

PCDDS, PCDFS AND PCBS IN FISH AND FISH FINGERS ON SALE IN THE UK

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Introduction

To estimate dietary exposure to PCDD/Fs and PCBs it is important to take into account the contribution from as many different foods as possible. In the UK the Total Diet Study (TDS) provides some of this information¹. The fish food group from this study includes both marine and freshwater fish in proportion to their consumption in the UK. A previous survey of farmed trout has provided data for the PCDD/F and PCB content of freshwater fish but only limited data for marine fish were available². This paper presents results of a survey of PCDD/Fs and PCBs in retail marine fish and fish fingers available in the UK in order to estimate the dietary exposure of consumers to these chemicals from fish. For the survey 108 samples of marine fish, 12 samples of salmon and 12 samples of fish fingers had their PCDD/F and PCB content determined.

Marine fish have been surveyed in other countries, especially for PCBs³⁻⁸.

Materials and Methods

Samples of fish were either fillets, for larger species such as cod and haddock, or whole fish. Whole fish samples were filleted and all fillets were skinned, sub-sampled and homogenised. Fish fingers were homogenised complete with their breadcrumb coatings. All analysis was done on raw samples in contrast to the TDS fish sample in which the foods were analysed as consumed i.e. cooked.

The seventeen 2,3,7,8-substituted dioxins and furans, four non-*ortho*-PCBs (77, 81, 126 and 169) and twenty one *ortho*-PCBs (18, 28, 31, 47, 49, 51, 52, 99, 101, 105, 114, 118, 123, 128, 138, 153, 156, 157, 167, 180 and 189) were determined.

The extraction, clean up and analysis methods used have been published previously⁹.

Results and Discussion

More information on this survey is available in a UK MAFF/Department of Health Joint Food Safety and Standards Group Food Surveillance Information Sheet¹⁰.

The results ranges and mean concentrations for individual species are presented in Table 1.

In summary the concentrations of PCDD/Fs and dioxin-like PCBs found in the fish samples ranged between 0.9 and 140 ng WHO-TEQ/kg fat. In general, concentrations found in this survey are similar to those found elsewhere. Concentrations of PCDD/Fs and PCBs in samples of fish taken from the Baltic Sea, which is known to be contaminated, have been found to be higher^{6,7}.

For white (<10% fat) fish (including fish fingers):

- PCDD/Fs concentrations were in the range 0.3 – 43 ng WHO-TEQ/kg fat.

- Dioxin-like PCBs concentrations were in the range 0.3 – 91 ng WHO-TEQ/kg fat.
- Combined PCDD/Fs and PCBs were in the range 0.9 – 110 ng WHO-TEQ/kg fat.

For oily (>10% fat) fish:

- PCDD/Fs concentrations were in the range 1.0 – 38 ng WHO-TEQ/kg fat.
- Dioxin-like PCBs concentrations were in the range 2.5 – 110 ng WHO-TEQ/kg fat.
- Combined PCDD/Fs and PCBs were in the range 3.4 – 140 ng WHO-TEQ/kg fat.

Concentrations of PCDD/Fs and PCBs found in the survey varied with the fish species, fat content and sampling month. Concentrations of PCDD/Fs and PCBs on a fat basis were significantly higher in herring, red fish and plaice than in the other species. Significantly lower concentrations of PCDD/Fs and PCBs on a fat weight basis were found in haddock and mackerel. A trend towards lower concentrations on a fat weight basis was seen for samples collected in February than those collected in November and May. On a whole weight basis this trend was not apparent, possibly due to seasonal variations in fat deposit patterns in fish.

Dietary exposures to PCDD/Fs and PCBs have been estimated from the results of this survey, using the mean concentrations determined in each fish species and dietary survey data^{11,12,13}. Imported and UK fish were considered together for the purpose of calculating the mean concentration in individual species. Concentrations of PCDDs and PCBs in food products derived from fish tissue were assumed to be those of the parent fish species i.e. concentrations in kippers were assigned the same values as those found in raw herring. Fish cakes and cod in bread crumbs were assigned the same concentration values as fish fingers. Trout PCDD/F and PCB content was assumed to be that found in the previous survey¹⁴. The concentrations of PCDD/Fs and PCBs for the other food groups were assumed to be those estimated in the 1992 TDS survey.

Estimated average and high level (97.5th percentile) dietary exposures to PCDD/Fs and PCBs by UK adult consumers of marine fish, in combination with the rest of the diet are presented in Table 2. In summary, the dietary exposures to PCDD/Fs and PCBs from the consumption of fish and the rest of the diet were estimated to be:

- 2.6 pg WHO-TEQ/kg bodyweight/day for average adult consumers and 5.6 pg WHO-TEQ/kg bodyweight/day for a high level (97.5th percentile) adult consumer;
- 2.8 pg WHO-TEQ/kg bodyweight/day for the average schoolchild (age 10 – 15 years) consumer and 4.7 pg WHO-TEQ/kg bodyweight/day for a high level schoolchild consumer; and
- 5.5 – 6.5 pg WHO-TEQ/kg bodyweight/day and 8.3 – 10 pg WHO-TEQ/kg bodyweight/day for average and high level toddler consumer respectively, depending on age group.

Analysis was carried out on raw samples. It has been observed by others that cooking can result in the concentrations of PCBs reducing by an average of 46%¹⁵⁻¹⁸. These findings are consistent with the results from TDS surveys¹. PCB concentrations in herring from the Baltic Sea, which have been the subject of long-term monitoring, are seen to be declining by 6.3 – 13% per year¹⁹. It is likely that PCDD/F and PCB concentrations in marine fish on sale in the UK are also falling in line with the trend seen in other studies¹.

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References

1. Ministry of Agriculture, Fisheries and Food (1997). Food Surveillance Information Sheet No. 105, MAFF, London.
2. Ministry of Agriculture, Fisheries and Food (1992). Food Surveillance Paper No. 31, publ. The Stationery Office.
3. Becher, G., Eriksen, G.S., Lund-Larsen, K., Skaare, J.U., Schlabach, M. and Alexander, J. (1998). Paper presented at 18th Symposium, on Halogenated Environmental Organic Pollutants, Stockholm, 17-21 August 1998.
4. Atuma, S.S., Linder, C.-E., Wicklund-Glynn, A., Andersson, Ö. and Larsson, L. (1996). *Chemosphere* 33, 791-799.
5. Ali, I.B., Joiris, C.R. and Holsbeek, L. (1997). *Bulletin of Environmental Contamination and Toxicology*. 58, 885-892.
6. Koistinen, J. (1990). *Chemosphere* 20, 1043-1048.
7. Atuma, S.S., Aune, M., Bergh, A., Wicklund-Glynn, A., Damerud, P.O., Larsson, L., Ohlsson, M. and Sandström, O. (1996). Paper presented at 18th Symposium, on Halogenated Environmental Organic Pollutants, Stockholm, 17-21 August 1998.
8. Becher, G., Jensen, A.J., Zubchenko, A., Haug, L.S., Hvidsten, N.A., Johnsen, B.O. and Kashin, E. (1998). Paper presented at 18th Symposium, on Halogenated Environmental Organic Pollutants, Stockholm, 17-21 August 1998.
9. Krokos, F., Creaser, C.S., Wright, C. and Startin, J.R. (1997). *Fresenius Journal of Analytical Chemistry* 357, 732-742.
10. Ministry of Agriculture, Fisheries and Food (1999). Food Surveillance Information Sheet No. 184, MAFF, London. [<http://www.maff.gov.uk/food/infsheet/index.htm>]
11. Gregory, J., Foster, K., Tyler, H. and Wiseman, M. (1990) Dietary and nutritional survey of British adults, publ. The Stationery Office.
12. Department of Health, Committee on Medical Aspects of Food Policy (1989) The diets of British schoolchildren. Report on Health and Social Subjects No. 36, publ. The Stationery Office.
13. Gregory, J.R., Collind, D.L., Davies, P.S.W., Hughes, J.M. and Clarke, P.C. (1995) National Dietary and Nutritional Survey: children aged 1' to 4' years. Volume 1: report of the diet and nutritional study, publ. The Stationery Office.
14. Ministry of Agriculture, Fisheries and Food (1998). Food Surveillance Information Sheet No. 145, MAFF, London.
15. Salama, A.A., Mohamed, M.A.M., Duval, B., Potter, T.L. and Levin, R.E. (1998). *Journal of Agricultural and Food Chemistry* 46, 1359-1362.
16. Trotter, W.J. and Corneliussen, P.E. (1989). *Journal of the Association of Official Analytical Chemists* 72, 501-503.
17. Zabik, M.E. and Zabik, M.J. (1995). *Bulletin of Environmental Contamination and Toxicology* 55, 264-269.
18. Zabik, M.E., Booren, Al., Zabik, M.J., Welch, R. and Humphrey, H. (1996). *Food Chemistry* 55, 231-239.
19. Bignert, A., Olsson, M., Persson, W., Jensen, S., Zakrisson, S., Litzén, K., Eriksson, U., Häggberg, L. and Alsberg, T. (1998). *Environmental Pollution* 99, 177-198.

Table 1: Concentrations of PCDD/Fs and PCBs in edible tissue samples from marine fish (ng WHO-TEQ/kg fat).

Fish Type	n	Concentrations (ng WHO-TEQ/kg fat)					
		PCDD/Fs		PCBs		PCDD/Fs & PCBs	
		Mean	Range	Mean	Range	Mean	Range
UK landed							
Cod	17	9	2.1-24	17	3.3-76	26	7.2-98
Haddock	16	6.9	1.1-14	7.4	2.2-22	14	5.5-24
Plaice	10	25	3.6-43	42	9.5-55	67	13-90
Whiting	14	8.3	2.0-20	23	2.4-91	32	4.4-110
Herring	10	24	13-38	59	12-110	83	26-140
Mackerel	13	3.8	1.0-9.0	14	2.5-31	17	3.4-40
Salmon	11	6.5	4.6-11	19	12-30	25	16-38
Fish fingers	12	0.7	0.3-2.4	1.6	0.3-6.2	2.3	0.9-6.6
Imported							
Cod	13	6.1	1.4-18	9.7	2.0-32	16	6.3-50
Haddock	10	4.6	1.9-8.5	5.4	1.9-12	10	4.2-19
Plaice	3	20	16-27	33	21-57	54	37-84
Salmon	1	3.4	3.4	12	12	16	16
Red fish	2	14	12,16	43	42,44	57	57,57

Table 2: Estimated upper bound dietary exposure of adults to PCDD/Fs and PCBs from marine fish and the rest of the diet (pg WHO-TEQ/kg bodyweight/day)

Fish Type	Average consumer			High level consumer		
	PCDD/Fs	PCBs	PCDD/Fs and PCBs	PCDD/Fs	PCBs	PCDD/Fs and PCBs
Cod	0.02	0.03	0.05	0.05	0.09	0.14
Haddock †	0.01	0.01	0.02	0.02	0.02	0.04
Plaice	0.11	0.18	0.29	0.22	0.36	0.58
Whiting †	0.01	0.03	0.04	0.03	0.07	0.09
Fish fingers/cakes	0.01	0.03	0.04	0.04	0.08	0.12
All white fish‡	0.03	0.06	0.09	0.15	0.25	0.40
Herring	0.86	2.20	3.0	1.7	4.4	6.1
Mackerel	0.21	0.76	1.0	0.51	1.9	2.4
Salmon	0.17	0.51	0.68	0.59	1.7	2.3
All oily fish††	0.22	0.60	0.82	1.3	3.5	4.8
All fish	0.14	0.33	0.47	0.94	2.5	3.4
All fish + rest of diet‡‡	1.6	1.0	2.6	2.9	2.9	5.6

† Consumed by less than 60 (2.5%) of participating adult consumers. High level to be treated with caution.

‡ Also includes dogfish, halibut, hake, lemon sole, scampi, skate, sole, squid and turbot at concentrations found in 1992 TDS fish group sample.

†† Also includes trout at concentrations found in farmed trout survey and consumption of anchovies, bloaters, eels, pilchards, sprats, tuna and turbot at concentrations found in 1992 TDS fish group sample.

‡‡ Dietary intakes from the rest of the diet were estimated from concentrations found in the 1992 TDS samples for food groups other than fish.