

TRENDS IN THE DIOXIN AND PCB CONTENT OF THE UK DIET

Alwyn Fernandes¹, Barbara Gallani², Martin Gem², Shaun White¹, Martin Rose¹

¹Central Science Laboratory, York

²Food Standards Agency, London

Introduction

The monitoring of food for common contaminants and nutrients is increasingly being carried out by government organisations as well as food producers. These studies provide data on the constituents of the diet and allow assessment of the quality of food available to consumers. They also allow the estimation of exposure of different population groups to contaminants such as PCBs and dioxins that may be present in food.

Two of the major known pathways by which dioxins and PCBs enter the food chain are via environmental transfer from sources such as incineration processes and the open-ended use of PCBs. In the past incinerators were the major source of dioxins to the UK environment. However, releases of dioxins from industries have been controlled for some years under Pollution Prevention and Control and previous Integrated Pollution Control regulations. The most significant sources are now diffuse sources such as bonfires and fireworks. The use of PCBs in new equipment has been banned for many years, and under existing regulations, remaining PCB-containing equipment must be identified and suitably destroyed. The importance of animal feed as a source of dioxins and dioxin-like PCBs to the human food chain has been highlighted in recent years by food contamination incidents such as that involving citrus pulp from South America (2), the Belgian PCB/dioxin contamination of animal feed (3).

The dietary exposure of the UK population to dioxins and PCBs has been monitored by the analysis of food group samples from the Total Diet Study. The Total Diet Study is a model of the average domestic diet in the UK (4,5).

This paper evaluates the trends in dioxin and PCB concentration in food groups collected in the UK as part of the TDS from 1982, 1992, 1997 and 2001.

Sampling and Analysis

A total of 121 categories of food and drink are specified for inclusion in the Total Diet. These are assigned to one of twenty broad food groups. Foods are grouped so that commodities known to be susceptible to contamination (e.g. offals and fish) are kept separate, as are foods which are

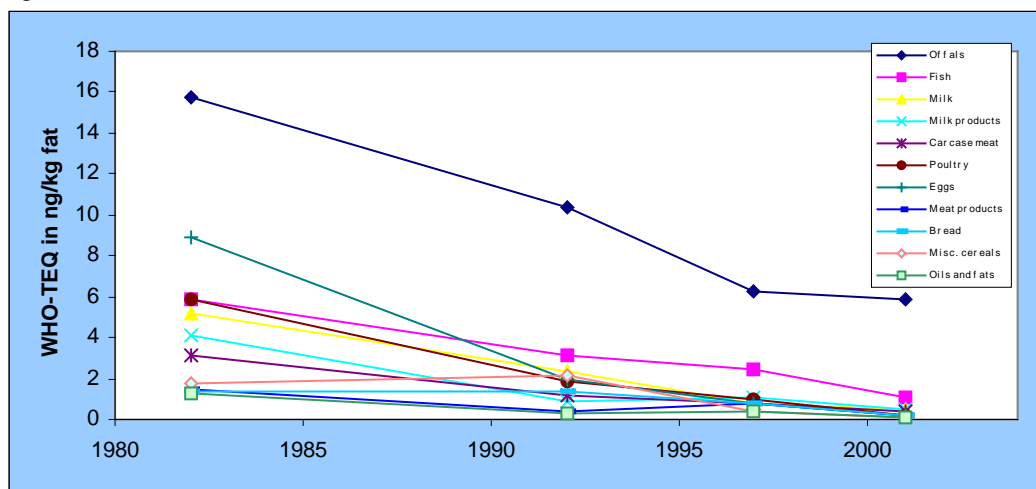
consumed in large quantities, e.g. bread, potatoes, milk. The quantities and relative proportions of each food that make up the Total Diet are largely based on data from the National Food Survey (NFS) (averages of the data from the previous three years) and are updated annually. For example, quantities of foods purchased for the 2001 TDS samples will have been determined by the average of the consumption data found in the NFS for 1998, 1999 and 2000. Food samples are purchased fortnightly from 24 randomly selected locations representative of the UK as a whole. The food samples are prepared and cooked according to normal consumer practice. The constituents of each food group are then homogenised and frozen.

Accredited and robustly validated methods used for the extraction and analysis of the samples have been reported previously (7). Sample batches included a blank and a BCR reference material. Data quality was ensured by continuous successful participation in international inter-calibration exercises (9,10,11) on the measurement of dioxins and PCBs in food and animal feed.

Results and Discussion

The concentration of dioxins and PCB WHO-TEQs detected in the various food groups are given in Table 1. (All data discussed in this paper are reported on an upper bound basis). The table includes only those food groups for which complete data are available for all 4 years that the dioxin surveys were conducted. This is because the 1982 and 1992 analyses were restricted to the 11 food groups that were most likely to contribute to human exposure. This choice was based on the fat content (meat, eggs, etc) or because of higher consumption (e.g. bread, milk). Thus food groups such as vegetables, fruits, sugars and preserves, etc were only measured for dioxin and PCB content in the 1997 and 2001 surveys. More detail on the concentration data for all the food groups is given elsewhere (8,12).

Figure 1: Trend in the dioxin WHO-TEQ content of UK food



The data for the 11 food groups has been plotted individually for dioxin (sum of PCDD and PCDF) WHO-TEQ and PCB WHO-TEQ over the period of the surveys (Figures 1 and 2). It is evident

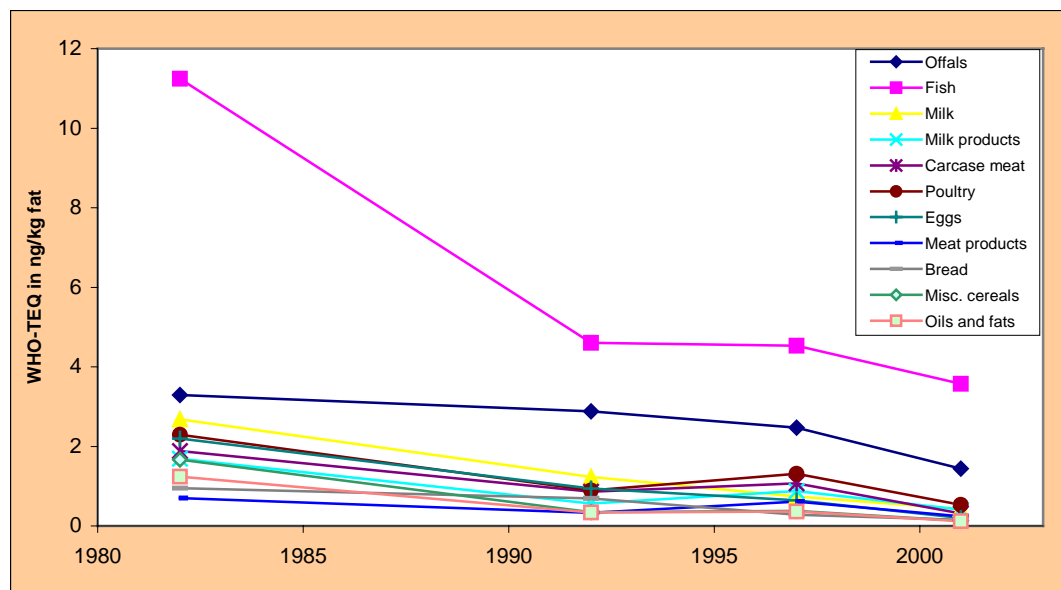
from these graphs that the measured concentrations for all the food groups declined over the 19 year period covered by the surveys. For the majority of the food groups the most striking reductions were observed over the first measurement interval although this was also the longest period between two measurements. Although a similar reduction is observed for most food groups between the last measurement interval it is likely that this is due in part at least to improvements in the sensitivity of the measurement of dioxins for the last set of data. The reduction in PCB WHO-TEQ is significantly lower than that observed for the dioxins for the 11 food groups discussed here – on average less than half that observed for dioxins.

The reasons for this difference are unclear. Dioxins and PCBs are structurally similar compounds and the range of occurrence (as WHO-TEQ) in the food groups at the time of the first measurement is similar, but input and removal mechanisms such as the levels of occurrence in animal feeds, the rate of metabolism in various species, environmental degradation, etc. may be quite different. Additionally, parts of the timescale coincide the introduction of pollution control measures (13) within the EU. (Integrated Pollution Control was only just coming into effect for incinerators when the 1992 TDS samples were collected). These would tend to have a greater influence on the decline in environmental, and subsequently food, concentrations of dioxins rather than PCBs. Although PCB usage has been severely restricted or banned (14) for some time now, the open-ended usage combined with high chemical stability may in part provide an explanation of the lower rate of reduction observed. The consequence of this lower rate of decline for the PCBs is that they increasingly make a more significant contribution to the combined WHO-TEQ. This can be seen in Figure 3 which plots the trend in average (of the 11 food groups) contribution of dioxins and PCBs to the WHO-TEQ.

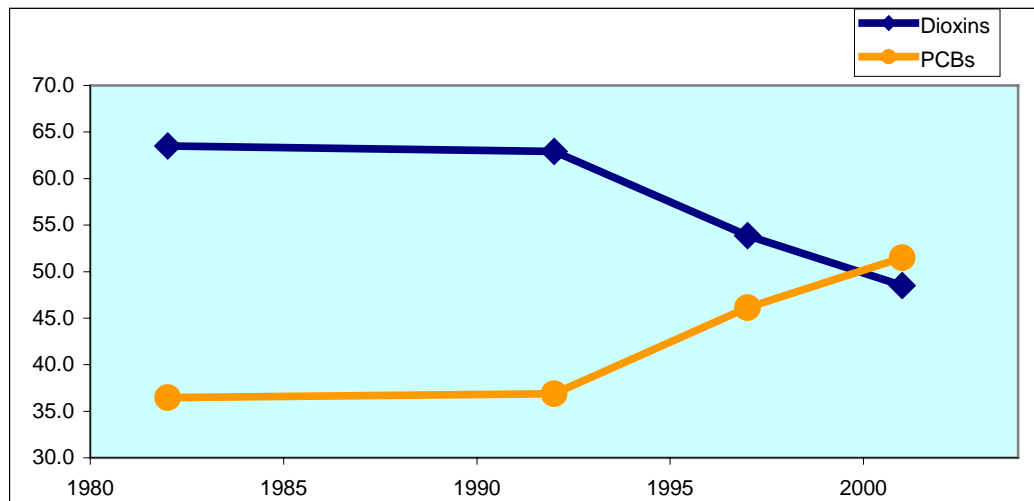
Table 1: Concentrations of dioxin and PCB WHO-TEQ in TDS food groups expressed as upper bound data in ng/kg fat

Year of Study =>	1982			1992			1997			2001		
Food group	Dioxin	PCB	Σ WHO-TEQ	Dioxin	PCB	Σ WHO-TEQ	Dioxin	PCB	Σ WHO-TEQ	Dioxin	PCB	Σ WHO-TEQ
Offals	15.76	3.29	19.05	10.33	2.88	13.21	6.29	2.47	8.76	5.88	1.44	7.32
Fish	5.83	11.24	17.07	3.14	4.6	7.75	2.4	4.53	6.93	1.06	3.57	4.63
Milk	5.21	2.68	7.88	2.38	1.23	3.61	0.83	0.74	1.57	0.47	0.43	0.9
Milk products	4.08	1.69	5.77	0.89	0.56	1.44	1.12	0.88	2	0.48	0.41	0.89
Carcase meat	3.16	1.88	5.04	1.15	0.86	2.01	0.8	1.07	1.87	0.42	0.31	0.73
Poultry	5.89	2.29	8.18	1.85	0.89	2.74	1.01	1.31	2.32	0.18	0.53	0.71
Eggs	8.93	2.2	11.12	1.97	0.94	2.91	0.77	0.64	1.41	0.24	0.2	0.44
Meat products	1.5	0.7	2.2	0.43	0.33	0.77	0.77	0.61	1.38	0.18	0.24	0.42
Bread	1.38	0.95	2.33	1.35	0.69	2.04	0.74	0.28	1.02	0.2	0.15	0.35
Misc. cereals	1.79	1.67	3.46	2.15	0.35	2.5	0.43	0.38	0.81	0.13	0.13	0.26
Oils and fats	1.29	1.24	2.54	0.29	0.34	0.64	0.44	0.36	0.8	0.07	0.12	0.19

Figure 2: Trends in the PCB WHO-TEQ content of UK food



The largest reductions were observed for the dioxin WHO-TEQs for poultry and eggs. Eggs also showed a large reduction for the PCB WHO-TEQ. The smallest reductions were observed for offal and fish that consistently showed the highest dioxin and PCB concentrations of all the food groups except for the 1982 dioxin WHO-TEQ for eggs. However, for the most recent measurement interval the concentrations of dioxins were below the EU regulatory limits (1) for all the food groups studied in the TDS.

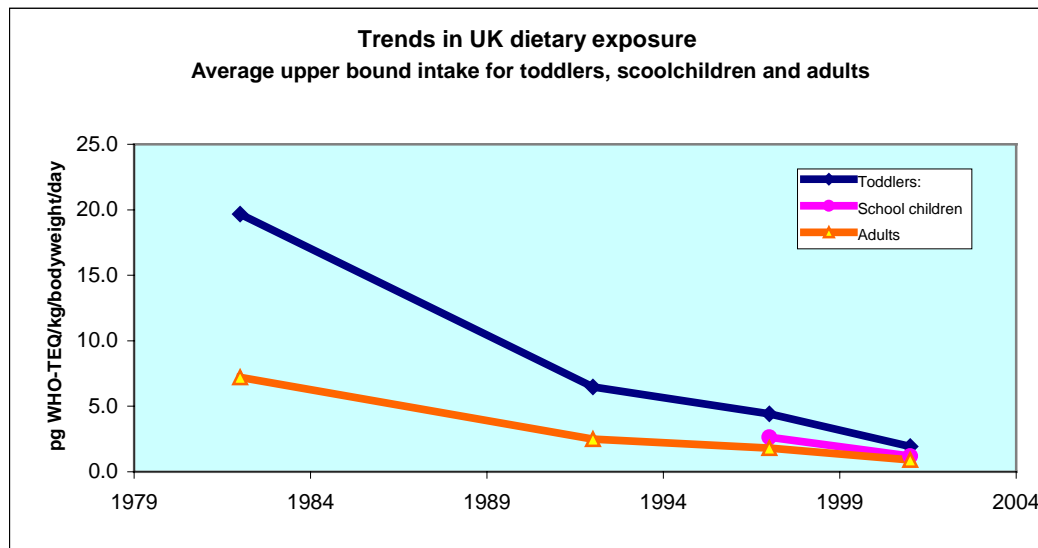
Figure 3: Percentage Contribution of Dioxins and PCBs to Σ WHO-TEQ

Dietary exposure

The observed decline in dioxin and PCB content of the various food groups is reflected in the estimated dietary intakes of the various UK population groups (8). Since 1982 the average adult dietary intake of dioxin and PCB WHO-TEQ has reduced from 7.2 pg WHO-TEQ/kg bodyweight/day to 0.9 pg/kg bodyweight/day in 2001. A similar decrease in average dietary intake is observed for very young children (toddlers) between the ages of 1.5 and 4.5 years of age with a reduction from 23 - 17 pg/kg bodyweight/day in 1982 to 2.2 - 1.7 pg/kg bodyweight/day in 2001. The dietary intake for school children also fell to a range of 1.8 – 0.7 pg/kg bodyweight/day in 2001 for an age group covering 4 to 18 years.

In general, estimated dietary intakes have fallen substantially over the last 19 years for all population groups. For example, the average intake has reduced 8-fold for adults and just under an order of magnitude for the youngest children (1.5 – 2.5 years of age). The intake figures for 2001 for all population groups are either within the current UK TDI of 2 pg WHO-TEQ/kg bodyweight/day or just exceed it (2.2 pg/kg bodyweight/day for the youngest toddlers). They are however well within the recommended WHO/JECFA limit of 70 pg WHO-TEQ/kg bw/month. Similarly the percentage of consumers that are estimated to exceed the UK TDI have also declined to about 1 % for adults, 10% on average for schoolchildren and 37% on average for children aged between 1.5 and 4.5 years. The trends in intake are summarized in Figure 4.

Figure 4: Trends in the estimated dietary intake for the UK



The estimated adult dietary intake compares well with data published for other countries. The average estimated exposure in the Basque county in Spain was 2.6 pg WHO-TEQ/kg bodyweight/day for food collected in 2000 (15). A similar exposure is reported (16) for adults in the Catalonia region of Spain for dioxin WHO-TEQ only, although the samples were collected in 1996. TDS samples collected in Japan (17) in 1999-2000 gave a dietary intake figure of 3.22 pg WHO-TEQ/kg bodyweight/day for a 50kg adult (this upper bound exposure was calculated by including the undetected values at $\frac{1}{2}$ LOD). In general, the trend in countries such as the UK, Germany and the Netherlands that have implemented dioxin emission controls since the early 1990s and for which data is available, is to decreasing PCDD and PCB levels in food and consequently dietary intake.

Conclusions

The concentrations of dioxins and PCBs in the TDS food groups declined over the 19 year period covered by the surveys. The largest reductions were observed for poultry and eggs; offal and fish showed the smallest reductions. The data for the most recent measurement interval showed that the concentrations of dioxins were below the EU regulatory limits for all food groups.

The reduction in PCB WHO-TEQ is significantly lower than that observed for the dioxins for the 11 food groups discussed here – on average less than half that observed for dioxins.

Acknowledgements

The authors are grateful to the UK Food Standards Agency for funding this work.

The opinions expressed are those of the authors and do not necessarily reflect those of either organisation.

References

1. European Commission (2001) Council Regulation (EC) No 2375/2001 of 29/11/2001, *Official Journal of the European Communities*, L 321, 06.12.2001, p1-5
2. Malish R, (2000), *Chemosphere*, **40**, 1041-1053
3. A Bernard C, Hermans F Broeckaert G Poorter A DeCock G Houins (1999) *Nature*, **40**, 231-2.
4. Ministry of Agriculture, Fisheries and Food. (1994). The British Diet: finding the facts. Food Surveillance Paper, 40. HMSO.
5. M E Peattie, D Buss, D.Lindsay and G.A. Smart, (1982). *Fd. Chem. Toxic.* **21** 4 503-507.
6. A Gleadle, M Gem and N Harrison (2000), *Organohalogen Compounds*, **47**, 292-295
7. A Fernandes, S White, K Dsilva and M Rose (2004), *Talanta*, (in press).
8. Food Standards Agency, 2003, Dioxins and dioxin-like PCBs in the UK diet: 2001 total diet study samples, *Food Survey Information Sheet* No. 38/03, Food Standards Agency, London
9. "Interlaboratory Comparison on dioxins in food – Second round of an International Study" National Institute of Public Health, Oslo, Norway, (2001) ISBN 82-7364-178-3
10. "Interlaboratory Comparison on dioxins in food – Third round of an International Study" Norwegian Institute of Public Health, Oslo, Norway, (2002) ISBN 82-8082-016-7
11. "Interlaboratory Comparison on dioxins in food – Fourth round of an International Study" Norwegian Institute of Public Health, Oslo, Norway, (2003) ISBN 82-8082-049-3
12. Central Science Laboratory (2003), PCDDs, PCDFs and PCBs in 2001 Total Diet Samples, CSL Report FD 02/41.
13. European Commission (1996). Council directive 96/61/EC.. *Official Journal of the European Communities*, L 257, 10.10.1996, 26.
14. DETR (2000), Environmental Protection Regulations, England and Wales: The disposal of PCBs and other dangerous substances, 2000, SI 1043. HMSO
15. Cuervo L, Jalon M, Rose M, Fernandes A, White S, and Gonzalez de Galdeano L (2002) *Organohalogen compounds*, **55**, 219 – 222.
16. J Domingo, M Schuhmaker, S Granero and J Llobet (1999), *Chemosphere*, **38(15)**,3515-3528
17. Tsutsumi T et al (2001), *Chemosphere*, **45**, 1129-1137