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Arsenic and Cadmium Levels in Imported Fresh and Frozen Fish in Jordan

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The past few decades have witnessed an increased awareness of problems concerning food pollution. Among them, the heavy metals are one of the most persistent and accumulative pollutants. They are natural constituents of earth crust, thus, heavy metal pollution describes elevated concentrations in different environmental compartments to a level that is detrimental to the living organisms (Robert 1991). Human beings are exposed to heavy metals via polluted air, water, and food. Previous studies have shown that fish is the major source of exposure to arsenic (Winger et al. 1984; Buchet et al. 1994). On the other hand, smoking is considered to be a major source of exposure to cadmium; yet, different researchers around the world have reported toxic levels in edible fish meat (Allen 1995). Fish are of high bioaccumulative affinity towards arsenic and cadmium and consequently, they are a good bioindicators of water pollution with such metals. Arsenic readily accumulates in fish muscular tissue. Arsenobetaine is the major chemical form found in fish, the more potent compound, inorganic arsenic, is present in smaller concentrations. The EPA guidelines (EPA 1995) recommend 30% inorganic arsenic of the total arsenic in fish be considered in the calculations of arsenic human health criterion. Cadmium is not uniformly distributed in fish body, but it accumulates selectively in the kidney and liver, where muscular tissue is several order of magnitudes lower.

Arsenic and cadmium are of no biological function in human system and they are potentially toxic even at trace concentrations (Robert 1991). It was claimed that acute and chronic arsenic poisoning is often overlooked initially in the evaluation of patients with multisystem diseases. Skin, nervous system, gastrointestinal system and blood are commonly involved in arsenic poisoning (Schoolmeester and White 1980). Kidneys are the critical target following long term exposure to cadmium, in addition to hepatotoxicity, skeletal impairment and neurotic effects (Misra et al. 1998). The hazardous impacts of such toxic and carcinogenic metals have driven the toxicologists' attention to measure their concentrations in different foodstuffs. Local Jordanian authorities (JS 400 1997), as well as many other organizations in different countries (Bugdahl and Von 1975; EPA 1995; Tchounwou 1996) have established minimum safety levels of arsenic and cadmium, among other standards, that have to be fulfilled before fish is allowed to the market.

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This study is the first attempt to investigate the level of arsenic and cadmium in fresh and frozen imported fish as the major sources of dietary fish in Jordan. Further, based upon the results obtained, an attempt has also been made to estimate the exposure level to both metals via fish consumption. Atomic Absorption Spectroscopy was applied in this study for the determination of the metals in the fish tissue.

MATERIALS AND METHODS

Fifty-six fresh and frozen fish samples were collected from the local market during a three-month interval. The samples were selected on the basis of relative abundance and availability due to the wide array of imported species and sources of supply. Table 1 shows the major five countries that export fish to Jordan, among 30 more countries, with a total of annual average of 7000 tons of fish.

Table 1. Representative relative quantities (Kg) of imported fish (fresh and frozen)during the period 1995-1998.

	Country	1995	1996	1997	1998	Average
1	*Argentina*	6,916,518	224,741	1,205,052	2,466,055	3,125,144
2	*Oman*	633,461	1,674,243	1,588,541	1,514,025	1,106,304
3	*Yemen*	326,153	1,171,490	1,368,317	648,580	948,785
4	*Uruguay*	103,518	224,828	390,162	709,839	357,087
5	*Netherlands*	619,144	370,363	213,961	162,776	334,466

According to the Department of Statistics in Jordan (1992-1998).

"Brotola" species from Argentina and Uruguay was chosen to represent imported frozen fish. *"Acanthobrama"* species from Yemen was collected as fresh imported fish samples. The dorsolateral muscles were dissected, rinsed, and dried in dry oven. The tissues were ground and digested by concentrated nitric acid in kjeldahl apparatus. Hydride generation-Atomic Absorption Spectroscopy (HG-AAS) was used to determine arsenic levels and Flame Atomic absorption Spectrophotometer was used for cadmium levels in the fish tissue.

Appropriate controls were used to ensure the validity and precision of the analytical methods. The levels of arsenic and cadmium determined were reported as Mean $\pm$ S.E.M.

RESULTS AND DISCUSSION

The determination of Arsenic and Cadmium in fish tissue, both fresh and frozen samples, was performed using the methods as described elsewhere. Using appropriate controls throughout the study validated the analytical methods. The determined levels of Arsenic and Cadmium in fish samples are presented in tables 2 and 3, respectively. The mean value of arsenic in *"Brotola"* species was found to be 4.09$\pm$ 0.21 ppm and in *"Acanthobrama"* species it was noted as 1.39$\pm$0.11 ppm.

Table 2. Concentration of Arsenic in analyzed fish samples.

Sample	n	Mean	SD	SEM	CV%
"Brotola" species	28	4.09	1.14	0.21	28%
"Acanthobrama" species	28	1.39	0.57	0.11	41%

The level of cadmium mean values in *"Brotola"* and *"Acanthobrama"* species were 3.32 $\pm$ 0.19 ppm and 1.46 $\pm$ 0.11 ppm respectively.

Table 3. Cadmium concentration in analyzed fish samples.

Sample	n	Mean	SD	SEM	CV%
"Brotola" species	28	3.32	1.01	0.19	30%
"Acanthobrama" species	28	1.46	0.58	0.11	40%

Comparison of the relative levels of Arsenic and Cadmium in fresh and frozen fish tissues show that both metals concentrations in frozen fish were more than in fresh fish.

The Jordanian Institution for Standards and Metrology has established 1.0 ppm as the acceptable level of arsenic and 0.2 ppm of cadmium in edible fish tissue. The results of this study show that arsenic and cadmium concentrations in the fish samples analyzed exceeded far beyond the prescribed acceptable in both the Jordanian as well as international safety standards Table 4.

Table 4. Standard safety level of arsenic and cadmium in fish tissue based on dry weight measurements.

Organization	As ppm	Cd ppm
Jordanian Institution for Standards & Metrology (JS 400:1997)	1.0	0.2
Food and Drug Agency (Tchounwou, *et al.* 1996)	1.0	0.2
Environmental Protection Agency (EPA 1995)	1.0	0.2
German Regulation Institute (Bugdahl, *et al.*, 1975)	0.5	0.05

The most interesting aspect underlying this subject is that it is fairly difficult to identify metals contamination by an ordinary consumer. Neither the smell nor the fish tissue integrity is affected (Gill et al. 1992). The multiplicity of exposure sources and routes (Vos 1988) dictates essential concerns regarding the magnitude of human exposure, and evaluation of subsistence food safety. This is more relevant in view of the fact that the recent human approach towards healthy food recommends fish as a meal for all ages.

The level of exposure could have an important bearing on the section of society that depends on fish as the primary food. Further, the ingested arsenic is almost completely absorbed via GIT, and a large fraction of this dose is cleared within a period of approximately ten days. Yet, the inorganic form of arsenic is not easily eliminated and arsenic build up can occur with regular exposure. (Del Razo, et al. 1997). That, in turn, may decrease the efficiency of the metabolic pathways and lead to chronic toxicity problems. Moreover, arsenic is the only metal that is reported to cause cancer via the oral route with potential level of 1.75 mg/Kg (EPA 1995).

Cadmium seems to be potentially dangerous in view of its long half-life in human body. Approximately 5% of ingested dose is absorbed and retained almost completely for 16 to 30 years. The effects of long term of exposure to elevated levels of cadmium are already reported in several studies (Skerfving1999).

In this study, it was also found that Arsenic and cadmium concentrations in frozen fish were more than in fresh fish. The literature reviewed revealed that there is inadequate information on the impact of storage and transport of fish on the level of metal accumulation in the fish tissue. One such study reported that fish storage in daylight or in oxidizing environment might change the arsenobetaine into other more toxic inorganic form (Murer et al. 1992). Another study (Reinke et al. 1975), discussed the rapid reduction of arsenate to arsenite after fish death. Living fish accumulates arsenic, cadmium and other metals via their gills, food and skin. There are no scientific reports available that clarify whether heavy metal can migrate into fish muscles after fish death. This could have a major role since anything that contributes to fish exposure is possible such as metallic containers, polluted or contaminated package, especially with frozen fish that travels long distances and stored for months before it finally reaches the consumer.

One more issue to be investigated is metals mobilization between fish tissues and organs after fish death. For example, cadmium accumulates mainly in fish liver and kidneys whereas high concentrations were reported in muscular tissues.

The present study, though smaller in its nature, has thrown light on a very important toxicological aspect regarding fish consumption. The results indicate that the levels of arsenic and cadmium in fresh and frozen fish samples are far above the limits suggested by the local and the international regulatory bodies. In essence, based on the results of this study, the Jordanian consumer of fish is exposed to potentially toxic levels of arsenic and cadmium. And therefore, it is suggested that more intensive efforts should be put up for the monitoring of the levels of, at least, these two metals.

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