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Investigation into levels of polychlorinated naphthalenes (PCNs) in carcass fat, offal, fish, eggs, milk and processed products

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SUMMARY

The Food Safety Authority of Ireland FSAI in collaboration with the Department of Agriculture, Fisheries and Food and the Marine Institute have carried out a study of levels of polychlorinated naphthalenes (PCNs) in carcass fat, liver, eggs, fish and milk produced in Ireland and a select number of processed products available at retail level. The study was undertaken because of awareness 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. Furthermore the aim of this study also was to proactively monitor the Irish food supply for emerging contaminants, and to aid national and international efforts in the management of these contaminants.

This study demonstrates the presence of PCNs in the foodstuffs examined and provides baseline information on the concentrations found. Whilst there is variation in occurrence depending on individual congeners of these contaminants and the types of food studied, the widespread detection in Irish foodstuffs underlines the ubiquity of these contaminants, since Ireland generally shows food contamination levels that are below the European average for environmental contaminants such as dioxins and PCBs except following specific contamination incidents.

The profile of PCN congener occurrence in some foods (e.g. some vegetable-based foods, fish etc, where metabolic or other degradation pathways are unlikely to be significant) is similar to that of commercial mixtures, and despite other sources such as incineration being reported, the legacy of past commercial usage still appears to strongly influence the background pattern of occurrence.

Overall, the survey shows that Irish produce contains low amounts of the persistent biopersistent toxicants measured in this survey, however levels observed do not raise concern for human health.

ABBREVIATIONS

Abbreviation	Full Name
b.w.	body weight
congener	a chemical substance related to another
DAFF	Department of Agriculture, Fisheries and Food
EC	European Community
EFSA	European Food Safety Authority
FSAI	Food Safety Authority of Ireland
HSE	Health Service Executive
JECFA	FAO/WHO Joint Expert Committee Food Additives and Contaminants
LOD	Limit of Detection
LOQ	Limit of Quantification/Quantitation
MI	Marine Institute
ng	nanogram (0.000000001 g)
PCB	polychlorinated biphenyl
PCDD/F	abbreviation for PCDDs and PCDFs
PCDDs	polychlorinated dibenzo-*p*-dioxins
PCDFs	polychlorinated dibenzofurans
PCNs	polychlorinated naphthalenes
pg	picogram (0.000000000001 g)
ppb	parts per billion (equal to ng/g or µg/kg)
SCF	Scientific Committee of Food
TDI	Tolerable Daily Intake
TEF	toxic equivalency factor
TEQ	toxicity equivalent
TWI	Tolerable Weekly Intake
Upper-bound	Analytical results reported below the LOD set at the LOD value
w.w.	wet weight or whole weight
µg	microgram (0.000001 g)
Σ	Sum

BACKGROUND

The Food Safety Authority of Ireland (FSAI) mission is 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 the Official Agencies under service contract to the Authority. These include the Health Service Executive (HSE), the Department of Agriculture, Fisheries and Food, the Sea Fisheries Protection Authority, the Marine Institute and the local authorities. The FSAI also conducts targeted food safety surveillance in areas where potential safety issues have been identified. This report provides the results of a targeted surveillance study on levels of polychlorinated naphthalenes (PCNs) in carcass fat, offal, eggs, fish and milk produced in Ireland and a selection of processed products available at retail level.

The study is the first examination of Irish food for the presence of PCNs undertaken by FSAI and aims to monitor the Irish food supply for emerging contaminants, and to aid national and international efforts in the management of these contaminants

Polychlorinated naphthalenes

Polychlorinated naphthalenes (PCNs) comprise a sub-group of 75 congeners, some with recognised toxic, bio-accumulative and persistence properties. As an industrial chemical, commercial PCN mixtures (e.g. Halowaxes) were mass produced over much of the last century and were commonly used in electrical equipment due to their physical properties of hydrophobicity, high chemical and thermal stability, good weather resistance, good electrical insulating properties and low flammability. Apart from the environmental release associated with this commercial use, PCNs are also reported to be produced in small amounts as combustion products[1,2].

The structural similarity of PCNs to the highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) molecule indicates an aryl hydrocarbon (Ah) receptor-mediated mechanism of toxicity, and a number of toxic responses such as mortality, embryotoxicity, hepatotoxicity, immunotoxicity, dermal lesions, teratogenicity and carcinogenicity have been reported[3,4,5,6,7]. In humans, severe skin reactions (chloracne) and liver disease have both been reported after occupational exposure to PCNs. Other symptoms found in workers include cirrhosis of the liver, irritation of the eyes, fatigue, headache, anaemia, haematuria, anorexia, and nausea[8]. A European Food Safety Authority (EFSA) scientific colloquium on dioxins in 2004 concluded that compounds such as PCNs that exhibited dioxin-like toxicity should be considered for the Toxic Equivalency Factor (TEF) approach to defining toxicity[9]. This conclusion was shared by the expert panel reviewing the WHO TEF system in 2005[10].

In common with other similar environmental contaminants such as dioxins and PCBs, the main pathway to human exposure is likely to be through dietary intake.

MATERIALS AND METHODS

Study outline

The present study was undertaken to investigate the current levels of PCNs in carcass fat, offal, eggs, fish and milk and processed product.

For this survey the following types of food samples were collected (1)

Table 1 Food Samples included in this survey

SAMPLE TYPE/SPECIES	MATRIX	NUMBER OF SAMPLES	NUMBER OF SUB-SAMPLES PER SAMPLE
AVIAN	FAT	13	10-40 TISSUE SAMPLES
	LIVER	3	10-40 TISSUE SAMPLES
	EGGS	20	24 UNITS
BOVINE	FAT	9	10 TISSUE SAMPLES
	LIVER	2	10 TISSUE SAMPLES
	MILK	32	1 TANKER SAMPLE
OVINE	FAT	10	10 TISSUE SAMPLES
	LIVER	3	10 TISSUE SAMPLES
PORCINE	FAT	6	10-20 TISSUE SAMPLES
	LIVER	2	10 TISSUE SAMPLES
EQUINE	LIVER	2	10 TISSUE SAMPLES
VEGETABLES	POTATOES	2	1KG COMPOSITE
	CABBAGE	1	4 UNITS
	TOMATOES	1	22 UNITS
	MUSHROOMS	1	5*250G PACKETS
PROCESSED VEGETABLES	BAKED BEANS (CANNED)	1	5 CANS
	CANNED SWEETCORN	1	6 CANS
	CANNED TOMATO PUREE	1	12 CANS
CEREALS	OATFLAKES	1	5 PACKETS
	CORNFLAKES	1	5 PACKETS
	BREAD	1	5 PACKETS
	RICE (MICROWAVEABLE)	1	4 PACKETS
PROCESSED MEAT	HAM	1	8 PACKETS
	SAUSAGES	1	4 PACKETS
DAIRY PRODUCTS	BUTTER	5	5 PACKETS
	CHEESE	1	4 PACKETS
FISH	SALMON	5	1 INDIVIDUAL
	MACKEREL	3	50 INDIVIDUALS
	TROUT	3	44-50 INDIVIDUALS
	OYSTERS	5	50-100 INDIVIDUALS

Carcass fat, offal, milk and egg samples were supplied by officers of the Department of Agriculture, Fisheries and Food at production level (slaughterhouse: fat and liver, farm/dairy tanker: milk, packing station: eggs), fish and oysters were supplied by the Marine Institute and the remainder taken by officers of the Food Safety Authority of Ireland at retail level.

Analysis of the samples was undertaken by Food and Environment Research Agency (FERA), York, UK, during 2007-2008 under contract to FSAI.

Analytes included in the survey

PCN Congeners

• PCN 52	1,2,3,5,7-PentaCN	• PCN71/72	1,2,4,5,6,8-hexaCN/1,2,4,5,7,8-HexaCN
• PCN 53	1,2,3,5,8-PentaCN	• PCN 73	1,2,3,4,5,6,7-heptaCN
• PCN 66/67	1,2,3,4,6,7-hexaCN/1,2,3,5,6,7-hexaCN	• PCN 74	1,2,3,4,5,6,8-heptaCN
• PCN 68	1,2,3,5,6,8-hexaCN	• PCN 75	Octachloro-CN
• PCN 69	1,2,3,5,7,8-hexaCN		

The choice of congeners selected in this study was based principally on the toxicological characteristics of individual PCN congeners and the levels and patterns of occurrence. In practice however, the selection was limited by the availability of reliable reference standards. Thus the congeners analysed in this study included mostly penta- to octa- chlorinated compounds, and generally those that are reported to show the highest toxicological effect e.g. PCN 66, 67, 68, 73, etc.

Analytical methods

Sample preparation

The pooled samples were frozen by the Food Safety Authority of Ireland and sent to FERA. The homogenates of the samples were freeze-dried by the laboratory and further homogenized by means of grinding.

Sample Analysis

Samples were fortified with ^{13}C-labelled analogues of target compounds and exhaustively extracted using mixed organic solvents. PCNs were chromatographically fractionated from potential interferants such as PCBs, using activated carbon. The extract was further purified using adsorption chromatography on alumina. Analytical measurement was carried out using high resolution gas chromatography coupled to high resolution mass spectrometry (HRGC-HRMS). Additional control was provided by the inclusion of methods blanks and a reference material. The method limits of detection (LODs) were computed from instrument sensitivity and levels detected in the method blanks. The LODs ranged typically from 0.02-0.1 ng/kg on a whole weight basis for individual PCN congeners. The analytical recovery rate (measured using $^{13}C_{10}$ labeled PCNs) was typically of the order of 55 – 91% for the foods reported here. Measurement uncertainty was also estimated and for PCN concentrations around 1 ng/kg, the uncertainty returned is ~20%; for concentrations approaching, or at the limit of detection (0.02 ng/kg), the value can rise to ~200%. A full description of the procedures used for the extraction and analysis has been reported earlier[11].

RESULTS

Table 2 presents concentrations of PCN congeners measured during this study. Results are expressed as ng/kg fresh weight. In each case results are presented as upper-bound values, substituting values below the analytical limit of quantification with the limit of quantification (<LOQ=LOQ).

TEF values for PCNs have not yet been adopted by regulatory bodies, however, to provide an interim indication of the possible PCN-associated toxicity PCN TEQ values relative to Tetrachlorodibenzodioxin (TCDD) have been calculated and included in Table 2.

The TEFs were derived from four relative potency studies[4,6,7,12] using the highest values where applicable for each congener analyzed and assuming that, where congeners coeluted, the content comprised only the congener with the higher or only TEF (see footnote to Table 2). These PCN TEQ values so calculated have been included in Table 2.

Table 2 Concentration of PCNs in food expressed as ng/kg fresh weight and total TEQ

Samples		N	Fat %	PCN Congener (ng/kg fresh weight)									Sum	TEQ[a]
				52/60	53	66/67	68	69	71/72	73	74	75		
Other	Basmati Rice	1	1.4	0.13	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.25	0.0002
	Bread	1	2.2	0.19	0.09	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.42	0.0003
	Cornflakes	1	1	0.31	0.23	0.04	0.03	0.05	0.03	0.02	0.02	0.04	0.77	0.0004
	Oats	1	6.8	0.30	0.05	0.04	0.03	0.05	0.03	0.02	0.02	0.04	0.58	0.0004
	Cabbage	1	0.2	0.53	2.09	0.01	0.03	0.05	0.10	0.01	0.01	0.01	2.84	0.0003
	Vine Tomatoes	1	0.2	0.03	0.09	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.19	0.0001
	Mushrooms	1	0.3	0.45	1.20	0.01	0.01	0.02	0.04	0.01	0.01	0.01	1.76	0.0002
	Potatoes	1	0.1	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.16	0.0001
	Rooster Potatoes	1	0.2	0.08	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.18	0.0001
	Sweetcorn	1	2	0.07	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.20	0.0001
	Tomato puree	1	0.7	0.08	0.08	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.25	0.0001
	Sausages	1	35.4	0.14	0.13	0.14	0.01	0.03	0.02	0.03	0.01	0.03	0.54	0.0007
	Ham	1	2.5	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.13	0.0001
	Red Cheddar	1	27.1	0.17	0.03	0.26	0.02	0.03	0.01	0.12	0.01	0.03	0.68	0.0015

Table 2 continued Concentration of PCNs in food expressed as ng/kg fresh weight and total TEQ

Samples		N	Statistics	Fat %	PCN Congener (ng/kg fresh weight)									Sum	TEQ[a]
					52/60	53	66/67	68	69	71/72	73	74	75		
Fish	Mackerel	3	Mean	4.25	5.42	1.20	0.32	0.27	0.24	0.32	0.03	0.13	0.02	7.94	0.0028
			Min	3.10	4.30	0.53	0.17	0.13	0.18	0.24	0.03	0.12	0.02	5.90	0.0017
			Max	5.20	8.57	1.98	0.73	0.61	0.38	0.46	0.03	0.14	0.03	12.90	0.0057
	Farmed Salmon	5	Mean	14.96	32.70	2.56	3.32	1.46	1.36	1.26	0.43	0.17	0.03	43.28	0.0223
			Min	11.00	9.52	0.81	0.86	0.40	0.41	0.39	0.06	0.15	0.03	12.65	0.0058
			Max	17.50	45.07	3.66	4.84	2.06	1.96	1.77	0.69	0.18	0.03	59.30	0.0321
	Trout	3	Mean	2.33	2.12	0.79	0.25	0.24	0.29	0.45	0.08	0.08	0.03	4.32	0.0026
			Min	1.80	0.90	0.32	0.13	0.13	0.16	0.24	0.03	0.04	0.02	2.08	0.0014
			Max	2.70	3.57	1.58	0.35	0.43	0.54	0.80	0.10	0.13	0.04	7.47	0.0042
	Pacific Oysters	5	Mean	2.12	0.75	0.28	0.01	0.01	0.02	0.01	0.01	0.01	0.01	1.11	0.0001
			Min	1.7	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.18	0.0001
			Max	3.1	1.61	0.65	0.01	0.01	0.03	0.02	0.01	0.01	0.01	2.34	0.0002
Dairy	Milk	15	Mean	3.9	0.04	0.03	0.03	0.01	0.01	0.01	0.03	0.03	0.05	0.22	0.0003
			Min	2.6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.0001
			Max	5.1	0.08	0.05	0.04	0.01	0.01	0.01	0.06	0.05	0.11	0.38	0.0004
	Butter	5	Mean	81.66	0.53	0.11	0.67	0.07	0.09	0.05	0.35	0.06	0.09	2.04	0.0042
			Min	80.9	0.45	0.09	0.16	0.06	0.09	0.05	0.05	0.03	0.08	1.31	0.0012
			Max	83	0.66	0.14	1.42	0.08	0.10	0.06	0.73	0.08	0.10	3.13	0.0084
Eggs	Eggs	15	Mean	10.12	0.34	0.07	0.05	0.04	0.06	0.03	0.02	0.01	0.02	0.62	0.0005
			Min	8.8	0.11	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.23	0.0002
			Max	11.2	1.47	0.12	0.11	0.11	0.26	0.08	0.05	0.01	0.02	2.22	0.0015
Liver	Avian	3	Mean	5.00	0.22	0.04	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.37	0.0002
			Min	4.8	0.08	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.18	0.0001
			Max	5.1	0.43	0.05	0.03	0.03	0.02	0.01	0.03	0.01	0.02	0.61	0.0003
	Bovine	2	Mean	3.55	0.09	0.02	0.09	0.01	0.02	0.01	0.04	0.01	0.02	0.30	0.0006
			Min	3.3	0.08	0.02	0.08	0.01	0.02	0.01	0.03	0.01	0.02	0.29	0.0005
			Max	3.8	0.09	0.02	0.09	0.01	0.02	0.01	0.05	0.01	0.02	0.31	0.0006
	Equine	2	Mean	4.25	0.08	0.03	0.34	0.02	0.01	0.02	0.04	0.01	0.02	0.55	0.0015
			Min	3.8	0.07	0.02	0.29	0.01	0.01	0.01	0.03	0.01	0.02	0.53	0.0013
			Max	4.7	0.08	0.04	0.38	0.02	0.01	0.03	0.04	0.01	0.02	0.57	0.0017
	Ovine	3	Mean	5.40	0.11	0.12	1.18	0.01	0.02	0.02	0.93	0.02	0.03	2.44	0.0077
			Min	4.3	0.07	0.06	0.69	0.01	0.01	0.01	0.42	0.01	0.01	1.34	0.0041
			Max	7	0.18	0.24	1.96	0.02	0.02	0.03	1.80	0.03	0.05	4.26	0.0135
	Porcine	2	Mean	3.95	0.09	0.06	0.10	0.01	0.02	0.01	0.02	0.01	0.02	0.33	0.0005
			Min	3.7	0.07	0.03	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.28	0.0005
			Max	4.2	0.11	0.09	0.11	0.01	0.02	0.01	0.02	0.01	0.02	0.37	0.0005
Carcass Fat	Avian	6	Mean	84.63	3.39	1.01	0.51	0.41	0.38	0.27	0.43	0.05	0.09	6.54	0.0054
			Min	67	0.88	0.29	0.17	0.25	0.17	0.14	0.26	0.05	0.08	2.81	0.0029
			Max	92.7	8.60	1.54	0.98	0.69	0.75	0.53	0.73	0.06	0.12	13.41	0.0095
	Bovine	5	Mean	81.52	0.53	0.13	1.03	0.05	0.09	0.05	0.30	0.05	0.09	2.32	0.0054
			Min	75.8	0.47	0.11	0.95	0.05	0.08	0.05	0.26	0.05	0.08	2.24	0.0050
			Max	87.3	0.62	0.17	1.08	0.05	0.09	0.05	0.34	0.05	0.09	2.52	0.0057
	Ovine	5	Mean	87.50	0.58	0.25	1.85	0.06	0.09	0.09	0.53	0.06	0.10	3.61	0.0094
			Min	84.2	0.42	0.10	1.51	0.06	0.09	0.06	0.34	0.04	0.09	2.95	0.0075
			Max	93.7	0.69	0.47	2.26	0.06	0.10	0.12	0.71	0.07	0.11	4.17	0.0116
	Porcine	5	Mean	71.04	0.58	0.32	0.31	0.06	0.10	0.10	0.08	0.06	0.11	1.72	0.0019
			Min	64.8	0.42	0.10	0.24	0.06	0.09	0.06	0.06	0.04	0.09	1.63	0.0017
			Max	77.2	0.95	0.46	0.45	0.08	0.13	0.12	0.08	0.07	0.13	1.90	0.0024

[a] TEF values taken from Behnisch et al., 2003; Blakenship, et al., 2000; Hanberg et al., 1990; Villeneuve et al., 2000 (PCN52: 0.000025, PCN53: 0.0000018, PCN66/67: 0.004, PCN68: 0.0028, PCN69: 0.002, PCN71/72: 0.00009, PCN73: 0.0031, PCN74: 0.0000041, PCN75: 0.00001).

All samples apart from rice, processed tomatoes and beans (Other Foods category), showed the presence of PCNs, although the frequency of detection and relative abundance varied depending on the congener and the type of food. Fish showed a larger range of detected congeners as well as the most abundant occurrence. The moderately chlorinated congeners (penta-) dominated the profile, with abundance gradually declining as the degree of chlorination increased. A similar profile was observed for eggs, but for most meat (apart from poultry) and dairy products, the toxicologically more significant congeners - PCN 66/67 and PCN 73, were often the only congeners detected.

This contrasting profile observed for tissues from higher order animal and milk/dairy products may be the result of selective bio-accumulation or metabolic processes. Only three popular species of fish were investigated – mackerel, salmon and trout, but of these the most oily fish, salmon (15% fat), showed the highest levels – on average, an order of magnitude higher than trout (2.3% fat).

Relatively high concentrations were also observed in the samples of animal fat which reflect PCN concentration in meat, although avian (chicken) fat was found to contain higher levels than the other species. Ovine fat showed comparable levels to some of the avian fat, and this is also reflected in the samples of ovine liver.

TEQ values ranged from 0.0001 ng/kg TEQ mainly for vegetables and vegetable-based foods and some shellfish to 0.03 ng/kg TEQ for fish.

EXPOSURE ESTIMATES

Exposure of the Irish population to PCNs has been calculated using Crème probabilistic modelling software[13] based on the occurrence data for carcass fat, milk, eggs, offal and fish shown in this report.

Estimated contribution to the total TEQ from PCNs from consumption of food of animal origin was calculated at approximately 0.14 pg/kg bw/month. This can be compared with the exposure of the average adult population to upperbound Total WHO TEQ PCDD/Fs & DL-PCBs from consumption of food of animal origin, which is estimated at 12 pg/kg bw/month[14]. The contribution made by the PCNs to the total WHO TEQ is approximately 1% of the estimated for dioxins and PCBs. This finding is in line with the considerably lower PCN TEQ concentrations in the samples analysed in this study.

DISCUSSION

This study demonstrates the universal presence of PCNs in food and provides baseline information on the concentrations found in Irish food. Whilst there is variation in occurrence depending on individual congeners of these contaminants and the types of food studied, the widespread detection in Irish food underlines the ubiquity of these contaminants, since Ireland generally shows food contamination levels that are below the European average for environmental contaminants such as dioxins and PCBs except following specific contamination incidents.

The profile of PCN congener occurrence in some foods (e.g. in some vegetable-based foods, fish etc, where metabolic or other degradation pathways are unlikely to be significant) is similar to that of commercial mixtures of PCNs, and despite other sources such as incineration being reported, the legacy of past commercial usage still appears to strongly influence the background pattern of occurrence.

It is clear from the data that PCN TEQ is considerably lower for the samples analysed in this work, than for similar samples from Ireland analysed for PCB and dioxin TEQ. For example an average TEQ of 0.03 ng/kg for salmon can be an order of magnitude or more lower compared to other dioxin-like compounds (average - 0.54 ng/kg PCDD/F TEQ and 1.61 ng/kg PCB-TEQ for fish) in similar foods[15],[16].

The levels of PCNs observed in this Irish study are broadly similar to the few, recently reported levels in other countries[11,17,18,19] Comparisons with data from the current study are limited primarily due to the scarcity of data, but also because there are only a few congener-specific studies, and these have investigated environmental media[2] or environmental biota[20]. Congener selective measurement is an important consideration for food safety given that the emerging information on PCN toxicology increasingly involves estimates of potency for individual PCN congeners. Recent studies on edible fish and food [17,21,22] have reported data on the sum of PCN homologue groups or different sets of congeners, and it is important to note that, in comparison with these data, the sum of the 12 targeted PCN congeners reported in the current study will always be an underestimate of the total PCN content. Thus the median whole weight concentrations of 340 ng/kg for Baltic salmon, 57 ng/kg for Baltic herring, and 71 ng/kg for Baltic sprat[17] compare with 46.5 ng/kg for salmon, 6.5 ng/kg for mackerel, and 3.41 ng/kg for trout in this study. Similarly the average concentration reported in a recent Spanish study on food for the sum of PCNs in fish [22] was 47.1 ng/kg as compared to 21.7 ng/kg in this study. Average concentrations for eggs and milk were 4.3, and 0.8 ng/kg, respectively[22], compared to 0.62, and 0.22 ng/kg, respectively, in this study. A recent congener specific survey conducted on individual samples in the UK[11] reported ranges similar found to the ones reported in pooled samples in this survey.

CONCLUSIONS

This study demonstrates the universal presence of PCNs in food. However, the survey shows that Irish produce contains low amounts of the persistent bio-accumulative toxicants measured in this survey compared to other legacy POPs such as dioxins and PCBs, and levels observed do not raise concern for human health.

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Food Safety
AUTHORITY OF IRELAND

Abbey Court,
Lower Abbey Street,
Dublin 1.

Advice Line: 1890 336677
Telephone: +353 1 817 1300
Facsimile: +353 1 817 1301
Email: info@fsai.ie
Website: www.fsai.ie