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Full Length Research Paper

Analysis and determination of mercury, cadmium and lead in canned tuna fish marketed in Iran

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The objective of this study is to determine mercury, cadmium and lead concentrations in 60 canned tuna fish samples produced and distributed in Iran after digestion by the standard methods of the Association of Official Analytical Chemists. Mercury contents in canned tuna fish were determined by cold vapor atomic absorption spectrophotometry while cadmium and lead were determined by graphite furnace atomic absorption spectrophotometry. The metal contents, expressed in µg g^{-1} wet weight for mercury, cadmium and lead varied from 0.010 to 0.401 (average of 0.125), 0.008 to 0.150 (average of 0.050) and 0.021 to 0.301 (average of 0.096), respectively. The values were comparable and in the range of the literature values. The results of this study indicate that tuna fish produced and marketed in Iran have concentrations well below the standards of FAO/WHO levels of these toxic metals.

Key words: Canned tuna fish, heavy metals, mercury, cadmium, lead.

INTRODUCTION

Fish is widely consumed in many parts of the world by humans because it has high protein content, low saturated fat and also contains omega-3, calcium, phosphorus, iron, trace elements like copper and a fair proportion of the B-vitamins known to support good health (Tucker, 1997).

Beside good health benefits of fish, there have been many reports on contamination of fish by chemicals in the environment (Tuzen and Soylak, 2007). Heavy metals are considered the most important constituents of pollution from the aquatic environment and the sea because of their toxicity and accumulation by marine organisms, such as fish (Inskip and Piotrowsiki, 1985; Emami et al., 2005). While mercury, cadmium and lead can be tolerated at extremely low concentrations, they are extremely toxic, persistent and not easily biodegradable (Ikem and Egiebor, 2005), and high contaminated fish may cause health risk to human. The toxic effects of heavy metals, particularly mercury, arsenic, cadmium and lead, have been broadly studied (Porto et al., 2005; Houserova et al., 2007; Catsiki and Strogyloudi, 1999). The major source of exposure of humans to heavy metals is through food ingestion (Ikem and Egiebor, 2005).

Tuna which was recognized as a predator is able to concentrate large amounts of heavy metals (Inskip and Piotrowsiki, 1985). Canned tuna fish are frequently and largely eaten in Iran, so the toxic metal content should be of some concern to human health. Publication on the concentrations of heavy metals in pressed or canned fish in Iran is limited. Canned tuna fish from the Persian Gulf area were used because of the heavy trafficking of oil in this region that is expected to contaminate the water way (Emami et al., 2005). The objectives of this study was to analysis and determine the content of mercury, cadmium

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Table 1. Recovery of mercury, cadmium and lead (μg g^{-1}) in canned tuna samples.

Metal	Concentration added (μg g^{-1})	Concentration recovered (μg g^{-1})	% Recovery
Mercury	0.02	0.0192	96
	0.05	0.0508	101
	0.10	0.0103	103
	0.20	0.0206	103
Cadmium	0.10	0.107	107
	0.20	0.211	105
	0.50	0.510	102
	1.00	0.991	99
Lead	0.20	0.202	101
	0.40	0.397	99
	0.60	0.595	99
	1.00	1.044	104

Table 2. Mean contents of mercury, cadmium and lead (μg g^{-1}) in canned tuna samples.

Metal	Range	Mean	SD
Mercury	0.010-0.401	0.125	0.085
Cadmium	0.008-0.150	0.050	0.039
Lead	0.021-0.301	0.096	0.058

and lead by precise methods in canned tuna fish produced and distributed in Iran.

MATERIALS AND METHODS

All glassware used were soaked in detergent solution overnight before being rinsed and soaked in 10% (v/v) HNO_3 overnight, followed by rinsing with distilled water. All reagents used were of analytical reagent grade Merck, Germany. Standard stock solutions of mercury, cadmium and lead were prepared by diluting concentrated solutions to obtain solutions of 1000 mgl^{-1}. Canned tuna samples were purchased from popular supermarkets in Sahr-e Kord and Isfahan, Iran, during September 2008 - June 2009. Sixty tuna cans were used in this study.

After opening, each cans oil was drained off and the meat was homogenized thoroughly in a food blender with stainless steel cutters. Each sample was then taken and digested promptly as follows: for mercury determination, 1 ± 0.001 g of homogenized sample was weighed into a 100 ml Erlenmeyer flask and 1 ml of concentrated HCl was added, and then, 10 ml of conc HNO_3 and 5 ml of conc. H_2SO_4 were slowly added. The flask was then placed on top of a steam bath unit to complete dissolution. It was then removed from the steam bath, cooled and the solution transferred carefully in to a 20 ml volumetric flask; for the reduction of mercury, 5 ml $SnCl_2$ was used. For the determination of lead and cadmium, about 10 ± 0.001 g of homogenized sample were weighed into a 200 ml beaker and 10 ml of concentrated HNO_3 were added. The beaker was covered with a watch glass, and after most of the sample was dissolved by standing overnight, it was then heated on a hot plate with boiling until any vigorous reaction had subsided. The solution was allowed to cool, transferred into a 50 ml volumetric flask and diluted to the mark with distilled water (Voegborlo et al., 1999). For each run, a duplicate sample, spiked samples for recovery and two blanks were carried through the whole procedure.

Validity of analytical methodology was checked by spiking the samples with various concentrations of heavy metals for the recovery. The recoveries of the metals were determined by adding increasing amounts of metals to the samples which were then subjected to the digestion procedure. The resulting solutions were analyzed for the metal concentrations. The results are reported in Table 1.

Mercury was determined in all the digests using cold vapor atomic absorption spectrophotometry flow infection mercury/hydride analyzer (FIAS 4100, Perkin Elmer, USA), equipped weigh hollow cathode mercury lamp operated at a wave length of 253.7 nm. Quartz absorption cell was used for the mercury determination.

Cadmium and lead concentrations were determined by graphite furnace atomic absorption spectrophotometry (Perkin Elmer 4100, USA), employing paralytic platform graphite tubes (Perkin Elmer, AS-40), ascorbic acid and palladium for matrix modification.

RESULTS AND DISCUSSION

Sixty samples of canned tuna fish were analyzed for mercury, cadmium and lead. Good recoveries of spiked samples show accuracy of the analytical methods (Table 1). The results of this study indicated that the concentration varied form 0.010 to 0.401 with mean ± SD value of 0.125 ± 0.085μg g^{-1} for mercury, from 0.008 to 0.150 with a mean value of 0.050 ± 0.039μg g^{-1} for cadmium and from 0.021 to 0.301 with a mean value of 0.096 ± 0.058μg g^{-1} for lead (Table 2).

Many previous literatures have shown that the occurrence of toxic elements contamination is related to length, weight, age and sex of fish (Agusa et al., 2005; Emami Khansari et al., 2005; De Marco et al., 2006; Storelli et al., 2002). Season and place are also important in the

Table 3. Mercury, cadmium and lead level (μg g^{-1}) in canned tuna fish reported internationally.

Country	Mercury	Cadmium	Lead	Reference
Australia	0.01 - 0.89	0.01 - 0.12	0.02 - 1.0	Suppin et al. (2005)
Libya	0.20 - 0.66	0.09 - 0.32	0.18 - 0.40	Voegborlo et al. (1999)
Malaysia	0.004 - 0.500	-	-	Hgjeb et al. (2009)
	-	0.06 - 0.14	0.40 - 0.76	Zahari et al. (1987)
Turkey	-	0.025 - 0.494	0.076 - 0.314	Celik and Oehlenschlager (2006)
	-	0.06 - 0.25	0.09 - 0.40	Tuzen and Soylak (2007)
Saudi Arabia	0.18 - 0.86	0.08 - 0.66	0.14 - 0.82	Ashraf (2006)
	-	0.07 - 0.64	0.03 - 0.51	Ashraf et al. (2006)
USA	0.02 - 0.76	0.0 - 0.05	0.0 - 0.03	Ikem and Egiebor (2005)
Iran	0.045 - 0.253	0.005 - 0.072	0.016 - 0.073	Emami Khansari et al. (2005)
	0.010 - 0.401	0.008 - 0.150	0.021 - 0.301	This study

levels of toxic elements accumulation in fishes (Kagi and Schaffer, 1998). However, good agreements were observed when our results were compared with those reported by other authors (Committee for Inland Fisheries of Africa, 1992).

Mercury has been recognized as severe environmental pollutant, with high toxicity even at low concentrations and it has the ability to enter into biological systems (Porto et al., 2005). It has strong tendency to accumulate in aquatic food chain, and about 95% of the methyl mercury in humans originated from ingested fish (Houserova et al., 2007; Voegborlo and Akagi, 2007). Mercury and methyl mercury are neurological toxicants to humans. In addition, methyl mercury is also classified as a Group C possible human carcinogen (Commission of the European Communities, 2001). Base on the wet weight, all of the canned tuna fish samples commonly consumed by Iranians analyzed in this study had mercury concentrations below 0.5μg g^{-1} wet weights; the guideline level established by European Communities and Joint FAO/WHO Expert Committee on Food Additives (Food Agriculture Organization, 1976; Commission of the European Communities, 2001). Mercury concentrations in canned tuna fish found in this study were in good agreement with those reported by other studies (Table 3).

Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults (Commission of the European Communities, 2001). The maximum lead level permitted for canned fishes is 0.2 μg g^{-1} according to the European communities (Commission of the European Communities, 2001). In this study, the mean, lowest and highest lead levels in samples were 0.096 μg g^{-1}, 0.021 μg g^{-1} and 0.301 μg g^{-1}, respectively, and only 6.7% of samples showed slightly elevated levels of lead (>0.2 μg g^{-1}). The results were compared with the literature values (Table 3). The fact that toxic metals are present in high concentrations in fishes is of particular importance in relation to the FAO/WHO (1976) standards for lead and cadmium as toxic metals. The maximum permissible doses for an adult are 3 mg lead and 0.5 mg cadmium per week, but the recommended sources are only one-fifth of those quantities.

Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies (Tuzen and Soylak, 2007). The mean of cadmium concentration in analyzed canned fish samples were lower than the European communities (maximum 0.05 mg Cd/kg) (Commission of the European Communities, 2001), but, out of total 60 samples analyzed, 27 (45%) showed slightly elevated levels of cadmium (>0.05 μg g^{-1}). However, these are approximately 8 times below the codex committee on Food Additives and Contaminants (CCFAC, 2001) draft guideline of 0.5 μg g^{-1}. The lowest and highest cadmium levels were 0.008μg g^{-1} and 0.150μg g^{-1}, respectively. Cadmium contents in literature have been reported in the range of 0.0 -0.0.66 μg g^{-1} in canned tuna fish samples in previous studies (Table 3).

Conclusion

The levels of some toxic elements in analyzed canned fish samples were found to be above legal limits. The level may be reduced by more careful handling practices and processing of raw materials. Canned fish samples should be analyzed more often in Iranian supermarkets with respect to toxic elements. This study improves the baseline data and information on mercury, cadmium and lead concentration in canned tuna fish commonly marketed in Iran. Such data provide valuable information on safety of fishes commonly consumed by the public.

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