Precis

Ce communiqué concerne les niveaux de l'arsénique dans les poissons les crustacés et les coquillages qui sont mis à terre aux principaux ports écossais. Les résultats démontrent que les poissons plats ont des niveaux plus élevés que les autres espèces de poissons et que les crustacés ont des niveaux plus élevés que les mollusques.

Ce communiqué propose qu il y a une possibilité d'un rapport direct entre les niveaux de l'arsénique dans la nourriture et les differentes especes de poissons et que ce peut être la cause des différences dans les niveaux de l'arsénique dans les mêmes espèces pris dans des régions differentes d'échantillonage. Des études préliminaires sur les poissons suggerent qu'il se produit avec l'âge ou avec la taille une accumulation de l'arsénique.

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ARSENIC IN FISH AND SHELLFISH FROM SCOTTISH WATERS

by

R.J. Shepherd and G. Topping
Marine Laboratory, Aberdeen, Scotland, UK

Abstract

This paper reports on a survey of arsenic in fish and shellfish landed at major Scottish fishing ports. The results show that flat fish contain higher levels than round fish and that crustacea contain higher levels than molluscs. It is argued that the differences between species may be directly related to the level of arsenic in the food and that this factor may be responsible for the differences in arsenic levels in the same species from different sampling areas. Some preliminary work on fish suggests that there is an accummulation of arsenic with age/size.

Introduction

The occurrence of high levels of arsenic in marine organisms has been known for some time (Chapman and Linden, 1926) but until recently little information was available on the concentration and variation of arsenic in individual fish and shellfish (IDOE, 1972; Windom et al., 1973; Leblanc and Jackson, 1974; Freeman and Uthe, 1974; Bohn, 1975 and Zook et al., 1976). Even now few data are available on the arsenic content of fish and shellfish from the North Sea area.

This report presents the findings of the survey during 1975-1976 conducted by the Marine Laboratory of the arsenic content of most of the commercially exploited fish and shellfish species landed at Scottish fishing ports. This survey formed part of a national study of arsenic levels in foodstuffs.

Materials and Methods

Fish Sampling

The fish market sampling programme was designed to allow the collection of representative commercial species from all high catch areas and from the Firth of Clyde and Firth of Forth.

In general, samples consisted of ten individuals which covered the size range landed for each area. Each fish was filleted, skinned and homogenised by kneeding in a plastic bag. Only the edible portions of shellfish were taken; samples of shrimps, nephrops and periwinkles consisted of 50 individuals, which were bulked to produce a homogenate. Sub-samples of muscle tissue and bulked homogenates were stored in plastic containers in the deep freeze prior to analysis.

Total arsenic analysis

Total arsenic was determined using a composite arsine/flame atomic absorption method based on the techniques described by Fernandez, 1973; Uthe et al., 1974; Thompson and Thomerson, 1974 and Aggett and Aspell, 1976. 1-3 g of wet tissue was heated gently with concentrated nitric acid (5 ml) in the presence of vanadium pentoxide (0.1 g) for 10-15 minutes. After cooling and adding concentrated sulphuric acid (4 ml) the solution was refluxed for 1 hour until white fumes appeared. The solution was cooled and made up to 25 ml using distilled water. A 3 ml aliquot of this solution was treated with 2 ml of 20% solution of sodium borohydride to reduce the inorganic arsenic to arsine. The gaseous products of this reaction were passed into the hydrogen/argon flame of an atomic absorption spectro photometer and the absorbence measured. The method was calibrated using As standards.

This analytical procedure has been recently intercalibrated with a number of other methods employed by UK laboratories. Good agreement was achieved using reference samples containing 1-10 µg As/g.

Results and Discussion

The results are summarised in Tables 1-2 giving mean values and range of values for each species on an area basis.

The concentration of arsenic in the edible tissue of fish falls in the range 0.2 - 89.9 µg/g. In general flat fish contain more arsenic than round fish eg maximum values in plaice, witch, lemon sole and common dab are 89.9, 44.2, 30.0 and 11.6 µg/g respectively whereas maximum values in cod, haddock, whiting, saithe, mackerel and herring are 18.6, 6.7, 2.6, 1.8, 1.6 and 2.4 µg/g respectively.

Arsenic values in shellfish tissue ranged from 4.5 - 38.2 µg/g; highest values being found in the white meat of edible crabs and lowest values in the muscle tissue of queens. In general the crustaceans contain more arsenic than the molluscs. It would seem that the feeding behaviour of these respective groups of animals influences the eventual body burden of arsenic ie filter feeders (scallops and queens) have consistently lower levels of arsenic than scavengers such as lobsters, crabs and shrimps.

It is generally accepted that most of the arsenic present in the marine organisms is organically bound and less toxic than inorganic arsenic. Lunde (1973) showed that the majority of the organically bound arsenic in fish and shellfish is stable. Leblanc and Jackson (1974) argued that the complexed arsenic may not be eliminated by certain marine species and that the high levels and variations in arsenic content may be ascribed to the difference in food taken by the individual species. The data collected here would appear to support this latter statement. Round fish such as whiting and saithe, which feed primarily on small fish have consistently low levels of arsenic whereas flat fish such as plaice, sole and witch whose food consists of bottom living invertebrates, small crustaceans, molluscs and worms have relatively high levels of arsenic. Copepods, which form the main food of herring and mackerel, have been shown by Bohn (1975) to contain relatively small concentrations of arsenic (ca 0.6 µg As/g wet weight). Dogfish and ling, which are active predators of round fish, have arsenic levels similar to the round fish group. In his comparison of the feeding habits of whiting and haddock Jones (1954) stated that haddock eat relatively more crustaceans, molluscs and worms than

whiting which might explain why occasional high values are associated with haddock. Likewise the relatively high values associated with cod, which is primarily a fish eater, could be explained by the fact that it is known to prey heavily on crustaceans when this food is abundant (Rae, 1966). The range of values of arsenic associated with megrim (1.2 - 3.4 ug/g) is low compared to the rest of the flat fish group. According to Rae (1969), however, the diet of the largest megrims consists almost entirely of fish and therefore the values of arsenic obtained for megrim are consistent with the findings for round fish.

Although the above argues that food is an important factor in the ultimate body burden of marine fish it should be recognised that levels will also be affected by the metabolism of the fish. Unfortunately there is little information available on arsenic metabolism in relation to marine organisms. Likewise there is no information on seasonal variation of arsenic content in marine organisms.

On the basis of the data presented in Table 1, it is difficult to judge whether there are differences in arsenic levels for the same species from different areas. Values for plaice from the Ling and Bergen Bank areas however are considerably higher than for plaice from any other area. During 1977 further samples of plaice were collected from this area of the North Sea in an attempt to confirm the incidence of high values and also to examine the relationship between arsenic levels and size of fish. The arsenic values obtained for these samples were lower than the first set of samples and in general fell in the range of values encountered during 1975 for the remaining sampling areas. These data (Fig. 1) suggests that arsenic levels in plaice tend to increase with age or weight of fish.

It appears that the arsenic content of the muscle tissue of fish can depend on two factors (a) the arsenic content of the fish's food and (b) the size of the fish. The high arsenic values found in plaice from the central North Sea reflect these two factors and indicate that the arsenic content of the prey of the plaice in this area is higher than elsewhere. Is it possible that plaice from this area are feeding preferentially on organisms with a high, but natural, arsenic content or are the fish feeding on a typical plaice diet but one with unnaturally high arsenic levels? Further studies are obviously needed to answer this question.

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TABLE 1

TOTAL ARSENIC LEVELS IN FISH FROM SCOTTISH WATERS

SAMPLING AREA

Mean (and Range) Values/ug g^{-1} wet weight

SPECIES	BERGEN BANK	LING BANK	FIRTH OF FORTH	ABERDEEN	MORAY FIRTH	LERWICK	AYR (CLYDE)	WEST COAST
PLAICE Pleuronectes platessa	15.8 (6.7-27.5)	43.2 (9.5-89.9)	3.9 (1.0-8.0)	7.2 (4.0-11.2)	15.1 (3.3-41.3)	2.5 (1.5-3.1)	9.1 (5.6-14.4)	
LEMON SOLE Microstomus kitt			15.3 (14.0-16.0)	11.5 (6.8-19.5)				
WITCH Glyptocephalus cynoglossus	14.5 (6.8-28.2)	12.7 (4.6-44.2)					15.6 (8.1-23.5)	
DABS Limanda limanda				4.5 (2.5-11.6)				
MEGRIM Lepidorhombus whiffiagonis								2.2 (1.2-3.4)
SKATE Raja sp.				15.4 (9.1-31.8)				
ANGLER Lophius piscatorius				8.2 (2.7-17.5)		7.9 (3.7-17.5)	12.4 (4.0-21.4)	
DOGFISH Squalus acanthias				2.7 (1.9-3.8)				
LING Molva molva				2.4 (1.2-3.8)				
HADDOCK Melanogrammus aeglefinus	4.9 (1.1-5.7)	3.3 (1.4-6.7)	3.0 (2.2-4.1)			1.5 (1.1-2.4)	5.5 (3.9-6.7)	
COD Gadus morhua	1.4 (0.6-2.4)	1.6 (0.5-4.3)	2.1 (0.8-4.6)			0.7 (0.4-2.0)	4.6 (0.7-18.6)	
WHITING Merlangius merlangus	1.7 (0.8-2.6)	1.5 (0.8-2.[illegible])	1.5 (1.0-1.9)			1.0 (0.6-1.2)	1.4 (0.9-2.4)	

TABLE 1 (cont.)

SAMPLING AREA

Mean (and Range) Values/ug g^{-1} wet weight

SPECIES	BERGEN BANK	LING BANK	FIRTH OF FORTH	ABERDEEN	MORAY FIRTH	LERWICK	AYR (CLYDE)	WEST COAST
SAITHE Pollachius virens	0.9 (0.2-1.8)	1.4 (0.5-3.5)	0.6 (0.4-0.8)			0.6 (0.4-1.0)	0.8 (0.6-1.3)	
HAKE Merluccius merluccius							0.8 (0.5-1.5)	
HERRING Clupea harengus						1.0 (0.4-1.4)	1.5 (1.0-2.4)	1.1 (0.5-1.7)
SPRAT Sprattus sprattus							1.5 (0.8-2.2)	
MACKEREL Scomber scombrus	1.0 (0.7-1.6)		0.4 (0.2-0.7)			0.7 (0.3-1.4)	1.5 (0.4-1.7)	

TABLE 2

TOTAL ARSENIC LEVELS IN SHELLFISH FROM SCOTTISH WATERS

SAMPLING AREA

Mean (and Range) Values/ug g^{-1} wet weight

SPECIES	LING BANK	FIRTH OF FORTH	MORAY FIRTH	ORKNEY	LERWICK	AYR	WEST COAST	FARNE DEEPS
SQUID Loligo forbesii	3.8 (3.3-4.8)					8.0 (5.3-9.9)	5.9 (4.0-7.2)	
NEPHROPS Nephrops norvegicus		2.7	6.6			2.6	5.8	
SHRIMPS Pandalus borealis								11.4
LOBSTER Homarus vulgaris								
CLAW				5.7 (3.3-11.0)				
TAIL				6.4 (3.9-17.9)				
CRAB Cancer pegurus								
White Meat		22.3 (8.0-38.2)		11.3 (4.5-28.9)				
Brown Meat		1.64 (7.9-25.4)		10.0 (3.3-22.7)				
SCALLOPS Pecten maximus					1.4 (0.8-2.1)	1.0 (0.8-1.2)		
QUEENS Chlamys opercularis					0.9 (0.4-1.1)			
LITTORINA Littorina littorea		16.1				2.2		

Figure 1. The accumulation of arsenic in plaice with age and weight of fish