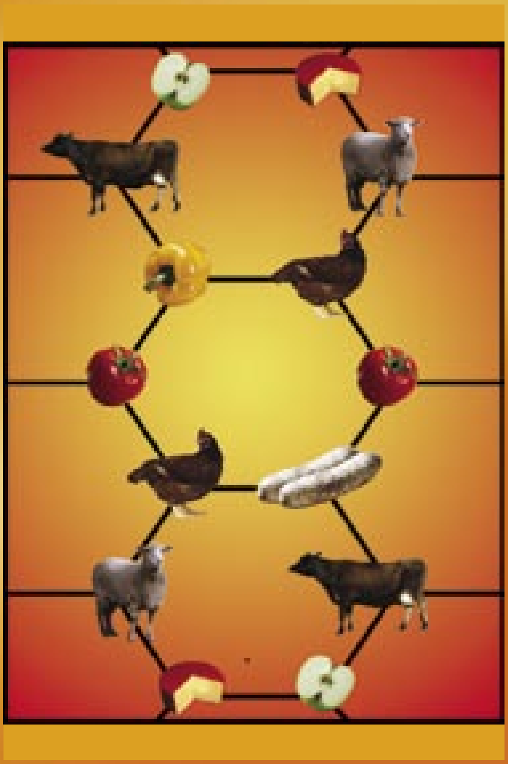
Food Safety
AUTHORITY OF IRELAND



Investigation into levels of dioxins, furans, PCBs and PBDEs in Irish food 2004.

Chemical Contaminants & Residues in Food

Investigation into levels of dioxins, furans, PCBs and PBDEs in Irish food 2004.

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Food Safety Authority of Ireland Discussion Paper: Investigation into levels of dioxins, furans, PCBs and PBDEs in Irish food 2004.

Summary

The Food Safety Authority of Ireland (FSAI), in collaboration with official food agencies, has carried out a surveillance study of levels of dioxins (PCDDs), furans (PCDFs), polychlorinated biphenyls (PCBs) and polybrominated flame retardants (polybrominated diphenylethers, PBDEs) in a variety of food available on the Irish market, including meat, offal, dairy products, fruit and vegetables. The study was undertaken because of concern about the possible effects on human health of these biopersistent environmental contaminants known to be present in a number of foodstuffs, notably meat, fish, eggs and dairy products.

The study showed that levels of PCDDs and PCDFs in Irish produce were well below existing legal limits. Whereas the lowest concentration (frequently below the limit of analytical detection, LOD) of all the substances tested were observed in fruit, vegetables, cereals and soup powder, the highest concentrations were found in animal liver, which, due to the nature of the substances tested and the metabolic function of this organ, was to be expected.

The total mean upper-bound levels of PCDDs, PCDFs and dioxin-like PCBs, expressed as WHO-TEQs, ranged from <0.13 ng/kg fat – 5.46 ng/kg fat for meat, offal, dairy products, soup powder and fats and oil; whereas fruit, vegetables and cereals, which are expressed on a whole weight basis did not exceed a level of WHO-TEQs <0.06 ng/kg w.w. The result of 5.46 ng/kg fat was obtained in sheep liver, and was by far the highest level observed in all samples tested. For PBDEs, the same pattern was observed with concentrations ranging from <0.8 µg/kg – 1.29 µg/kg fat (found in liver).

The results of the study are in line with those from previous FSAI studies on dioxin and furan levels in milk, fish and eggs and support the conclusion that levels in Irish food are relatively low compared with similar products from more industrialised countries in the European Union, and well below limits in current and proposed European Regulations. The findings indicate that exposure of consumers of Irish food to dioxins and furans in food is therefore likely to be lower than the European average.

The full study report follows, providing further details and discussion of these results.

Abbreviations

Ah receptor	aryl hydrocarbon (Ah) receptor
b.w.	body weight
DCMNR	Department of Communication, Marine and Natural Resources
EC	European Community
EU	European Union
EFSA	European Food Safety Authority
FSAI	Food Safety Authority of Ireland
HSE	Health Service Executive (formerly the Health Boards)
JECFA	FAO/WHO Joint Expert Committee Food Additives and Contaminants
LOD	Limit of Detection
LOQ	Limit of Quantification/Quantitation
Lower-bound	Analytical results reported below the LOD set at zero
MI	Marine Institute
ng	nanogram (0.000000001 g)
pg	picogram (0.000000000001 g)
ppb	parts per billion (equal to ng/g or µg/kg)
TEF	toxic equivalence factor
TEQ	toxicity equivalent
PTMI	Provisional Tolerable Monthly Intake
SCF	Scientific Committee of Food
TWI	Tolerable Weekly Intake
TDI	Tolerable Daily Intake
µg	microgram (0.000001 g)
Upper-bound	Analytical results reported below the LOD set at the LOD value
w.w.	wet weight or whole weight

PCDDs	polychlorinated dibenzo-*p*-dioxins
PCDFs	polychlorinated dibenzofurans
PCB	polychlorinated biphenyl
PBDEs	polybrominated diphenylethers
PCDD/F	PCDDs /PCDFs
dl PCB	dioxin-like PCB
TCB	tetrachlorobiphenyl
PnCB	pentachlorobiphenyl
HxCB	hexachlorobiphenyl
HpCB	heptachlorobiphenyl
PnCDD	pentachlorodibenzo-p-dioxin
HxCDD	hexachlorodibenzo-p-dioxin
HpCDD	heptachlorodibenzo-p-dioxin
OCDD	octachlorodibenzo-p-dioxin
PnCDF	pentachlorodibenzofuran
HxCDF	hexachlorodibenzofuran
HpCDF	heptachlorodibenzofuran
OCDF	octachlorodibenzofuran
Σ 7PCB	7 marker PCBs
Σ	Sum

Background

The Food Safety Authority of Ireland (FSAI) has a statutory responsibility to ensure the safety of food consumed, distributed, produced and sold on the Irish market. In this respect, the FSAI co-ordinates the collation of food safety surveillance information from laboratories run by its official agents, the Health Service Executive (HSE), the Department of Agriculture and Food, the Department of Communication, Marine and Natural Resources, the Marine Institute and the local authorities. The FSAI also conducts targeted food safety surveillance in areas where potential safety issues have been identified and/or on food contaminants for which there are currently no testing facilities in Ireland, such as dioxins. This report provides the results of a targeted surveillance study on levels of dioxins (PCDDs), furans (PCDFs), polychlorinated biphenyls (PCBs) and brominated flame retardants (PBDEs) in a number of foods available on the Irish market.

The study builds on previous studies undertaken by the FSAI into levels of these environmental contaminants in milk, fish/fish oils and eggs, and was undertaken against the background of increased awareness in the European Union (EU) of the possible health risks posed by these substances in the food chain. It also reflects Ireland's participation in the 2004 – 2006 EC monitoring programme for the background presence of dioxins, furans and dioxin-like PCBs in foodstuffs which has been agreed between the European Commission and the Member States via Commission Recommendation 2004/705/EC.

Dioxins and furans

The term 'dioxins' covers a group of 75 polychlorinated dibenzo-p-dioxin (PCDD) and 135 polychlorinated dibenzofuran (PCDF) congeners, of which 17 are of toxicological concern. Exposure to dioxins can result in a wide range of toxic responses, including dermal toxicity (chloracne), immunotoxicity, carcinogenicity, reproductive toxicity and possible neurobehavioral (cognitive) effects. Studies on children exposed *in utero* to dioxins are reported to have shown endocrine and developmental changes, persisting for long periods. The toxicological effects of the dioxins are thought to arise due to binding of the dioxins to a specific receptor protein in the cells, the aryl hydrocarbon (Ah) receptor present in most tissues of animals and humans. The most toxic dioxin congener is 2, 3, 7, 8-tetrachlordibenzo-p-dioxin (TCDD), and is classified by the International Agency for Research on Cancer (IARC) and other international organisations as a known human carcinogen. By analogy, other dioxins are therefore considered as presumed carcinogens. The EU Scientific Committee for Food (SCF), in line with the World Health Organisation (WHO), has however concluded that the carcinogenic effect of dioxins does not occur at levels below a certain threshold.

Dioxins and furans are environmental contaminants and have no commercial applications, other than for preparation of analytical standards and research materials. They are formed during combustion processes when the element chlorine is present, for example in the incineration of municipal waste. However, natural combustion processes such as forest fires and bonfires also result in dioxin formation. They can also occur as by-products of industrial processes, for example production and use of pentachlorophenol-containing wood preservatives, production and use of certain herbicides and bleaching of paper pulp using chlorine. As a result of these emissions, dioxins have been identified in almost all environmental compartments in industrialised countries. Emissions to air result in deposition in the terrestrial environment and in aquatic sediments, followed by uptake into the food chain e.g. by ruminants and by fish. Dioxins are highly resistant to degradation processes in the environment, and consequently persist in the environmental compartments where they have been deposited. This is due to their lipophilic characteristics, which also results in accumulation in the fatty tissues of the primary intake species, e.g. cows or fish. Approximately 90% of human exposure to these compounds results from the consumption of contaminated food. Exposure by other routes, such as inhalation and ingestion of particles from air, ingestion of contaminated soil and dermal absorption, normally contributes less than 10% of daily intake.

Because humans are the ultimate receivers in the food chain, there is a significant potential for accumulation of dioxins in human tissues as a result of exposure via food. In the case of cows or other lactating species, high levels of dioxins can potentially occur in milk, specifically in milk fat, and consequently also in cream and in milk products such as cheese, in addition to carcass meat. In fish, high levels may be found in fatty tissues such as liver, and consequently in fish liver oils. In Europe, the fraction of the dietary intake of dioxins contributed by these foods is:

Fish and fish products: 2 – 63 %;
Meat and meat products: 6 – 32 %;
Milk and dairy products: 16 – 39 %.
Fruit and vegetables provide only a minor contribution to human intake [1].

The Belgium dioxin crisis in 1999 triggered an increased awareness in the EU of the dangers posed by dioxins, furans and polychlorinated biphenyls in the food chain and, as a consequence of this crisis, the European Community (EC) established maximum levels for dioxins in furans in foodstuffs.

PCBs

The polychlorinated biphenyls (PCBs) are a group of extremely stable aromatic chlorinated compounds which, like the dioxins, are resistant to biological degradation and hence, persist and accumulate in the environment and in the food chain. There are 209 possible PCB compounds, with one to ten chlorine atoms per molecule. They have excellent electrical and heat transfer properties, which led to their widespread use in a variety of industrial, commercial and domestic applications. The production and use of PCBs has been discontinued in most countries, due to concern about their toxicity and persistence, but large amounts remain in electrical equipment, plastic products, buildings and the environment. Disposal of such material results in continued release to the environment, adding to existing levels present as a consequence of past releases.

As a class, PCBs are generally regarded as having potentially adverse effects on health, with particular concern being expressed about the 12 so-called dioxin-like PCBs. This group of non-ortho (PCBs 77, 81, 126, 169) and mono-ortho (PCBs 105, 114, 118, 123, 156, 157, 167, 189) PCBs are assumed to have essentially the same toxicity profile as the dioxins and furans, since they also bind to the Ah receptor. Other PCBs (non-dioxin-like PCBs) do not exert their toxicological effects via binding to the Ah receptor but nonetheless are associated with a wide spectrum of toxic responses in toxicological studies, including developmental effects, immuno- and neurotoxicity, endocrine disrupting effects and tumour promotion. They have been evaluated, *inter alia*, by the International Programme on Chemical Safety (IPCS) that noted that the PCB congener pattern found in food, human tissues and the environment is different from that of commercial PCB mixtures on which the majority of toxicological studies have been carried out. The so-called marker or indicator PCBs (i.e. PCBs 28, 52, 101, 118, 138, 153 and 180) are detected in these media using readily applicable analytical techniques, and have been used as indicators of the total PCB content or body burden of environmental biota, food and human tissue.

Toxic equivalence factors and tolerable intakes for dioxins and dioxin-like PCBs

The toxicity of PCDD, PCDF and the dioxin-like PCB congeners are expressed using toxic equivalence factors (TEFs) (see Tables 1 and 2) representing the relative toxicity of the compound being measured to the most toxic congener, TCDD. This, in turn, reflects the relative strength of binding to the Ah receptor. It should however be noted that the toxicity of many of these substances, both dioxins and PCBs, has not been extensively evaluated. An arbitrary TEF of 1 is assigned to TCDD, and by multiplying the analytically determined amounts of each congener in a sample by the corresponding TEF and summing the contribution from each congener, the total TEQ value of the sample can be obtained using the following equation:

TEQ = (PCDDi X TEFi) + (PCDFi X TEFi) + (*dioxin-like* PCBi X TEFi)

Several different TEF schemes have been proposed.

For many years, the most widely used schemes were that of NATO/CCMS, giving the so-called International TEFs (I-TEFs) for PCDDs and PCDFs and the WHO-ECEH (European Centre for Environment and Health of the World Health Organization) scheme for PCBs. WHO-ECEH has however recently proposed a new scheme of WHO-TEFs, which is now the most commonly used scheme. Dioxin TEQ values for food and human samples based on WHO-TEFs are approximately 10-20% higher than those obtained by using the I-TEFs of NATO/CCMS.

Table 1 TEFS FOR DIOXINS

PCDDs and PCDFs	Toxic Equivalency Factor (TEF)	
	I-TEF[2]	WHO-TEF[3]
2,3,7,8-TCDD	1	1
1,2,3,7,8-PnCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0001
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PnCDF	0.05	0.05
2,3,4,7,8-PnCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

Abbreviations: *PnCDD=pentachlorodibenzo-p-dioxin; HxCDD=hexachlorodibenzo-p-dioxin; HpCDD= heptachlorodibenzo-p-dioxin; OCDD=octachlorodibenzo-p-dioxin; PnCDF=pentachlorodibenzofuran; HxCDF=hexachlorodibenzofuran; HpCDF=heptachlorodibenzofuran; OCDF=octachlorodibenzofuran.*

Table 2 TEFS FOR DIOXIN-LIKE PCBS

PCBs (IUPAC No. in parenthesis)	Toxic Equivalency Factor (TEF)	
	I-TEF(2)	WHO-TEF(3)
Non-*ortho* PCBs		
3,3',4,4'-TCB (77)	0.0005	0.0001
3,4,4',5-TCB (81)	-	0.0001
3,3',4,4',5-PnCB (126)	0.1	0.1
3,3',4,4',5,5'-HxCB (169)	0.01	0.01
Mono-*ortho* PCBs		
2,3,3',4,4'-PnCB (105)	0.0001	0.0001
2,3,4,4',5-PnCB (114)	0.0005	0.0005
2,3',4,4',5-PnCB (118)	0.0001	0.0001
2,3,4,4'5-PnCB (123)	0.0001	0.0001
2,3,3',4,4',5-HxCB (156)	0.0005	0.0005
2,3,3',4,4',5'-HxCB (157)	0.0005	0.0005
2,3',4,4',5,5'-HxCB (167)	0.00001	0.00001
2,3,3',4,4',5,5'-HpCB (189)	0.0001	0.0001
Di-*ortho* PCBs		
2,2',3,3',4,4',5-HpCB (170)	0.0001	0.0001
2,2',3,4,4',5,5'-HpCB (180)	0.00001	0.00001

Abbreviations: *TCB=tetrachlorobiphenyl; PnCB=pentachlorobiphenyl; HxCB=hexachlorobiphenyl; HpCBheptachlorobiphenyl.*

Risk assessment of dioxins and PCBs in food

The SCF has carried out a risk assessment of dioxins and dioxin-like PCBs in food, as a consequence of which it concluded that the Tolerable Weekly Intake (TWI) for PCDDs, PCDFs and dioxin-like PCBs should be no more than 14pg WHO-TEQ/kg body weight (b.w.)[4]. This is very similar to the Provisional Tolerable Monthly Intake (PTMI) of 70pg/kg b.w. per month, as calculated by the FAO/WHO Joint Expert Committee on Food Additives and Contaminants (JECFA)[5]. It has been stated that the European average dietary intake is 1.2-3.0pg WHO-TEQ/kg b.w./day, which translates into a weekly intake of between 8.4-21pg WHO-TEQ/kg b.w. This exceeds the TWI established by the SCF.

However, several studies carried out by the FSAI have shown that levels of dioxins in Irish food are relatively low. Summary results of these previous studies are provided in the Appendix to this report. The 2002 collaborative study between Cork County Council and the FSAI on milk[6] showed dioxin levels ranging from 0.28-0.42 pg WHO-PCDD/F-TEQ/g fat over the period 1995-2001, compared with a regulatory Maximum Limit (ML) of 3pg WHO-TEQ/g fat (Table 3). Similarly, the FSAI/Marine Institute (MI) study on levels of Dioxins in Farmed Fish and Fish Oil Supplements[7] showed levels of dioxins in wild salmon ranging from 0.14-0.62ng WHO-TEQ/kg fresh weight, in farmed salmon from 0.59-1.50ng WHO-TEQ/kg and in farmed trout from 0.17-0.55ng WHO-TEQ/kg, compared with a regulatory Maximum Limit (ML) of 4ng WHO-TEQ/kg for fish muscle meat fat (Table 3). These levels are lower than those found in comparable foodstuffs from the more industrialised EU countries. Hence, it is likely that the exposure of the Irish population to dioxins in food is less than the European average.

This conclusion is supported by the results of a recent study carried out by the FSAI on levels of PCDDs, PCDFs and dioxin-like PCBs in breast milk from Irish mothers. This study was part of an international WHO study aiming (a) to produce reliable and comparable data on levels of dioxins in human milk to further improve health risk assessment in infants, (b) to provide an overview of exposure levels and to determine trends in exposure levels in the participating countries and regions, and (c) to identify highly exposed local populations.

At a national level, it provided baseline exposure data on dioxins for the Irish population. Four pooled samples of breast milk were collected from first-time mothers in Dublin, Wicklow, Donegal and Cork. Each pooled sample comprised 10 separate breast milk samples. These were taken from mothers living in the area for the past five years with a first-born infant aged between 2-6 weeks. Analysis of samples was carried out at a recognised laboratory in Germany. The results provided the first information relating to human exposure to dioxins in Ireland and showed that the body burden, as measured in breast-feeding Irish mothers, was relatively low by European standards.

The results of the WHO study[8] showed that in Europe, industrialised countries such as the Netherlands, Italy and Spain had relatively high levels of PCDDs/PCDFs in breast milk (median values range from approximately 12-18 pg WHO-TEQ/g fat). Low PCDD/PCDF levels have been found in Bulgaria, Croatia, Hungary, and Ireland (median values range from about 6-7 pg WHO-TEQ/g fat). Outside Europe, very high PCDD/PCDF levels have been found in Egyptian breast milk (median 22.8 pg WHO-TEQ/g fat), whereas Brazil showed the lowest PCDD/PCDF levels in the WHO study (median about 3.7 pg WHO-TEQ/g fat), followed by Australia and New Zealand. High levels of dioxin-like PCBs were found in breast milk from Ukraine, Italy and the Czech Republic (median values range from about 15-20 pg WHO-TEQ/g fat). Low levels (< 4 pg WHO-TEQ/g fat) were found in samples from Brazil, Hungary, Australia and New Zealand. The levels in Irish breast milk were also relatively low, with a median value of 4.57 pg/g, the lowest figure for any EU country taking part in the survey.

The weekly average dietary intake of dioxins by some of the European population exceeds the TWI established by the SCF. On a European scale, it is desirable to reduce the exposure of the population to dioxins. In 2001, the European Commission published its Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls, aimed at achieving a reduction in human exposure to dioxins and PCBs. Environmental legislation designed to limit dioxin emissions is in the process of discussion at European level. Other source-directed measures have been introduced to reduce the contamination of feedingstuffs for animal nutrition (Council Directive 2001/102/EC amending Directive 1999/29/EC on the undesirable substances and products in animal nutrition).

In addition, as part of its reduction strategy, the EC has also introduced a Regulation that sets maximum levels for PCDDs and PCDFs in foodstuffs, namely Council Regulation (EC) No. 2375/2001 amending Commission Regulation 466/2001 which sets maximum levels for certain contaminants in foodstuffs. The currently applicable maximum levels for PCDDs and PCDFs in food are shown in Table 3.

Table 3 Maximum Levels for dioxins and furans in food

FOOD	PCDDs + PCDFs (WHO-TEQ)
5.1.1. Meat and meat products [1] originating from	
— Ruminants (bovine animals, sheep)	3 pg /g fat [2]
— Poultry and farmed game	2 pg /g fat [2]
— Pigs	1 pg /g fat [2]
5.1.2. Liver and derived products originating from terrestrial animals	6 pg /g fat [2]
5.2. Muscle meat of fish and fishery products and products thereof[3,4]	4 pg /g fresh weight
5.3. Milk[5] and milk products, including butter fat	3 pg /g fat [2]
5.4. Hen eggs and egg products[6]	3 pg /g fat [2]
5.5. Oils and fats	
— Animal fat	
— from ruminants	3 pg /g fat [2]
— from poultry and farmed game	2 pg /g fat [2]
— from pigs	1 pg /g fat [2]
— mixed animal fats	2 pg /g fat [2]
— Vegetable oil and fats	0,75 pg /g fat [2]
— Fish oil (fish body oil and fish oil) intended for human consumption	2 pg /g fat [2]

1 *Meat of bovine animals, sheep, pig, poultry and farmed game as defined in Article 2(a) of Council Directive 64/433/EEC (OJ L 121, 29.7.1964, p. 2012/64), as last amended by Directive 95/23/EC (OJ L 243, 11.10.1995, p. 7) and Article 2(1) of Council Directive 71/118/EEC (OJ L 55, 8.3.1971, p. 23), as last amended by Directive 97/64/EC (OJ L 24, 30.1.1998, p.31), and Article 2(2) of Council Directive 91/495/EEC (OJ L 268, 24.9.1991, p. 41) as last amended by Directive 94/65/EC (OJ L 368, 31.12.1994, p. 10), excluding edible offal as defined in Article 2(e) of Directive 64/433/EEC and Article 2(5) of Directive 71/118/EEC.*

2 *The maximum levels are not applicable for food products containing < 1 % fat.*

3 *Muscle meat of fish and fishery products as defined in categories (a), (b), (c), (e) and (f) of the list in Article 1 of Council Regulation (EC) No 104/2000 (OJ L 17, 21.1.2000, p. 22). The maximum level applies to crustaceans excluding the brown meat of crab and to cephalopods without viscera.*

4 *Where fish are intended to be eaten whole, the maximum level shall apply to the whole fish*

5 *Milk (raw milk, milk for the manufacture of milk-based products and heat treated milk as defined in Council Directive 92/46/EEC (OJ L 268, 14.9.1992, p. 1) as last amended by Council Directive 96/23/EC (OJ L 125, 23.5.1996, p. 10)).*

6 *Hen eggs and egg products as defined in Article 2 of Council Directive 89/437/EEC (OJ L 212, 22.7.1989, p. 87), as last amended by Council Directive 96/23/EC (OJ L 125, 23.5.1996, p. 10).*

Legislation to cover dioxin-like PCBs is currently being discussed at EC level and is likely to be adopted for both feedingstuffs and foodstuffs in 2005. Current legislation also carries with it an obligation for Member States to monitor the levels of dioxins in foodstuffs and report to the European Commission. Under this obligation, Ireland is required to carry out monitoring in a variety of foodstuffs. The dioxin monitoring program scheduled for 2003 included meat, offal, fruit, vegetables and eggs. The results for the last-named group have been published previously and the report is available on the FSAI website[9]. This report provides results for the remaining groups.

These data will ultimately be used to review the maximum limits and gauge the effectiveness of the reduction strategy.

A risk assessment for the non-dioxin-like PCBs in food has not yet been carried out at European level. The Scientific Panel on Contaminants within the European Food Safety Authority (EFSA) has initiated work in this area, to include identification of the most relevant/sensitive toxicological endpoints for the PCB-congener patterns usually found in food. However, the EFSA risk assessment is not anticipated to be completed before mid 2005 at the earliest.

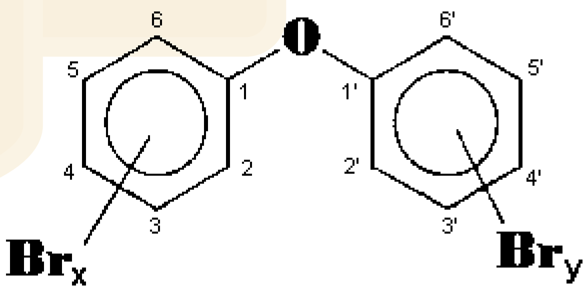
Poly Brominated Diphenyl Ethers (PBDEs)

Brominated flame retardants are a group of chemicals which are added to many household products for the purpose of fire prevention. The types of products containing these chemicals include, clothing and household textiles, furniture, computers and televisions.

There are five major classes of brominated flame retardants: brominated bisphenols, brominated diphenyl ethers, brominated cyclododecanes, brominated phenols and brominated phthalic acid derivatives. This survey covers polybrominated diphenyl ethers (PBDEs) only.

The term PBDEs refers to three commercial mixtures of decabromodiphenyl ether (DBDE), octabromodiphenyl ether (Octa, OBDE), and pentabromodiphenyl ether (Penta, pentaBDE). The EU banned the production of both pentaBDE and octaBDE in 2004. However, decaBDE (DBDE) is still in use.

The general chemical formula of brominated diphenyl ethers is



(Source: WHO, 1994, BROMINATED DIPHENYL ETHERS, ENVIRONMENTAL HEALTH CRITERIA 162, Geneva)

The PBDEs are similar in structure to the PCBs, and also have some similarities to the dioxin family of chemicals. They contain the element bromine rather than the chlorine element found in the PCBs. Like the dioxins and PCBs, the PBDEs break down slowly in the environment and in living organisms, including the human body. Continuous exposure to them leads to build-up in the body. Because they have similarities to dioxins and PCBs, they may have some of the same effects on health as these chemicals, although they appear to be less toxic. Recent toxicological studies have shown that some of them are endocrine or hormone disruptors (an effect that is also associated with the dioxins and PCBs), and is thought to be associated with changes in fertility, sexual development and possibly certain types of cancer, such as breast, testicular and prostate. It has also been reported that they can have an effect on brain development in mice, slowing the learning process. As with PCBs, exposure to PBDEs may be particularly harmful during a critical window of brain development during pregnancy and early childhood. While the pentabromo compounds appear to be the most toxic, many of these persistent chemicals have not been extensively studied.

PBDEs were first reported in wildlife species, including fish, seals, whales and birds' eggs. In the late 1990s, they were reported in the breast milk of mothers in Sweden, and research showed that levels had increased from zero in 1970 to high levels in the 1990s in parallel with the use of PBDEs. Following restrictions on their use in Sweden, followed by the EU-wide ban on Penta and Octa, levels in breast milk in European women are now dropping, but levels in human tissues and breast milk in North America are still rising rapidly.

A recent study carried out by Hites *et al*[10] has reported PBDEs to be present in both farmed and wild salmon. Although the levels of the contaminants were generally higher in farmed fish than wild fish, one species of wild salmon contained the highest level of PBDE found in the study.

There is only very limited information on the presence of PBDEs in other foods. The EC is currently considering the establishment of maximum limits for these chemicals in food, and is encouraging Member States to carry out measurements to assist in this process.

As part of its wider survey of dioxin and PCB levels in eggs, the FSAI has recently carried out a study looking for the presence of 16 of the PBDEs in Irish eggs (free range and battery). Traces of four of these compounds were found, PBDE-99, PBDE-100, PBDE-153 and PBDE-47. PBDE-47 and PBDE-99 are the predominant congeners found in environmental samples, including human specimens.

Levels in Irish eggs were approximately 0.1 parts per billion (ppb) in total egg. The approximate level expressed in ppb per kg egg fat was 1 ppb, and this may be compared with levels ranging between 17-460 ppb body fat in women in San Francisco, and an average level of 16 ppb for six species of fish taken from San Francisco Bay in 2002[11]. Levels in retail farmed salmon reported by Hites *et al* [(10)] range between 0.6-3.9 ppb w.w. In 2004, the MI[12] measured PBDEs in Irish farmed fish and found levels ranging from 2.28-4.61 (mean 3.05) ppb w.w. and 0.7-1.8 (mean 1.17) ppb w.w. for the sum of the 17 individual PBDEs and for total HBCD respectively. However, there are differences in the number of congeners determined in the various studies listed, and direct comparisons of the datasets cannot therefore be made.

The FSAI is currently carrying out another study to determine the levels of PBDEs in a range of fish species, the results of which are expected in 2005.

Risk assessment of PBDEs in food

A Tolerable Intake Level (Tolerable Daily or Weekly Intake, TDI/TWI) has not been determined for the PBDEs by expert bodies such as EFSA, because there is, as yet, insufficient information available on their toxicity and their occurrence in food. Because of the lack of information, the FSAI considers that exposure to them should be minimised.

Study outline

For this survey, the following types of food samples were collected (see table 4):

1. Animal carcass fat
2. Offal
3. Cereals
4. Fruit
5. Vegetables
6. Dairy products (butter, spreads, yoghurts, cheeses)
7. Fats & Oils
8. Instant soup powders

Groups 1-5 were provided by officers of the Department of Agriculture and Food (DAF) at production level, and the remainder taken by officers of the FSAI at retail level.

Analysis of the samples was undertaken by the Central Science Laboratory (CSL), York, UK, under contract to the FSAI.

Table 4 Sample Details

Category	Food	No Samples	Origin	No of incremental samples/ sample	Weight of aggregate sample
Oils and fats	Animal/Vegetable Fat mixture	1	Retail	6	
	Vegetable Oil	2	Retail	3	
Cereals	Wheat, Barley, Oats	3	Producer	1	
Dairy products	Cheese (Cheddar)	1	Retail	10	
	Cheese (soft cheese)	1	Retail	10	
	Cheese (processed cheese)	1	Retail	8	
	Butter	1	Retail	10	
	Dairy Spreads	1	Retail	10	
	Yoghurt	1	Retail	4	
Packet Soup	Packet soups	1	Retail	3	
Vegetables	Potatoes	1	Producer (Farm)	1 1kg sample	
	Cabbage	1	Producer (Farm)	1 1kg sample	
	Carrots	1	Producer (Farm)	1 1kg sample	
	Lettuce	1	Producer (Farm)	1 1kg sample	
	Mushrooms	1	Producer (Farm)	1 1kg sample	≥ 1 kg
	Tomatoes	1	Producer (Farm)	1 1kg sample	
	Onions	1	Producer (Farm)	1 1kg sample	
	Peppers	1	Producer (Farm)	1 1kg sample	
Fruit	Strawberries	1	Producer (Farm)	1 1kg sample	
	Raspberries	1	Producer (Farm)	1 1kg sample	
	Apples	1	Producer (Farm)	1	
Carcass fat	Bovine Fat	10	Processor (Slaughterhouse)	10	
	Avian fat	8	Processor (Slaughterhouse)	10	
	Ovine fat	8	Processor (Slaughterhouse)	10	
	Porcine Fat	8	Processor (Slaughterhouse)	10	
Offal	Liver - Avian	4	Processor (Slaughterhouse)	40	
	Liver - Ovine	1	Processor (Slaughterhouse)	10	
	Liver - Bovine	1	Processor (Slaughterhouse)	10	
	Liver - Porcine	1	Processor (Slaughterhouse)	10	

Methodology

Method of analysis

The samples were ground, fortified with known amounts of surrogate ($^{13}C_{12}$-labelled) analogues (internal standards) of target analytes and exhaustively extracted using mixed organic solvents. The extracts were cleaned up using adsorption chromatography. Ortho-PCBs, non-ortho-PCBs, PCDDs/PCDFs and PBDEs were segregated into two separate fractions. Each fraction was concentrated and further cleaned up before the inclusion of additional surrogate standards. Final determination was by high resolution gas chromatography with either low resolution mass spectrometric detection (ortho-PCBs) or high resolution mass spectrometric detection (non-ortho-PCBs, PCDDs/PCDFs and PBDEs).

The analytical limits of detection for the methodology used are significantly below the maximum and action limits as detailed in recent EC directives, and are as follows:

- 0.1 ng/kg (fat) or better for most dioxin congeners
- 0.2 ng/kg (fat) or better for most non-*ortho*-substituted PCB congeners
- 0.1 µg/kg (fat) for *ortho*-substituted PCB congeners
- 0.2 µg/kg (fat) for PBDE congeners.

Quality control procedures

The congener-specific determination of PCBs, PCDDs and PCDFs is analytically demanding. In order to demonstrate that adequate confidence can be placed in the results obtained, the following requirements were observed. All analytical data met published[13] acceptance criteria for PCDDs and PCDFs and equivalent criteria for PCBs. The method used has been validated and published after peer review[14]. The same methodology was slightly modified and used for PBDEs. Each batch of samples analysed incorporates one of several reference materials (RMs), for which results are compared with certified or assigned data and laboratory performance (indicative) data. Results for the batch RM which fell outside the acceptable range have been reported as indicative only. Each batch of samples analysed includes a full reagent blank extract. The contribution from the batch blank was found to be negligible. The analytical performance of the laboratory in international intercomparison studies, using essentially the same method, has been adjudged to be acceptable or better. Results are calculated using internationally accepted toxic equivalency factors (TEF).

Analytes included in the survey

1. PCDDs/PCDFs and PCBs

The 17 PCDD/PCDF congeners[i] of toxicological concern shown in Table 1 and the following PCB congeners, including the 12 dioxin-like PCBs and the 7 marker PCBs[ii] were analysed in this study.

PCB 18	PCB 60	PCB 118	PCB 180
PCB 28	PCB 66	PCB 123	PCB 183
PCB 31	PCB 74	PCB 126	PCB 185
PCB 33	PCB 77	PCB 138	PCB 187
PCB 37	PCB 81	PCB 141	PCB 189
PCB 41	PCB 87	PCB 151	PCB 191
PCB 44	PCB 99	PCB 153	PCB 193
PCB 47	PCB 101	PCB 156	PCB 194
PCB 49	PCB 105	PCB 157	PCB 201
PCB 51	PCB 110	PCB 167	PCB 203
PCB 52	PCB 114	PCB 169	PCB 206
			PCB 209

2. PBDEs

The following 16 PBDE congeners were analysed in this study.

BDE-17	BDE-28	BDE-47	BDE-49
BDE-66	BDE-71	BDE-77	BDE-85
BDE-99	BDE-100	BDE-119	BDE-126
BDE138	BDE153	BDE 154	BDE-183

[i] (PCBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
[ii] (PCBs 28, 52, 101, 118, 138, 153, 180)

Results

Dioxins, furans and PCBs

Table 5 presents the levels of PCDD/Fs, dioxin-like PCBs and marker PCBs in cereals, fruits, vegetables, fats and oils. Results are expressed as total WHO-TEQs in ng/kg (pg/g) whole weight for PCDD/Fs and dioxin-like PCBs separately and for the sum of PCDD/Fs and dioxin-like PCBs together, and as the sum total in µg/kg whole weight for the 7 marker PCBs 28, 52, 101, 118, 138, 153 and 180. In each case, results are presented as upper-bound mean values. No PCDDs/PCDFs or PCBs were found above the detectable level of 0.03 ng/kg WHO-TEQ (LOD) in cereals, fruit or vegetables.

Table 5 Mean upper-bound levels (<LOD=LOD) of PCDD/Fs, dioxin-like PCBs and total TEQs and sum of 7 Marker PCBs in cereals, fruit, vegetables, fats and oils

			whole weight (upper-bound)			
		N	***Dl PCBs***	***PCDD/F***	***Sum of dl PCBs&PCDD/F***	***7 Marker PCBs***
			WHO TEQs ng/kg			µg/kg
Cereals	Wheat/Barley/Oats	3	0.03 (=LOD)	0.03 (=LOD)	0.06	0.11
Fruit	Apples/Raspberries/Strawberries	3	0.03 (=LOD)	0.03 (=LOD)	0.06	0.07
Vegetables	Cabbage/Carrots/Lettuce/Mushrooms/RedPeppers/ Potatoes/Spring Onions/Tomatoes	8	0.03 (=LOD)	0.03 (=LOD)	0.06	0.07
Fat	Animal/Vegetable Fat	1	0.21	0.24	0.45	1.16
Oil	Vegetable Oil	2	0.05	0.05	0.1	0.43

Table 6 presents the levels of PCDD/Fs, dioxin-like PCBs and marker PCBs in carcass fat, dairy products, offal (liver) and soup powder. Results are expressed as total WHO TEQs in ng/kg (pg/g) fat weight for PCDD/Fs and dioxin-like PCBs separately and for the sum of PCDD/Fs and dioxin-like PCBs together, and as the sum total in µg/kg fat weight for the 7 marker PCBs 28, 52, 101, 118, 138, 153 and 180. In each case, results are presented as upper-bound[iii] mean, median, minimum and maximum values, where applicable.

[iii] For levels below the limit of detection (LOD), the value was assumed for further calculations.

Table 6 Mean upper-bound levels (<LOD=LOD) of PCDD/Fs, dioxin-like PCBs and total TEQs and sum of 7 Marker PCBs in fat, offal, dairy products and soup powder

				fat weight based (upper-bound)			
		N		*Dl PCBs*	*PCDD/F*	*Sum of dl PCBs&PCDD/F*	*7 Marker PCBs*
				WHO TEQs ng/kg			ug/kg
Carcass fat	Bovine	10	Mean	0.45	0.43	0.88	1.73
			Median	0.46	0.44	0.88	1.85
			Minimum	0.34	0.26	0.6	1.29
			Maximum	0.61	0.62	1.23	2.07
	Avian	7	Mean	0.19	0.18	0.37	1.04
			Median	0.15	0.17	0.31	0.74
			Minimum	0.11	0.12	0.23	0.64
			Maximum	0.38	0.26	0.62	1.76
	Avian (Duck)	1	Mean	0.05	0.12	0.17	0.26
	Ovine	8	Mean	0.29	0.35	0.64	1.87
			Median	0.29	0.37	0.66	1.89
			Minimum	0.18	0.25	0.44	1.46
			Maximum	0.44	0.42	0.83	2.35
	Porcine	8	Mean	0.08	0.09	0.17	1.14
			Median	0.08	0.08	0.16	1.08
			Minimum	0.06	0.08	0.14	0.23
			Maximum	0.12	0.12	0.24	2.78
	Total carcass fat	34	Mean	0.26	0.27	0.53	1.44
			Median	0.24	0.26	0.53	1.51
			Minimum	0.05	0.08	0.14	0.23
			Maximum	0.61	0.62	1.23	2.78
Dairy products	Butter	1	Mean	0.27	0.24	0.51	1.24
	Cheddar	1	Mean	0.22	0.23	0.45	1.21
	Processed cheese	1	Mean	0.24	0.25	0.49	1.35
	Soft cheese	1	Mean	0.18	0.2	0.38	0.78
	Dairy spread	1	Mean	0.05	0.08	0.13	0.92
	Yoghurt	1	Mean	0.12	0.11	0.23	0.78
	Total Dairy	6	Mean	0.18	0.19	0.37	1.05
			Median	0.2	0.22	0.42	1.07
			Minimum	0.05	0.08	0.13	0.78
			Maximum	0.27	0.25	0.51	1.35
Offal	Bovine Liver	1	Mean	0.52	1.6	2.12	2.72
	Avian Liver (Chicken)	3	Mean	0.13	0.39	0.51	0.99
			Median	0.12	0.36	0.47	0.8
			Minimum	0.11	0.32	0.44	0.66
			Maximum	0.15	0.48	0.63	1.5
	Avian Liver (Turkey)	1	Mean	0.49	0.47	0.96	2.97
	Ovine Liver	1	Mean	1.42	4.04	5.46	3.34
	Porcine Liver	1	Mean	0.13	1.09	1.22	0.75
	Total Liver	7	Mean	0.42	1.19	1.61	1.82
			Median	0.15	0.48	0.96	1.5
			Minimum	0.11	0.32	0.44	0.66
			Maximum	1.42	4.04	5.46	3.34
Soup	Soup	1	Mean	0.07	0.12	0.19	0.47

Individual results for PCDDs, PCDFs, dioxin-like PCBs and non- dioxin-like PCBs measured in this study are presented in Table 7 (to download Table 7, please click here). These results are expressed on a fat basis and on a whole weight basis, where applicable.

PBDEs

Table 8 presents results for analysed PBDE congeners in vegetables, fruit and soup powder. No PBDE occurrence was found above the LOD in these foods.

Tables 9-12 show the calculated mean, minimum and maximum upper-bound levels for meat, offal, dairy products, fats and oils, and cereals. Results are expressed in µg/kg fat (except Table 11 - µg/kg whole weight). Levels above the LOD were recorded mainly for PBDE congeners BDE-47, BDE-99, BDE153, BDE 154 and BDE-100 as shown in Figure 1, expressing lower-bound (<LOD=0) occurrence levels and profile of all congeners measured.

Table 8 Vegetables and Fruit: BDE congener concentrations

Category	Food	BDE-17, BDE-28, BDE-47, BDE-49, BDE-66, BDE-71, BDE-77, BDE-85, BDE-99, BDE-100, BDE-119, BDE-126, BDE138, BDE153, BDE 154, BDE-183
Vegetables	Potatoes	< LOD (0.01µg/kg whole weight) LOD: 0.05 µg/fat or 0.01µ kg whole weight except BDE 183 LOD 0.1 µ/kg fat or 0.02µ kg whole weight
	Cabbage	
	Carrots	
	Lettuce	
	Mushrooms	
	Tomatoes	
	Onions	
	Peppers	
Fruit	Strawberries	
	Raspberries	
	Apples	
Other	Soup powder	

Table 9 Carcass fat: mean minimum and maximum upper-bound BDE congener concentrations (<LOD=LOD)

		BDE congener no (μg kg fat weight) upper-bound															
		17	28	47	49	66	71	77	85	99	100	119	126	138	153	154	183
Beef	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7
	Mean	0.05	0.05	0.11	0.05	0.05	0.05	0.05	0.05	0.13	0.06	0.05	0.05	0.05	0.06	0.05	0.1
	Median	0.05	0.05	0.09	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Minimum	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.23	0.05	0.05	0.05	0.05	0.06	0.36	0.15	0.05	0.05	0.05	0.13	0.06	0.1
Chicken	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Mean	0.05	0.05	0.18	0.05	0.05	0.05	0.05	0.05	0.31	0.05	0.05	0.05	0.05	0.07	0.05	0.1
	Median	0.05	0.05	0.18	0.05	0.05	0.05	0.05	0.05	0.29	0.05	0.05	0.05	0.05	0.07	0.05	0.1
	Minimum	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.25	0.05	0.05	0.05	0.05	0.05	0.37	0.06	0.05	0.05	0.05	0.08	0.05	0.1
Duck	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Ovine	N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Mean	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.11	0.05	0.1
	Median	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.1	0.05	0.1
	Minimum	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.11	0.05	0.05	0.05	0.05	0.06	0.05	0.1
	Maximum	0.05	0.05	0.08	0.05	0.05	0.05	0.05	0.05	0.16	0.06	0.05	0.05	0.05	0.16	0.07	0.1
Porcine	N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Mean	0.05	0.05	0.21	0.05	0.05	0.05	0.05	0.05	0.31	0.06	0.05	0.05	0.05	0.09	0.06	0.1
	Median	0.05	0.05	0.2	0.05	0.05	0.05	0.05	0.05	0.27	0.05	0.05	0.05	0.05	0.06	0.05	0.1
	Minimum	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.37	0.05	0.05	0.05	0.05	0.05	0.74	0.09	0.05	0.05	0.06	0.27	0.12	0.1
Total	N	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	31
	Mean	0.05	0.05	0.14	0.05	0.05	0.05	0.05	0.05	0.21	0.06	0.05	0.05	0.05	0.08	0.05	0.1
	Median	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05	0.15	0.05	0.05	0.05	0.05	0.07	0.05	0.1
	Minimum	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.37	0.05	0.05	0.05	0.05	0.06	0.74	0.15	0.05	0.05	0.06	0.27	0.12	0.1

Table 10 Dairy products: mean minimum and maximum upper-bound BDE congener concentrations (<LOD=LOD)

		BDE congener no (μg kg fat weight) upper-bound															
		17	28	47	49	66	71	77	85	99	100	119	126	138	153	154	183
Butter	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.12	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Cheddar	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.05	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Processed cheese	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.18	0.05	0.05	0.05	0.05	0.05	0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Soft cheese	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.1
Dairy spread	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.11	0.05	0.05	0.05	0.05	0.05	0.17	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Yoghurt	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.12	0.05	0.05	0.05	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Total	N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Mean	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.14	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Median	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.14	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Minimum	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.18	0.05	0.05	0.05	0.05	0.05	0.2	0.05	0.05	0.05	0.05	0.06	0.05	0.1

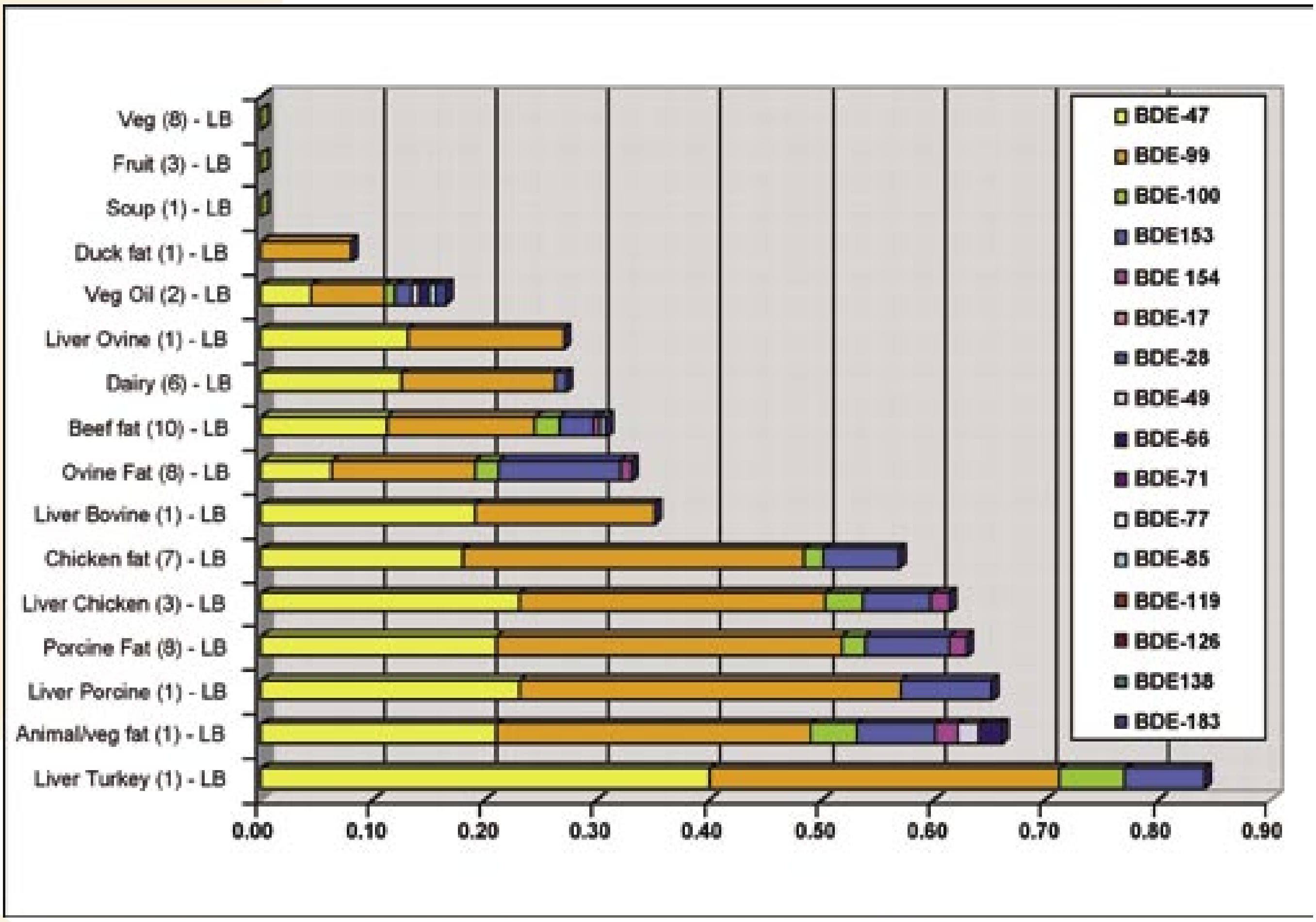
Table 11 Offal (Liver): mean minimum and maximum upper-bound BDE congener concentrations (<LOD=LOD)

		BDE congener no (µg kg fat weight) upper-bound															
		17	28	47	49	66	71	77	85	99	100	119	126	138	153	154	183
Bovine	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.19	0.05	0.05	0.05	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Chicken	N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Mean	0.05	0.05	0.23	0.05	0.05	0.05	0.05	0.05	0.33	0.07	0.05	0.05	0.05	0.08	0.05	0.1
	Median	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.05	0.25	0.05	0.05	0.05	0.05	0.09	0.05	0.1
	Minimum	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.39	0.05	0.05	0.05	0.05	0.05	0.57	0.1	0.05	0.05	0.05	0.09	0.05	0.1
Turkey	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.4	0.05	0.05	0.05	0.05	0.05	0.31	0.06	0.05	0.05	0.05	0.07	0.05	0.1
Ovine	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.14	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Porcine	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.05	0.05	0.23	0.05	0.05	0.05	0.05	0.05	0.34	0.05	0.05	0.05	0.05	0.08	0.05	0.1
Total	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Mean	0.05	0.05	0.23	0.05	0.05	0.05	0.05	0.05	0.28	0.06	0.05	0.05	0.05	0.07	0.05	0.1
	Median	0.05	0.05	0.19	0.05	0.05	0.05	0.05	0.05	0.25	0.05	0.05	0.05	0.05	0.07	0.05	0.1
	Minimum	0.05	0.05	0.13	0.05	0.05	0.05	0.05	0.05	0.14	0.05	0.05	0.05	0.05	0.05	0.05	0.1
	Maximum	0.05	0.05	0.4	0.05	0.05	0.05	0.05	0.05	0.57	0.1	0.05	0.05	0.05	0.09	0.05	0.1

Table 12 Cereals, Fats and Oils: mean minimum and maximum upper-bound BDE congener concentrations (<LOD=LOD)

		BDE congener no (µg kg whole weight) upper-bound															
		17	28	47	49	66	71	77	85	99	100	119	126	138	153	154	183
Vegetable Oil	N	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Mean	0.01	0.01	0.07	0.01	0.02	0.01	0.01	0.01	0.09	0.02	0.01	0.01	0.01	0.02	0.01	0.02
	Minimum	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Maximum	0.01	0.01	0.09	0.01	0.02	0.01	0.01	0.01	0.13	0.02	0.01	0.01	0.01	0.03	0.01	0.02
Animal/ Vegetable Fat	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	0.01	0.01	0.21	0.02	0.02	0.01	0.01	0.01	0.28	0.04	0.01	0.01	0.01	0.07	0.02	0.01
Cereals	N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Mean	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	Minimum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Maximum	0.01	0.01	0.09	0.02	0.01	0.01	0.01	0.01	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01

Figure 1 Mean Lower-bound (LB) Occurrence of PBDE Congeners (μg/kg fat weight) (< LOD = 0)



Discussion

Dioxins, furans and PCBs

The results of this study show that levels of dioxins and furans in the food commodities analysed were generally low, and were well below the maximum limits laid down in Council Regulation 2375/2001. The Regulation does not currently establish maximum limits for the dioxin-like or non-dioxin-like PCBs. However, dioxin-like PCBs will be included in 2005, and concentrations found in all foods covered by this survey are well below currently proposed legislation in this area.

Cereals, Fruits and Vegetables

Levels for dioxins, furans and dioxin-like PCBS were all below the LOD. Regarding non-dioxin-like PCBs, the majority of congeners tested were below the LOD, with a minor percentage of congeners having levels slightly in excess of the LOD. The relative absence of these contaminants can be attributed to the low percentage of fat in these foods.

Carcass fat

The mean upper-bound levels for PCDDs, PCDFs and dioxin-like PCBs expressed as ng/kg fat based WHO TEQs were as follows: beef 0.88, sheep 0.64, poultry 0.37 and pigmeat 0.17. Dioxins/furans and dioxin-like PCBs contributed equally to the total TEQ.

Dairy products

The mean upper-bound levels for PCDDs, PCDFs and dioxin-like PCBs expressed as ng/kg fat based WHO TEQs were as follows: butter 0.51; processed cheese 0.49; cheddar cheese 0.45; soft cheese 0.38; yoghurt 0.23; dairy spread 0.13. These levels are in line with findings of a previous survey conducted on milk in Ireland.

Offal

Of all products tested in this survey, liver showed the highest concentration of PCDDs, PCDFs and dioxin-like PCBs expressed as ng/kg fat WHO TEQs, which were as follows: sheep liver 5.46; beef liver 2.12; pig liver 1.22; chicken liver 0.51. For all other food categories, an equal share of dioxins/furans and dioxin-like PCBs could be observed. In the case of liver dioxins, they contribute on average 74% to the total TEQ, and in the case of pork, this proportion was 89%. Although there is a paucity of data, similar observations regarding the latter have been made in other EU Member States.

Fats & Oils

For the vegetable oils analysed, levels for dioxins, furans and dioxin-like PCBS were all below the LOD. Regarding non-dioxin-like PCBs, the majority of congeners tested were also below the LOD, with a minor percentage of congeners being slightly above the LOD. A mixture of animal and vegetable fat recorded a total TEQ ng/kg w.w. of 0.45 for PCDDs/ PCDFs and dioxin-like PCBs.

PBDEs

No PBDE occurrence was found above the LOD in vegetables, fruit and soup powder.

For the remaining foods, levels above the LOD were recorded mainly for PBDE congeners BDE-47, BDE-99, BDE153, BDE 154 and BDE-100, which is in line with findings in other EU Member States.

Conclusions

This study has demonstrated that levels of dioxins, furans, PCBs and PBDEs in Irish food are in general well below existing and proposed legislation, where appropriate. Levels of the marker or indicator PCBs (PCBs 28, 52, 101, 118, 138, 153, and 180), and the dioxin-like PCBs are similarly low, as are levels of those PBDEs measured in the study. The results of the study are in line with those from previous FSAI studies on dioxin levels in milk, fish and eggs, and confirm that dioxin levels in these foods are relatively low compared with similar products from more industrialised countries in the EU. The FSAI is pleased to report these results, and to note that Irish produce readily complies with existing and proposed future legislation. These findings support the interpretation that exposure of consumers of Irish food to dioxins is likely to be lower than the European average, a conclusion which should be reassuring to Irish consumers.

Appendix

Table 13 presents the levels of PCDD/Fs and dioxin-like PCBs in a variety of samples as analysed in previous surveys, expressed as total WHO TEQs in ng/kg (pg/g) for PCDD/Fs and dioxin-like PCBs together and for the sum of PCDD/Fs and dioxin-like PCBs separately. In each case, results are presented as the calculated mean, minimum and maximum upper-bound levels.

Table 13 **Mean, minimum and maximum upper-bound TEQs of PCDD/Fs, dioxin-like (dl) PCBs and Sum (Σ) of PCDD/Fs and dioxin-like PCBs**

			ΣPCDD/F + dl PCBs (WHO TEQ, ng/kg fat)			ΣPCDD/F (WHO TEQ, ng/kg fat)			Σdl PCBs (WHO TEQ, ng/kg fat)		
	Year analysed	**N**	Mean	Min.	Max.	Mean	Min.	Max	Mean	Min	Max
Battery eggs	2003	16	0.65	0.37	0.87	0.36	0.10	0.58	0.29	0.26	0.37
Free range eggs	2003	16	0.79	0.41	1.26	0.47	0.19	0.83	0.32	0.22	0.43
Organic eggs	2003	4	2.73	0.84	6.63	1.30	0.48	2.70	1.43	0.36	3.93
Barn eggs	2003	4	0.57	0.43	0.78	0.31	0.18	0.51	0.27	0.25	0.28
Fish oil supplements	2001	15	17.01	0.6	37.55	3.57	0.22	10.95	13.45	0.16	29.75
Milk	2002	15	0.92	0.47	1.80	0.39	0.27	0.81	0.53	0.19	1.23
Human Breast milk	2003	4	11.88	8.9	13.73	7.62	6.19	8.82	4.26	2.72	5.19

			ΣPCDD/F + dl PCBs (WHO TEQ, ng/kg ww)			ΣPCDD/F (WHO TEQ, ng/kg ww)			Σdl PCBs (WHO TEQ, ng/kg ww)		
	Year analysed	**N**	Mean	Min.	Max.	Mean	Min.	Max	Mean	Min	Max
Farmed trout	2001	15	1.36	0.77	1.98	0.32	0.17	0.55	1.04	0.6	1.43
Farmed salmon	2001	15	4.02	2.34	6.32	0.87	0.59	1.5	3.15	1.75	4.82
Wild salmon	2001	15	1.07	0.68	1.84	0.34	0.14	0.61	0.72	0.52	1.23

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