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Weight Dependence of Arsenic Concentration in the Arabian Sea Tuna Fish

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In recent years deep health concern has developed regarding the contamination of marine organisms by toxic trace metals. In this respect, the role of arsenic as a toxicant in fish is well established (Bohn 1975; Windom et al 1973; Passino 1982; Oladimeji 1984). Arsenic is also known as a carcinogen and has natural and anthropogenic origins wherefrom it enters the aquatic environment (La Touche 1982). Arsenic can also be released from the sediment by bacterial mobilization. However, not much is yet known about the distribution of arsenic concentration in various commercial fish. This is especially true about tuna fish which is abundantly consumed as canned fish throughout the world. Earlier studies on the weight dependence of trace metals in various fish were directed towards the estimation of Cu, Zn, Hg, Cd and Mn in several fish organs (Bache 1971; Ayling 1974; Boydon 1977). Recently arsenic levels in twelve Chilean marine species, irrespective of weight dependence, were reported by Santa Maria et al (1986).

The objective of the present investigation was to estimate the arsenic concentration in the edible muscle of Thunnus thynnus and Thunnus toggel (hereafter called tuna and longtail tuna) as they have great commercial value. These fish are widely available along the coastal line of Pakistan and are consumed abundantly in large bulk. Thus, it was felt justifiable on the basis of safety of human health that data, in the first instance, be obtained on arsenic concentration in tuna as a function of weight to check whether the metal distribution was species-specific or it depended on individual mode of development. The data, the first of the kind so far presented on the Arabian Sea tuna, would thus provide the required baseline quantitative information needed in future

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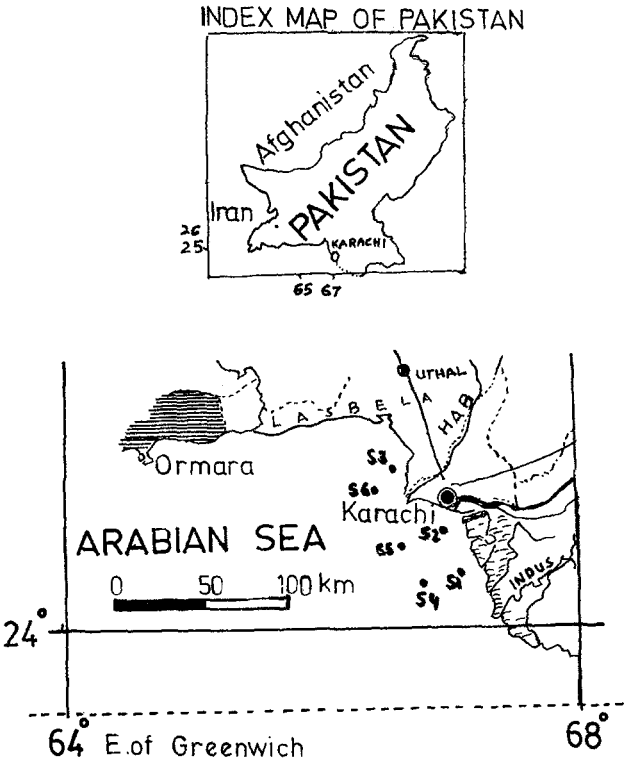

Figure 1. Location of sampling sites along Karachi coast.

studies on the physiological processes regulating the distribution and uptake of arsenic by these and other species of fish common to the region.

MATERIALS AND METHODS

All reagents used were of high purity (min 99.9%) spectroscopic grade. These were checked for any probable arsenic contamination at the detection level prior to use. All glassware used for the processing of the samples and for the preparation of standards was thoroughly washed with detergent solution and later with distilled water. It was then soaked in 5% nitric acid, rinsed with distilled water and kept for 3 h in electric oven at 100 °C prior to use at room temperature.

Sixteen samples of tuna and eighteen of longtail tuna were collected off the Karachi coast by professional fishermen during the period September 1986 to April 1987 (Figure 1). The concentration of arsenic in the edible muscle tissue was determined by the atomic

absorption method. Three to five parallel runs were conducted for each sample to ensure reliablity and reproducibility of data. The analytical procedure consisted of drying the homogenized wet samples at 130 °C in electric oven until constant weight was obtained. For the purpose of digestion, 30 g of the dried tissue were treated with 15 mL nitric acid (65%) and 15 mL sulfuric acid (d = 1.80 g/mL) at 20°C. When the sample decolorized completely, it was cooled down to room temperature. About 5 mL (3%) hydrogen peroxide was added and the heating process repeated until a clear solution was obtained. The digest was then cooled and made up to 100 mL with deionized water. The arsenic content was determined through the use of Arsenic Analyzer Assembly that could be interfaced to the Hitachi Atomic Absorption spectrophotometer, model 170-10. The measuring conditions were λabs 193.7 nm, bandpass 0.4$_3$ nm, lamp current 18 mA, air percolation 150-200 cm/min. FAO standards were used for intercalibration of our own standards.

RESULTS AND DISCUSSION

The data on the arsenic concentrations found in samples of two species of tuna are plotted in Figure 2 and Figure 3 as a function of weight of the fish. Salient features of the two groups of the data are summarized in Table 1 and the complete statistical analysis appears in Table 2.

The data plotted in the figures pertained to the mean concentration of arsenic computed on dry weight basis for replicate (3 to 5) measurements on each sample.

The data suggested that at least on average basis the arsenic content in the edible muscle of the two fish did not differ appreciably on the basis of t test, thus signifying that the two arsenic levels are identical. However, the spread around the mean arsenic concentrations was distinctly different for the two species, a fact supported by the corresponding % variation coefficient values. Although longtail tuna weighed more than tuna did, the arsenic concentrations in the former were found to be of relatively, as well as consistently, lower value. Thus, it could be inferred that the concentration of arsenic is species-specific. The closeness of the mean arsenic contents in the two fish species indicated that their arsenic levels were related to the levels of arsenic to which these species were exposed (Oladimeji 1984).

The data plotted in Figure 2 and Figure 3 clearly indicated a positive weight dependence of arsenic concentration in the muscle of the two tuna species. It turned out that in the case of longtail tuna, this

Table 1. Summary of data on the distribution of arsenic in the edible muscle of the tuna

Species/Location* (Samples)	Level	Arsenic Concentration (μg/g, dry wt)
Thunnus thynnus S1,S2,S3,S5,S6, (16)	maximum	2.948
	minimum	2.834
	mean ($\bar{X}$)	2.888
	±SD	0.040
	Variation Coefficient (%) **	1.971
Thunnus tonggel S1,S2,S3,S4,S5,S6 (18)	maximum	3.548
	minimum	1.844
	mean ($\bar{X}$)	2.511
	±SD	0.630
	Variation Coefficient (%) **	31.602

* With refrence to Figure 1;
** Variation Coefficient = 100 SD/$\bar{X}$

Table 2. Statistical analysis of data

Variable Number*	No.of Cases	Mean (μg/g)	Variance	Standard Deviation	Standard Error	Skewness	T-val	Kurtosis	T-val
1	16	2.888	0·002	0.040	0.010	0.002	0.00	-0·787	-0.72
2	16	1371.938	15624·729	124·999	31.250	-0·535	-0·95	-1.171	-1.07
3	18	2·511	0·397	0·630	0·149	0.438	0·82	-1.363	-1.31
4	18	616.444	19574·967	139·911	32.977	0.551	1.03	-0·807	-0·78

* 1, 3 = Concentration ; 2, 4 = Weight

dependence was not critical up to 500 g weight of the fish, beyond which there developed an almost linear increase in the arsenic concentration as a function of weight. The relative increase in the concentration of arsenic in this case was found to be about 0.1 μg per 100 g fish weight, while for weights beyond 500 g, the corresponding increase was about 6 times per 100 g fish weight. Hence, small fish (w < 500 g) showed at least promise of safety against any probable contamination. A uniquely different situation was encountered in the case of tuna for which an increase in arsenic

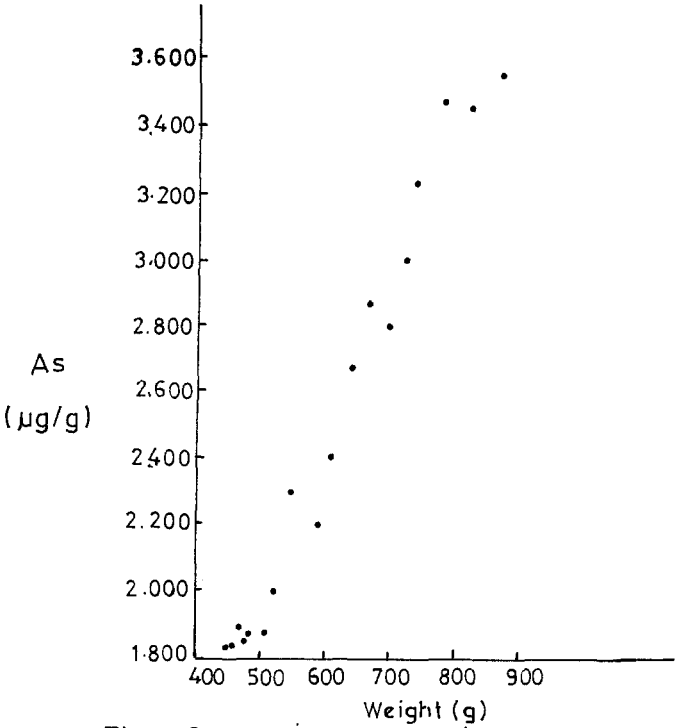

Figure 2. Arsenic concentration Vs. weight plot for longtail tuna.

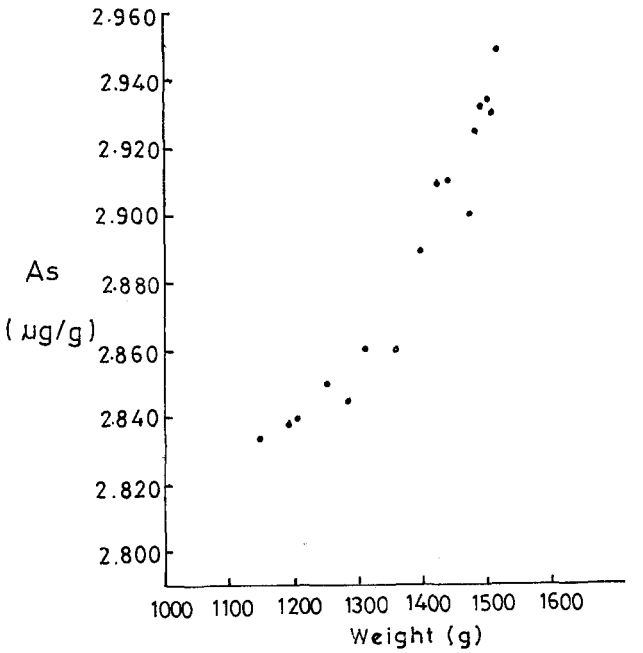

Figure 3. Arsenic concentration Vs.weight plot for tuna

concentration of about 0.01 µg per 100 g body weight (up to 1300 g) was observed, this suggested a greater uptake rate by longtail as a function of body weight. The inference drawn on the basis of current data on weight dependence related to the concentration of arsenic in the muscle of tuna fish caught from the same biotope since the weight dependence of the metal concentration would have become indistinct if data were compiled from geographically different localities. Besides, the absolute increase in heavy metals in muscle tissue of contaminated fish is much lower than in other organs, such as liver and kidney. A species-specific variation in metal content cannot, therefore, be judged by analysis of muscle. The tentative choice of muscle for analysis in this study was based on its edible character alone.

Regression analysis of the data was conducted using MSTAT statistical package on a WANG personal computer; the results of the analysis are presented in Table 2. The analysis established a positive correlation between the arsenic concentration (C) and the weight of the fish (W). In the case of tuna the correlation coefficient turned out to be 0.955, while for longtail it was 0.979. The ' best fit ' estimate of the C and W data yielded linear relation for tuna and longtail tuna: C=2.466+0.000307W and C=-0.209+0.000441W respectively. This analysis showed that the interrelation between C and W was highly significant (P=0.000).

The results presented here showed that the two tuna species were not rich in arsenic, and as such pose no physiological threat to the consumer. In the absence of specific comparative data, it was hard to compare our values against those representing the same species and origin. However, our data compare well with those by Cardeilhac (1981), though for different species belonging to diffrent origin.

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