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ARSENIC, A HARMLESS POISON IN FOODS OF MARINE ORIGIN

ARSEN, BEZAZLENI OTROV U HRANI IZ MORA

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In north Adriatic like in other seas, the concentration of total arsenic in foods of marine origin and in all marine animals is generally exceeding the concetrations approved by the sanitary food quality regulation. However, from the dietary point, arsenic does not represent a serious risk, bec ause it is mainly present in physiologically and toxicology inert organic forms.

INTRODUCTION

Arsenic is widely distributed in the environment in form of various inorganic and organic compounds of different toxicity to aquatic organisms (UNEP, 1978; Moore and Ramamorty, 1984; GESAMP, 1986; Atri, 1987; Michel, 1987; Fridberg, 1988; Ozretić *et al*.,1990). The toxicity of arsenic varies with the valency state, and inorganic forms are usually more toxic than organic ones. In ocean waters arsenic is present in the range 2-5 $\mu g\ l^{-1}$, in the Mediterranean it was found between 1.2-4.0 $\mu g\ l^{-1}$. In sediments, particulary in the regions nearby polluting sources the concetration is far higher. Arsenic is continuosly cycling among water, soil and sediments and it is present in all trophic levels. Most terrestrial and freshwater vegetal and animal foods contain less than 0.5 mg kg^{-1} w.w., but foods of marine origin are regularly overweighed with arsenic (Table 1). Thus sea foods are the predominant sources of human arsenic intake. In average, commercial teleost fish contain 2-8 mg As kg^{-1}, oysters 3-10, mussels as high as 120 and some prawns contain up to 170 mg kg^{-1}. Freshwater fish and crustacea have substantially lower concetrations of arsenic.

Table 1. Arsenic in the marine environment

Ocean waters	2.0 - 5.0	$\mu g\ l^{-1}$
Mediterranean	1.2 - 4.0	$\mu g\ l^{-1}$
Sediments	1 - >3000	$\mu g\ g^{-1}$
Marine biota $\mu g\ g^{-1}$ w.w. (n)		
Plankton	14 - 42	(3)
Macroalgae	1.4 - 179	(110)
Mollusca		
Bivalvia	5.0 - 1025	(10)
Gastropoda	9.0 - 640	(8)
Cephalopoda	6.4 - 99	(4)
Crustacea	8.4 - 272	(30)
Echinoderma	1.3 - 11	(4)
Polychaeta	4.0 - >2000	(3)
Teleostea	<0.2 - 449	(76)

Values were compiled from UNEP (1978) and Atri (1987). (n) - number of records.

OBJECTIVES

In the north Adriatic as well as in other seas, the concentration of total arsenic in marine animals was regularly exceeding the upper levels prescribed by the food quality regulation. The Sanitary Inspection Authorities when sampling marine foods from the fish market observed the presence of extremely high concentrations of arsenic. Thus the Rijeka Regional Department of Physical Planning and Environmental Protection initiated the organization of a research program to elucidate the problem. Sampling, chemical determination and integral presentation of results (As, Cd, Hg, Pb) were previously described (O z r e t i ć *et al.*, 1990). It is now our purpose to highlight the dietary significance and the toxicological implications of arsenic in marine foods and to appeal to the sanitary authorities to correct the maximum limits.

RESULTS AND DISCUSSION

Table 2 gives a synthetic view of the results obtained after the analysis of 108 samples of 29 benthic species collected from the Kvarner-Rijeka bay region (north Adriatic). The highest concentration of arsenic was found in Crustacea (8.8-182 mg As k^{-1}). In general the concentration in teleost fish and in Mollusca was significantly lower (1.2-47.1 mg,

and 2.3-19.0 kg^{-1} respectively) but still higher than the approved limits. Exceedingly high concentration were found in two samples of Selachia (280-1140 mg kg^{-1}). The mean concentration of arsenic in fish liver and in the invertebrate digestive gland was about twice that in the muscle tissue. The obtained results are in perfect agreement with data of previous cited authors.

Table 2. Total arsenic ($\mu g\ g^{-1}$ w.w.) in benthic organisms from Rijeka-Kvarner Bay region (North Adriatic).

	average	±s	range
Teleost fish			
muscle (25)	11.9	10.3	1.2 - 27.1
liver (9)	16.4	18.7	3.7 - 47.0
Selachia			
muscle (2)			280 - 1140
Crustacea			
muscle (9)	36.7	25.9	8.8 - 66.1
digestive gland (7)	92.1	70.4	16.7 - 182.7
Mollusca			
whole body (74)	6.9	7.0	2.3 - 19.0

(n) - number of samples

The Croatian food quality regulation (Sl. list 1983) imposes that the upper concentration levels of arsenic in foods of marine origin should not exceed 2 or 4 mg As kg^{-1} w.w. for fish or for Crustacea and Mollusca, respectively. Our results indicated that among the analyzed Crustacea not any was satisfactory, since their average concentration of arsenic was almost 6-18 times higher. Among fish only 22% were satisfactory, while Mollusca exhibited nearly 63% satisfactory records. Thus, almost all marine foods should be banned from the market: an inappropriate solution that in practice has never been adopted. These limiting values have been approved accordingly to the toxicity expected from inorganic arsenic compounds. However, from the public health aspect the high concentration of arsenic in marine animals does not represent a serious risk. Primarily, one must take in consideration that arsenic in marine organisms was present in geological time scale and, not a few human populations have evolved healthy consuming substantial amounts of marine foods. As a metter of fact the largest part of arsenic (90-98%) is actually present as a highly stable and physiologically inactive arsenobetain complex and small amounts of other organoarsenic derivates (F o w l e r , 1983; GESAMP, 1986; F r i d b e r g , 1988). It appears that the ingested arsenobetain is almost completely absorbed in the gastrointestinal tract and readily excreted unchanged. No accumulation nor toxic effect have been so far evidenced. When ingested, the remaining 2-10% inorganic arsenic are transformed by methylation to

organic forms and rapidly exceted, aand only small rasiduals tend to be accumulated. Chronic exposure to inorganic arsenic is by far the most toxic and teratogenic (hyperpigmentation, hyperkeratosis, skin cancer, "Black foot disease", chromosomal abnormalities)(F o w l e r 1983). According to the WHO Environmental Health Criteria (WHO, 1981), it was estimated that even a substantial average consuption of 60-150 g sea food per day in a lifetime does not increase the incidence of skin cancer (GESAMP, 1986). Only in case of an extreme daily consuption of 1 kg (!) of arsenic highly loaded flatfish, crustacea and mollusca over a lifetime one can approach the limits when a 5% increased skin cancer risk may occur. Whereas the significance of this projection is almost hypothetic, we have to consider that the population inolved is restricted mainly to fisherman. Since they are at the same time extensively exposed to sunlight, the incidence of skin cancer induced by UV irradiation is far higher of the expected cancerogenic effect of arsenic consumed with marine foods.

Finally, we must acknowledge that some arsenic compounds are authorized as additives in animal foods to favor growth and promote resistance to diseases (US Federal Drug Administration).

CONCLUSIONS

In conclusion we recommend to the Public Health Authorities concerned to reevaluate the maximal permissible limits of arsenic in foods of marine origin till to 20-40 mg kg^{-1} w.w. at least. To the Sanitary Inspection Authorities we suggest to neglect the amount of arsenic in samples from the fish market. We also encourage the consumers to eat particularly shrimps, lobsters, crabs, oysters and other exquisite arsenic carriers. The benefit and the pleasure is far higher than the risk.

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KRATKI SADRŽAJ

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