to the 50 ml volumetric flask and volume up using de-ionized water. The samples were tested for lead, cadmium using a Spectra AA 220 Zeeman Atomic Absorbent Spectrophotometer with graphite tube atomizer (Varian GTA-120), and background correction was applied. Samples were tested for mercury using a cold vapor atomic absorbance spectrophotometer (Varian

VGA-77). Then the data were recorded in excel 2010 and statistically analysed using SPSS 16 software.

Results and discussion

The variation of weight and length of fish is shown in Table 1. The highest mean length was recorded from swordfish (141 cm) and lowest mean length was recorded from red snapper (55 cm). The mean length value of yellowfin tuna was 128 cm. Meanwhile highest mean weight was recorded from swordfish (50.8 kg) and the lowest mean weight was recorded from red snapper (2.5 kg) while the mean weight of yellowfin tuna was 46.3 kg.

Table 1. The weight (kg) and length (cm) of studied fish species. Ranges are given in parentheses.

	Yellowfin tuna	Swordfish	Red snapper
Weight (kg)	46.3 (18.0-83.5)	50.8 (13.0-112.0)	2.5 (1.3-3.2)
Length (cm)	128 (78-173)	141 (87-240)	55 (43-75)

The spiked samples are routinely analysed to perform the methods validation procedure. The results of spiked samples were maintained within the range and the recovery limits between 80-120%.

The size of a fish is known as determining factor of its Hg burden (Kojadinivic et al. 2006) and has confirmed with the present data. Both swordfish and yellowfin tuna had positive significant correlation of body size with Hg and Cd. Body size of red snapper showed a positive correlation only with Cd concentration. (Table 3).

Table 2. Hg, Cd and Pb concentration (mg/kg in wet weight basis) in each fish species. ND - Not Detectable level.

	Mean Hg concentration (range)	Mean Cd concentration (range)	Mean Pb concentration (range)
Yellowfin tuna	0.39 (0.14-0.88)	0.02 (ND-0.09)	0.06 (ND-0.24)
Swordfish	1.24 (0.20-2.58)	0.13 (0.03-0.36)	0.03 (ND-0.15)
Red snapper	0.17 (0.09-0.28)	0.02 (ND-0.04)	0.04 (ND-0.15)

The analytical chemistry laboratory of NARA, where the analysis was performed, has participated proficiency testing program within the same time with Fapas/UK with satisfactory results (07115/2009, Z=0. 1).

Swordfish contained the highest mean mercury level of 1.24 mg/kg, as well as the highest mean cadmium concentration of 0.13 mg/kg, and the while yellowfin tuna contained the highest mean concentration of lead of 0.06 mg/kg. The mean mercury and cadmium concentrations between fish species were significantly ($p<0.05$), while the mean lead concentration was not significantly different ($p>0.05$). The summary of the trace metal results is given in Table 2. The highest risk was observed in swordfish considering the Hg concentration. Because, 57% of swordfish samples exceeded the maximum permissible levels (MPL) of European legislation (1 mg/kg) while none of the sample from other two did not show the exceeding the MPL value, regarding the Hg. According to the American Pregnancy Association (APA), they have categorized swordfish in the highest Hg group, yellowfin tuna in high Hg group and red snapper in lower Hg group (APA, 2013).

Table 3. Pearson correlation of Hg, Cd and Pb concentration in three fish species with their length and weight. * - significant at least at 0.05 probability level; ns – Not significant.

		Yellowfin tuna	Swordfish	Red snapper
Hg	Length	0.635*	0.743*	-0.029 (ns)
	Weight	0.323 (ns)	0.737*	-0.337 (ns)
Cd	Length	0.635*	0.631*	0.682*
	Weight	0.628*	0.697*	-0.173 (ns)
Pb	Length	-0.025 (ns)	0.034 (ns)	-0.384 (ns)
	Weight	-0.198 (ns)	0.332 (ns)	-0.089 (ns)

Conclusions

The levels of trace metals in studying fish species studied is generally, were safe according to the European legislation. However, higher levels of Hg in swordfish need to be considered when dealing with particularly sensitive sectors (pregnant woman, lactating woman infant and children) of the population. Positive relationships were observed between body size of swordfish and yellowfin tuna with Hg and Cd. Body size of red snapper showed a positive correlation only with Cd concentration.

Acknowledgement

We are thankful to laboratory staff of analytical chemistry laboratory, Institute of Post Harvest Technology of National Aquatic Resources Research and Development Agency.

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