Food Safety Authority of Ireland

Investigation into Levels of Dioxins, Furans, PCBs and some elements in Battery, Free-Range, Barn and Organic Eggs

March 2004

Table of Contents

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Summary

The Food Safety Authority of Ireland (FSAI) has carried out a surveillance study of levels of dioxins (PCDDs), furans (PCDFs), polychlorinated biphenyls (PCBs) and some elements (cadmium, lead, tin, aluminium, mercury, arsenic, copper, chromium and selenium) in battery, free-range, barn and organic eggs. The study was undertaken because of concern about the possible effects on human health of the bio-persistent PCDDs, PCDFs and PCBs, known to be present in a number of foodstuffs, notably meat, fish, eggs and dairy products. The toxic metals, lead, cadmium, mercury and arsenic have been reported in eggs, and also have adverse effects on human health.

The study showed that levels of dioxins and furans in Irish eggs are well below the legal limit of three picogram (pg) WHO-PCDD/F-TEQ[1]/gram (g) fat The total mean upper-bound level of PCDDs and PCDFs, expressed as WHO-PCDD/F- TEQ, was 0.49 ng/kg fat (pg/g) for all egg types taken together. Mean levels for battery, free range and barn eggs were 0.36, 0.47 and 0.31 pg WHO-PCDD/F-TEQ/g fat respectively, the overall mean being raised by the mean for organic eggs, at 1.30 pg WHO-PCDD/F-TEQ/g fat. Levels of dioxin-like and non-dioxin-like PCBs, including the so-called marker PCBs 28, 52, 101, 118, 138, 153 and 180, were also generally low in the majority of egg samples.

The results of the study are in line with those from previous FSAI studies on dioxin and furan levels in milk and fish and confirm that levels in Irish food are relatively low compared with similar products from more industrialised countries in the European Union. These findings support the conclusion that exposure of the Irish population to dioxins and furans in food is therefore likely to be lower than the European average. Estimation of the total intake of PCDD/F and dioxin-like PCBs resulting from weekly consumption of eggs provides a weekly intake of 0.19 WHO TEQ/kilogram (kg) body weight (b.w.), a figure which may be compared with the Tolerable Weekly Intake of 14 pg WHO TEQ/kg b.w. established for PCDDs, PCDF and dioxin-like PCBs by the EU Scientific Committee for Food. It can be concluded that this level of intake of PCDD/F and dioxin-like PCBs resulting from consumption of Irish eggs containing typical levels of dioxins and dioxin-like PCBs does not present a risk to the health of the Irish population. The levels of the toxic metals lead, cadmium, mercury, tin and arsenic detected indicate a very low level of occurrence of these contaminants in Irish eggs.

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

[1] The abbreviation "WHO-PCDD/PCDF-TEQ" refers to the toxic equivalence factors (TEF) established for a range of PCDDs and PCDFs by the World Health Organization (WHO). See Section 4 of this report.

1. Background

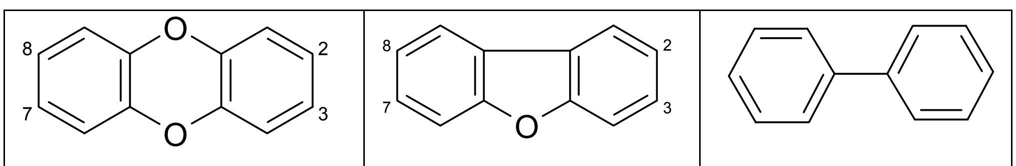
The Food Safety Authority of Ireland (FSAI) has a statutory responsibility to ensure the safety of food consumed, distributed, produced and sold on the Irish market. In this respect, the FSAI co-ordinates the collation of food safety surveillance information from laboratories run by its official agents, the health boards, the Department of Agriculture and Food, the Department of Communications, 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, furans, polychlorinated biphenyls (PCBs) and 10 elements (cadmium, lead, tin, aluminium, mercury, arsenic, copper, chromium, selenium and zinc) in battery, free-range, barn and organic eggs.

The study was undertaken against the background of increased awareness in the European Union of the possible health risks posed by dioxins, furans and PCBs in the food chain, and builds on previous studies undertaken by FSAI into levels of these contaminants in milk, fish and fish oils. The opportunity was taken at the same time to investigate the levels of a number of elements in these eggs, namely cadmium, mercury, lead, copper, selenium, tin, zinc, arsenic, aluminium and chromium. This reflects concerns about the possible health effects of certain metals such as lead, mercury, arsenic and cadmium, and the essential nutrient status of other elements such as selenium and copper. This study provided the opportunity to obtain information on the background levels of the dioxins, furans and PCBs, and also the elements mentioned above, in Irish eggs.

2. Dioxins and furans

The term 'dioxin' is commonly used to describe a family of organic chemicals with similar chemical structures (Figure 1) and a common mechanism of toxicity. It covers a group of 75 polychlorinated dibenzo-p-dioxins (PCDD) and 135 polychlorinated dibenzofurans (PCDF), which typically occur as a mixture of the different congeners. Seventeen of these are regarded as being of toxicological concern, and 2,3,7,8-tetrachlordibenzo-p-dioxin (TCDD) is the most toxic of the dioxin-like substances.

Figure 1: Molecular structure of dioxin and dioxin-like compounds



Dioxin structure	Furan structure	Biphenyl structure

These substances derive their toxic characteristics from the presence of one or more halogen atoms, commonly chlorine and less commonly, bromine. Most of the toxicity data are based on studies of the most toxic dioxin congener, TCDD, which is classified by the International Agency

for Research on Cancer (IARC) and other reputable international organisations as a human carcinogen. Toxicity is mediated via the aryl hydrocarbon (Ah) receptor present in most tissues of animals and humans, and toxicological studies have shown a wide range of toxic responses following exposure to dioxins, including dermal toxicity (chloracne), immunotoxicity, carcinogenicity, reproductive toxicity and possible neurobehavioral (cognitive) effects. Studies on children exposed before birth to dioxins are reported to have shown endocrine and developmental changes, persisting for long periods. By analogy with TCDD, all dioxins are considered as presumed carcinogens. The EU Scientific Committee for Food ("SCF"), in line with the World Health Organisation ("WHO"), have concluded however 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 uncontrolled incineration of waste, although 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. Dioxins have been identified in almost all environmental compartments in industrialised countries, as a result of these emissions. 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 possibility that dioxins may accumulate in human tissues as a result of exposure via food. In the case of cows or other lactating species, dioxins can potentially occur in milk, specifically in milk fat and consequentially also in cream and in milk products such as cheese, in addition to carcase meat, while in fish, they 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.

The presence of dioxins in food has been a matter of concern for a number of years, particularly since the Belgian dioxin crisis in 1999, when industrial transformer oil containing dioxins was included in fat that was being recycled for animal feed, resulting in entry of the contaminants into the human food chain. Evidence of this contamination was first recorded on Belgian chicken farms, with increased dioxin levels being found in chicken meat and eggs, and subsequently in a wide variety of other animal-derived foods. Since then, a number of countries including the Netherlands and the United Kingdom have reported high dioxin levels in eggs, particularly in free-range eggs. The latter finding has been attributed to foraging of the chickens on dioxin-contaminated land.

3. PCBs

The polychlorinated biphenyls or 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), who 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.

4. 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) 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 be noted however 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 × TEFi) + (PCDFi × TEFi) + (*dioxin like* PCBi × TEFi)

(Note: i = each congener + corresponding TEF, as listed in tables 1 and 2)

Several different TEF schemes have been proposed. For many years the most widely used scheme was 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

(NATO/CCMS scheme, 1988 (dioxins), WHO-ECEH scheme, 1994 (PCBs) and WHO scheme, 1998)

PCDDs and PCDFs	Toxic Equivalency Factor (TEF)	
	I-TEF	WHO-TEF
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: *OCDD, octachlorodibenzo-p-dioxin; PnCDF, pentachlorodibenzofuran; HxCDF, hexachlorodibenzofuran; HpCDF, heptachlorodibenzofuran; OCDF, octachlorodibenzofuran; PnCDD, pentachlorodibenzo-p-dioxin; HxCDD, hexachlorodibenzo-p-dioxin; HpCDD, heptachlorodibenzo-p-dioxin;.*

TABLE 2: TEFs FOR DIOXIN-LIKE PCBs

(NATO/CCMS scheme, 1988 (dioxins), WHO-ECEH scheme, 1994 (PCBs) and WHO scheme, 1998)

PCBs (IUPAC No. in parenthesis)	Toxic Equivalency Factor (TEF)	
	I-TEF	WHO-TEF
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; HpCB, heptachlorobiphenyl.*

Risk assessment of dioxins and PCBs in food

The European Scientific Advisory Committee on Food (SCF) have carried out a risk assessment of dioxins and dioxin-like PCBs in food, as a consequence of which they concluded that the Tolerable Weekly Intake (TWI) for PCDDs, PCDFs and dioxin-like PCBs should be no higher than 14 picogram (pg) WHO-TEQ/kilogram (kg) body weight (b.w.) per week. This is broadly similar to the Provisional Tolerable Monthly Intake (PTMI) of 70 pg/kg bw per month, as calculated by the FAO/WHO Joint Expert Committee on Food Additives and Contaminants (JECFA). It has been estimated that the European average dietary intake is 1.2 to 3.0 pg WHO-TEQ/kg b.w./day, which translates into a weekly intake of between 8.4 and 21 pg WHO-TEQ/kg b.w. The latter figure 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 generally low. Hence, it is likely that the exposure of the Irish population to dioxins in food is less than the European average.

Given that the weekly average dietary intake of dioxins by at least 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 (EC) published legislation 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). However, as an additional feature of the reduction strategy the EC has also published a regulation that sets maximum limits for dioxins in foodstuffs (Council Regulation 2375/01/EC amending Commission Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs). Council Regulation 2375/01/EC also carries with it an obligation for Member States to monitor the levels of dioxins in foodstuffs and report to the EC. Under this obligation, Ireland is required to carry out monitoring in a variety of foodstuffs. The dioxin monitoring program carried out in 2003 included meat, offal, fruit, vegetables and eggs, the results for the last-named group being reported in this study. 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), the scientific body that has taken over the work of the SCF, have 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 the end of 2004 at the earliest.

Metals and other elements

The metals cadmium, lead, tin, aluminium and mercury and the semimetal arsenic currently have no known beneficial health effects and are harmful to human health if consumed above certain threshold levels. The metals zinc, copper, chromium and the element selenium are nutrients and are essential, however consumption of excessive levels of these nutrients can also result in harmful effects. These metals/elements occur in foods, either naturally and/or as a result of human activities (e.g. agricultural practices, industrial emissions, car exhausts).

This study aims to assess occurrence levels of these metals/elements in eggs.

Study outline

Egg samples (excluding retail samples) were provided by the officers of the Egg and Poultry Division of the Department of Agriculture and Food (DAF), while planning and co-ordination of the project and sampling of eggs at retail level was undertaken by FSAI staff. The sampling protocol was drawn up jointly between DAF and the FSAI. A total of 40 samples (see Table 3) were analysed, consisting of 30 individual samples (eggs from one single producer) and 10 pooled samples (eggs from different producers). The size of the samples varied from five to 12 eggs per sample. This variation is largely due to availability of samples and loss/damage at transport of the samples to the laboratory. 30 samples were taken from egg packing stations in Monaghan, Meath, Westmeath and Louth, which receive the majority of eggs produced in the whole of Ireland, and 10 samples were taken in retail outlets in Dublin. For both free range and battery eggs, 16 samples each were taken, whereas for barn and organic eggs four samples each were taken. The low number of samples for the latter categories is due to the low production of these type eggs in Ireland.

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

Table 3: SAMPLE DETAILS

Egg type	Origin	Sample type	Sample Identification code	no of eggs in sample
Barn eggs	Cavan	Individual sample	8052	5
Barn eggs	Castleblayney	Individual sample	8055	6
Barn eggs	Monaghan	Individual sample	8056	6
Barn eggs	Retail	Retail	8028	12
Battery eggs	Louth	Individual sample	8047	6
Battery eggs	Dundalk	Individual sample	8048	6
Battery eggs	Monaghan	Individual sample	8049	6
Battery eggs	Monaghan	Individual sample	8053	6
Battery eggs	Monaghan	Individual sample	8054	6
Battery eggs	Monaghan	Individual sample	8057	6
Battery eggs	Monaghan	Individual sample	8061	6
Battery eggs	n/a	Pooled sample	8033	9
Battery eggs	n/a	Pooled sample	8034	9
Battery eggs	n/a	Pooled sample	8035	4
Battery eggs	n/a	Pooled sample	8039	9
Battery eggs	n/a	Pooled sample	8041	9
Battery eggs	Retail	Retail	8022	12
Battery eggs	Retail	Retail	8023	12
Battery eggs	Retail	Retail	8029	10
Battery eggs	Retail	Retail	8031	12
Free range eggs	Monaghan	Individual sample	8042	6
Free range eggs	Meath	Individual sample	8043	6
Free range eggs	Kilkenny	Individual sample	8044	6
Free range eggs	Wicklow	Individual sample	8050	6
Free range eggs	Monaghan	Individual sample	8058	6
Free range eggs	West Meath	Individual sample	8059	6
Free range eggs	Meath	Individual sample	8060	6
Free range eggs	n/a	Pooled sample	8032	9
Free range eggs	n/a	Pooled sample	8036	9
Free range eggs	n/a	Pooled sample	8037	9
Free range eggs	n/a	Pooled sample	8038	7
Free range eggs	Monaghan	Pooled sample	8040	8
Free range eggs	Retail	Retail	8025	11
Free range eggs	Retail	Retail	8026	9
Free range eggs	Retail	Retail	8027	10
Free range eggs	Retail	Retail	8030	12
Organic eggs	Meath	Individual sample	8045	6
Organic eggs	Monaghan	Individual sample	8046	5
Organic eggs	Monaghan	Individual sample	8051	6
Organic eggs	Retail	Retail	8024	11

Methodology

(1) Dioxins and PCBs

The samples were ground, fortified with known amounts of surrogate ($^{13}C_{12}$-labelled) analogues of target analytes and exhaustively extracted using mixed organic solvents. The extract was cleaned up using adsorption chromatography. *Ortho*-PCBs, non-*ortho*-PCBs and PCDDs/PCDFs were segregated into three 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 and PCDDs/PCDFs).

The analytical limits of detection for the methodology used are significantly below the maximum and action limits for eggs (fat weight) as detailed in recent EU directives.

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

Quality Control Procedures
The congener-specific determination of polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (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 acceptance criteria for PCDDs and PCDFs and equivalent criteria for PCBs. The method used has been validated and published after peer review. 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 all fell within the acceptable range except for 2,3,4,6,7,8-HxCDF which was just outside the acceptable range and for which data has been reported as indicative only. Each batch of samples analysed included 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 were calculated using internationally accepted Toxic Equivalency Factors.

(2) Metals/Elements

Aliquots of each blended sample (1g) plus certified reference materials (0.5g) were digested in nitric acid using quartz high pressure closed vessels and microwave heating prior to quantification by inductively coupled plasma-mass spectrometry (ICP-MS). Reagent blanks and a reagent blank spiked with a known amount of each analyte were analysed with the test samples for recovery estimate purposes. All data were corrected for reagent blank and spike recovery. The LOD was calculated from 3 x standard deviation of reagent blank values adjusted for dilution and sample weight. The LOQ is 10 x standard deviation of reagent blank values adjusted for dilution and sample weight. Reference material data were satisfactory.

Detection limits

	Al	Cr	Cu	Zn	As	Se	Cd	Sn	Hg	Pb
LOD value (based on 1.0g sample weight)	0.05	0.02	0.05	0.05	0.01	0.1	0.005	0.1	0.01	0.005
LOQ value (based on 1.0g sample weight)	0.17	0.07	0.17	0.17	0.03	0.3	0.017	0.3	0.03	0.017

Quality Control Procedures

Each analytical batch was assessed in accordance with the following quality procedures for multi-element analyses:

Instrument stability
Analyses include re-measurement of a calibration standard at the end of each analytical run. Acceptable values were +/- 20% of the original concentration.

Spike recovery
Data were accepted if the recovery of spike for each analyte lies within the range 60 to 140% with at least 75% of these recoveries lying within the range 80 to 120%.

Reference material data
For multi-element analyses, accepted results must all be within the certified range or +/- 40% of the quoted value. Where indicative values are shown on certificates, measured concentrations would be within a factor of 2 of the quoted value.

Replicate agreement
Replicate values for a given sample must have a relative standard deviation of ≤20% or a standard deviation of ≤LOQ to be deemed acceptable. In this study, 10% of the samples were analysed in duplicate.

Analytes included in the survey

1. PCDDs/PCDFs and PCBs

The 17 PCDD/PCDF congeners of toxicological concern shown in table 1 and the following PCB congeners, including the 12 dioxin-like PCBs (PCBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and the 7 marker PCBs (PCBs 28, 52, 101, 118, 138, 153 and 180), 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. Metals/Elements

Cadmium	Zinc
Mercury	Selenium
Lead	Aluminium
Arsenic	Copper
Chromium	Tin

Results

(A) PCDD/Fs and PCBs

Table 4 presents the levels of PCDD/Fs, dioxin-like PCBs and marker PCBs in all egg types taken together, expressed as total WHO TEQs in ng/kg (pg/g) fat 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 for the marker PCBs 28, 52, 101, 118, 138, 153 and 180. In each case results are presented as upper-bound and lower-bound levels and as the calculated mean, median minimum and maximum level.

Table 4: Mean, median, minimum and maximum upper- and lower-bound levels of PCDD/Fs, dioxin-like PCBs and total TEQs and sum of 7 Marker PCBs in Irish eggs

	N	Mean	Med	Min	Max
PCDD/F WHO TEQs (ng/kg fat lower-bound)	40	0.43	0.35	0.03	2.70
PCDD/F WHO TEQs (ng/kg fat upper-bound)	40	0.49	0.39	0.10	2.70
Dioxin- like PCBs WHO TEQ (ng/kg fat lower-bound)	40	0.26	0.13	0.07	3.89
Dioxin- like PCBs WHO TEQ(ng/kg fat upper-bound)	40	0.42	0.30	0.22	3.93
Total WHO TEQs (ng/kg fat lower-bound)	40	0.69	0.48	0.12	6.59
Total WHO TEQs (ng/kg fat upper-bound)	40	0.91	0.70	0.37	6.63
∑ Marker PCBs (μg/kg fat lower-bound)	40	9.79 (2.63)*	2.63 (2.48)*	0.92 (0.00)*	275.85 (6.37)*
∑ Marker PCBs (μg/kg fat upperbound)	40	9.95 (7.56)*	2.88 (7.22)*	1.32 (0.00)*	275.94 (13.22)*

**Numbers in brackets exclude data from two organic samples, for which extreme values were recorded.*

The overall mean upper-bound level for PCDD/Fs, averaged over all eggs, was 0.49 pg WHO-TEQ/g fat, with a minimum of 0.10 and a maximum of 2.70, while the upper-bound level for dioxin-like PCBs was 0.42 pg WHO-TEQ/g fat, with a minimum of 0.22 and a maximum of 3.93. The mean upper-bound level of the seven marker PCBs (summed) was 9.95 μg/kg fat, with a minimum of 1.32 and a maximum of 275.94.

Table 5 presents the levels of PCDD/Fs and dioxin-like PCBs in the four egg types separately, expressed as total WHO TEQs in ng/kg (pg/g) fat 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. Examination of the results for the individual egg types shows a mean upper-bound level for PCDD/Fs for barn eggs of 0.31 pg WHO-PCDD/F-TEQ/g fat, for battery eggs 0.36 pg/g fat and for free-range eggs

0.47 pg/g fat. The mean for organic eggs was higher, at 1.30 pg WHO-PCDD/F-TEQ/g fat. This result was however skewed due to one particularly high result which, at 2.70 pg/g fat, was the only sample out of 40 analysed to come close to the legal limit of 3 pg WHO-PCDD/F-TEQ/g fat. The levels found in eggs from the flocks of this producer may be attributed to the age of the birds, which ranged from 23 weeks to four years, since there was a close correlation between the age of the hens and the levels of dioxins found in the eggs. Values for the other three samples of organic eggs were 0.48, 0.77 and 1.25 pg WHO-PCDD/F-TEQ/g fat respectively (Table 12), giving a mean of 0.83 pg WHO-PCDD/F-TEQ/g fat.

Table 5: Mean, minimum and maximum upper-bound levels of PCDD/Fs in Irish battery, free range, organic and barn eggs

		Sum of PCDD/F + dioxin-like PCBs (WHO TEQ, ng/kg fat)			Sum of PCDD/F (WHO TEQ, ng/kg fat)			Sum of dioxin-like PCBs (WHO TEQ, ng/kg fat)		
	N	Mean	Min.	Max.	Mean	Min.	Max	Mean	Min	Max
Battery eggs	16	0.65	0.37	0.87	0.36	0.10	0.58	0.29	0.26	0.37
Free range eggs	16	0.79	0.41	1.26	0.47	0.19	0.83	0.32	0.22	0.43
Organic eggs	4	2.73	0.84	6.63	1.30	0.48	2.70	1.43	0.36	3.93
Barn eggs	4	0.57	0.43	0.78	0.31	0.18	0.51	0.27	0.25	0.28

Table 6 presents the sum of the seven marker PCBs in each egg type, expressed in µg/kg fat, again as the calculated mean, minimum and maximum upper-bound levels. Levels were generally low in all egg samples with the exception of the organic egg sample in which high levels of PCDD/Fs were detected. The sum of the marker PCBs for this sample was 275.94 µg/kg fat. The sum of the mean levels in the battery, free range and barn egg samples were 3.24, 2.52 and 3.02 µg/kg fat respectively. The mean levels in two of the three remaining organic egg samples were in this range (2.99 and 3.40 µg/kg fat), while the third sample had a somewhat higher level of 10.35 µg/kg. The two higher values for organic eggs contributed to the overall high mean sum for organic eggs of 73.44 µg/kg fat.

Table 6: Mean, minimum and maximum upper-bound levels of marker PCBs in Irish battery, free range organic and barn eggs

		Sum of marker PCBs (28, 52, 101, 118, 138, 153, and 180) (µg/kg fat)		
	N	Mean	Min.	Max.
Battery eggs	16	3.24	2.22	6.13
Free range eggs	16	2.52	1.32	4.35
Organic eggs	4	73.44	3.29	275.94
Barn eggs	4	3.02	1.87	4.40

The results for the individual PCDDs, PCDFs, dioxin-like PCBs and non-dioxin-like PCBs measured in this study are presented in Tables 7, 8 and 9 for the four egg types taken together. In each case results are presented as the upper-bound mean, median, minimum and maximum levels and are expressed in ng/kg fat in the case of PCDDs, PCDFs and dioxin-like PCBs and in µg/kg fat in the case of non-dioxin-like PCBs.

Table 7: Mean, median, minimum and maximum upper-bound levels of individual PCDD/Fs in Irish eggs

PCDDs (ng/kg fat) (upper-bound)	N	Mean	Med	Min	Max
2,3,7,8-TCDD	40	0.075	0.060	0.020	0.210
1,2,3,7,8-PeCDD	40	0.155	0.130	0.020	0.640
1,2,3,4,7,8-HxCDD	40	0.094	0.070	0.030	0.670
1,2,3,6,7,8-HxCDD	40	0.296	0.185	0.090	1.660
1,2,3,7,8,9-HxCDD	40	0.138	0.100	0.020	0.780
1,2,3,4,6,7,8-HpCDD	40	1.066	0.470	0.160	8.010
OCDD	40	3.219	1.815	0.590	24.240
PCDFs (ng/kg fat) (upper-bound)	**N**	**Mean**	**Med**	**Min**	**Max**
2,3,7,8-TCDF	40	0.265	0.160	0.080	1.650
1,2,3,7,8-PeCDF	40	0.166	0.100	0.050	1.490
2,3,4,7,8-PeCDF	40	0.215	0.155	0.020	1.660
1,2,3,4,7,8-HxCDF	40	0.184	0.140	0.070	1.500
1,2,3,6,7,8-HxCDF	40	0.119	0.080	0.040	0.930
1,2,3,7,8,9-HxCDF	40	0.041	0.040	0.010	0.080
2,3,4,6,7,8-HxCDF	40	0.126	0.080	0.020	0.950
1,2,3,4,6,7,8-HpCDF	40	0.526	0.235	0.090	4.390
1,2,3,4,7,8,9-HpCDF	40	0.050	0.035	0.020	0.200
OCDF	40	0.179	0.105	0.040	1.330

Table 8: Mean, median, minimum and maximum upper-bound levels of individual dioxin-like PCBs in Irish eggs

Mono-*ortho* PCBs (ng/kg fat) (upper-bound)	N	Mean	Med	Min	Max
PCB105	40	0.120	0.100	0.070	0.790
PCB114	40	0.094	0.100	0.070	0.110
PCB118	40	0.310	0.210	0.100	3.210
PCB123	40	0.099	0.100	0.070	0.280
PCB156	40	0.185	0.100	0.070	3.620
PCB157	40	0.104	0.100	0.070	0.480
PCB167	40	0.130	0.100	0.070	0.950
PCB189	40	0.141	0.100	0.070	1.790
Non-*ortho* PCBs (ng/kg fat) (upper-bound)	**N**	**Mean**	**Med**	**Min**	**Max**
PCB77	40	11.551	8.485	3.730	37.370
PCB81	40	0.938	0.685	0.290	3.100
PCB126	40	1.525	1.015	0.550	11.800
PCB169	40	0.387	0.230	0.070	4.330

Table 9: Mean, median, minimum and maximum levels of individual non-dioxin-like PCBs in Irish eggs

Non dioxin like PCBs (µg/kg fat) (upper-bound)	N	Mean	Med	Min	Max
PCB18	40	0.094	0.100	0.070	0.110
PCB28	40	0.474	0.210	0.100	4.640
PCB31	40	0.105	0.100	0.070	0.450
PCB33	40	0.094	0.100	0.070	0.110
PCB37	40	0.016	0.008	0.004	0.184
PCB41	40	0.099	0.100	0.070	0.180
PCB44	40	0.094	0.100	0.070	0.110
PCB47	40	0.134	0.110	0.070	0.420
PCB49	40	0.094	0.100	0.070	0.110
PCB51	40	0.094	0.100	0.070	0.110
PCB52	40	0.095	0.100	0.070	0.130
PCB56/60	40	0.115	0.100	0.070	0.370
PCB61/74	40	0.195	0.125	0.060	0.890
PCB66	40	0.236	0.190	0.070	0.920
PCB87	40	0.114	0.100	0.080	0.580
PCB99	40	0.159	0.115	0.080	0.720
PCB101	40	0.114	0.100	0.070	0.740
PCB110	40	0.096	0.100	0.070	0.130
PCB128	40	0.139	0.100	0.070	1.600
PCB129	40	0.112	0.100	0.070	0.830
PCB138	40	2.065	0.525	0.220	58.450
PCB141	40	0.192	0.100	0.070	4.010
PCB149	40	0.518	0.110	0.080	14.380
PCB151	40	1.487	0.285	0.090	43.920
PCB153	40	3.089	0.705	0.270	91.160
PCB170	40	2.084	0.235	0.090	73.490
PCB180	40	3.567	0.585	0.180	120.130
PCB183	40	0.867	0.160	0.080	27.470
PCB185	40	0.152	0.100	0.070	2.410
PCB187	40	2.009	0.310	0.100	64.420
PCB191	40	0.268	0.100	0.070	6.880
PCB193	40	0.148	0.100	0.070	2.220
PCB194	40	0.966	0.100	0.080	33.570
PCB201	40	1.042	0.140	0.080	34.710
PCB202	40	0.162	0.100	0.070	2.810
PCB203	40	0.932	0.145	0.080	30.450
PCB206	40	0.296	0.100	0.070	7.610
PCB208	40	0.156	0.100	0.080	2.130
PCB209	40	0.096	0.100	0.070	0.160

Tables 10 and 11 present results for the individual PCDDs, PCDFs, dioxin-like PCBs and other PCBs measured in this study for the four egg types individually while the results for each individual sample are presented in Table 12.

(B) elemental analysis

Levels of metallic and other elements analysed in Irish eggs in this study are presented in Table 13, as the upper-bound mean, median, minimum and maximum levels for all egg types in mg/kg, while Table 14 provides this information for the four individual egg types examined.

Table 13: Upper-bound levels of metallic and other elements in Irish eggs

Metals/Elements (mg/kg) (upper-bound)	N	Mean	Med	Min	Max
Aluminium	40	0.063	0.050	0.050	0.264
Chromium	40	0.029	0.020	0.020	0.316
Copper	40	0.584	0.587	0.521	0.652
Zinc	40	12.412	12.483	10.367	14.503
Arsenic	40	0.010	0.010	0.010	0.016
Selenium	40	0.412	0.385	0.241	0.923
Cadmium	40	0.005	0.005	0.005	0.005
Tin	40	0.100	0.100	0.100	0.100
Mercury	40	0.010	0.010	0.010	0.010
Lead	40	0.005	0.005	0.005	0.005

Table 14: Upper-bound levels of metallic and other elements in Irish eggs, per egg type

	Battery eggs (N=16)				Free range eggs (N=16)				Barn eggs (N=4)				Organic eggs (N=4)			
(mg/kg)	**Mean**	**Med**	**Min**	**Max**	**Mean**	**Med**	**Min**	**Max**	**Mean**	**Med**	**Min**	**Max**	**Mean**	**Med**	**Min**	**Max**
Aluminium	0.050	0.050	0.050	0.050	0.072	0.050	0.050	0.264	0.079	0.050	0.050	0.167	0.059	0.050	0.050	0.087
Chromium	0.021	0.020	0.020	0.026	0.041	0.020	0.020	0.316	0.021	0.020	0.020	0.023	0.020	0.020	0.020	0.021
Copper	0.583	0.583	0.532	0.629	0.590	0.594	0.521	0.652	0.577	0.572	0.559	0.603	0.571	0.575	0.528	0.607
Zinc	12.631	12.429	10.769	14.503	12.331	12.542	10.367	13.722	12.168	12.308	10.950	13.107	12.104	11.873	11.045	13.625
Arsenic	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.012	0.012	0.010	0.016
Selenium	0.400	0.369	0.278	0.727	0.415	0.385	0.249	0.581	0.425	0.459	0.295	0.489	0.428	0.273	0.241	0.923
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Tin	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Mercury	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Lead	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Discussion

Dioxins, furans and PCBs

The majority of eggs produced and on sale in Ireland are either free-range or battery eggs, whereas the other egg types (organic and barn eggs) only contribute a minor percentage to production. Because of the low production of the latter categories, only a limited amount of samples were available for this survey. Levels found can only serve as indicative spot-samples but may not be representative for these types of eggs in general.

The results of this study show that levels of dioxins and furans in Irish eggs are generally low, and are well below the maximum limit laid down in Council Regulation 2375/2001. This Regulation establishes a maximum level for dioxins (PCDD/PCDF) of 3 pg WHO-TEQ/g fat for hen eggs and egg products, excluding free range and semi-intensive eggs, as of 1 July 2002. Free range and semi-intensive eggs must comply with the maximum level from 1 January 2005. The Regulation does not currently establish maximum limits for the dioxin-like or non-dioxin-like PCBs, although these are under consideration.

There was no statistically significant difference in TEQ concentrations of dioxins and dioxin-like PCBs found in battery and free range eggs. Only four samples were available for organic and barn eggs and therefore no firm statistical comparison could be made. The overall mean upper-bound level for PCDD/Fs, averaged over all eggs, was 0.49 pg WHO-TEQ/g fat, with a minimum of 0.10 and a maximum of 2.70. Examination of the results for the individual egg types shows a mean upper-bound level for PCDD/Fs for barn eggs of 0.31 pg WHO-PCDD/F-TEQ/g fat, for battery eggs 0.36 pg/g fat and for free-range eggs 0.47 pg/g fat. The mean for organic eggs was higher, at 1.30 pg WHO-PCDD/F-TEQ/g fat. This result was however skewed due to one particularly high result which, at 2.70 pg/g fat, was the only sample out of 40 analysed to come close to the legal limit of 3 pg WHO-PCDD/F-TEQ/g fat. Values for the other three samples of organic eggs were 0.48, 0.77 and 1.25 pg WHO-PCDD/F-TEQ/g fat respectively, giving a mean of 0.83 pg WHO-PCDD/F-TEQ/g fat. This is still higher than values obtained for battery, barn or free-range eggs, due to the comparatively high level of 1.25 pg/g fat detected in one of the samples.

Further investigations were carried out into the high result obtained for one organic egg sample. These involved analysis of further samples of eggs from the same producer, together with analysis of feed samples and cod liver oil supplements administered to the birds. Results for seven different egg samples (analysed as pooled samples of between two and five eggs) showed upper-bound levels for PCDD/Fs ranging from 0.88 to 1.77 pg WHO-PCDD/F-TEQ/g fat, with a mean level of 1.34 pg/g fat. Levels were thus comparable to the mean of 1.30 pg/g fat obtained for organic eggs in the original study. Total WHO-TEQ including dioxin-like PCBs for the egg sample containing the highest dioxin levels was 7.78 pg/g fat. There was a close correlation between the age of the hens from which the eggs were taken and the levels of dioxins and dioxin-like PCBs found in the eggs. Levels of dioxins and dioxin-like PCBs in feed samples from this producer were very low. The upper-bound level of WHO-PCDD/F-TEQ in whole feed was 0.04 ng/kg for mixed feed and soya feed, 0.03 ng/kg for crushed bean feed and wheat feed, and levels of dioxin-like PCBs in these samples were similarly low. The upper-bound level of WHO-PCDD/F-TEQ in the cod liver oil supplement was 2.82 ng/kg, well below the level of 6 ng/kg permitted in fish oil used for animal nutrition in accordance with Council Directive 2001/102/EC. Analysis of soil samples taken from the foraging area of the flock are underway, but are not anticipated to show that environmental contamination of soil with dioxins is a significant source of the body burden of dioxins in these birds. Rather, the levels found in eggs from the flocks of this producer may be attributed to the age of the birds, which ranged from 23 weeks to four years.

Typical intakes of dioxins and dioxin-like PCBs from Irish eggs can be estimated from the consumption data for eggs provided in the North-South Food Consumption Survey carried out by the Irish Universities Nutrition Alliance (IUNA) in 2000. Table 15 shows the consumption data (mean, median, minimum, maximum and 95th percentile) on a daily, weekly and monthly basis for all consumers of eggs, the total number of subjects being 670. Table 16 shows the derived daily, weekly and monthly intake of dioxins and dioxin-like PCBs, expressed as total intake and intake per kg body weight for a 70 kg adult and assuming a mean upper-bound level of 0.91ng WHO-TEQ /kg (pg/g) fat for all egg types together (Table 4, sum of PCDD/F and dioxin-like PCB TEQs) and a mean fat content of 9%.

The figure of 161g egg mean total weekly consumption shown in Table 15 results in a total weekly intake of 13.18 pg WHO-TEQs dioxins and dioxin-like PCBs, or 0.19 pg/kg for a 70 kg adult[2] (see Table 16). The 97.5th percentile total weekly consumption figure of 484g gives a total weekly intake of 39.81 pg WHO-TEQs dioxins and dioxin-like PCBs, or 0.57 pg/kg for a 70 kg adult. These figures may be compared with the Tolerable Weekly Intake of 14 pg WHO TEQ/kg b.w. for PCDDs, PCDF and dioxin-like PCBs established by the EU Scientific Committee for Food. It can be concluded that these levels of consumption of Irish eggs (mean and 97.5th percentile) containing typical levels of dioxins and dioxin-like PCBs do not present a risk to the health of the Irish population.

Table 15: Average daily, weekly and monthly consumption of eggs by Irish consumers

	daily intake g	weekly intake g	monthly intake g
Mean	23	161	690
Median	17	120	514
Minimum	1	10	43
Maximum	148	1034	4429
97.5 Percentile	69	486	2083

Table 16: Daily, weekly and monthly intake of dioxins and dioxin-like PCBs (pg TEQ) expressed as total intake and intake per kg body weight

	Weekly intake pg TEQ dioxins and dioxin like PCBs	Monthly intake pg TEQ dioxins and dioxin like PCBs	Weekly intake pg TEQ per kg/bw	Monthly intake pg TEQ per kg/bw
Mean	13.18	56.50	0.19	0.81
Median	9.83	42.12	0.14	0.60
Minimum	0.82	3.51	0.01	0.05
Maximum	84.64	362.76	1.21	5.18
97.5 Percentile	39.81	170.63	0.57	2.44

The non-*ortho* and mono-*ortho* dioxin-like PCBs (PCBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) contributed between 40 and 47% of the total TEQs measured in the case of battery, free range and barn eggs and slightly above 50% in the case of the organic egg samples (Table 5). PCB 77 was the most abundant non-*ortho* dioxin-like PCB detected, at levels of 5 -20 times that of PCB126, depending on egg type, with a mean of 8 (Table 8) while PCB118 was the most abundant of the dioxin-

[2] Based on body weights recorded in the North/South Food Consumption Survey (see Ref 7). Average weight for females: 68 kg, average weight for males: 83 kg (ROI only)

like mono-*ortho* PCBs. Marker PCBs 28, 52, 101, 118, 138, 153, and 180 were generally low in all egg samples with the exception of the organic egg sample in which high levels of PCDD/Fs were detected. The sum of the marker PCBs for this sample was 275.94 µg/kg fat and levels of PCBs 118 to 209 were also consistently high. The sum of the mean levels in the battery, free range and barn egg samples were 3.24, 2.52 and 3.02 µg/kg fat respectively. The mean levels in 2 of the 3 remaining organic egg samples were in this range (2.99 and 3.40 µg/kg fat), while the third sample had a somewhat higher level of 10.35 µg/kg. These levels may be compared with the statutory limit of 200 µg/kg fat for the sum of the marker PCBs established for eggs in Belgium and France and the limit of 20 µg/kg for the individual congeners established in Germany. The congener found at the highest levels in these samples was PCB 180, followed closely by PCB 153 and then by the congeners 170, 138 and 187. This pattern bears a significant similarity to that reported for human adipose tissue samples by Costabeber and Emanuelli (2003), in which the congener found at the highest concentration was also PCB 180, at 134 µg/kg, followed by the congeners 153 and 138. Similar findings have been reported by other authors. The health significance of the levels of non-dioxin-like PCBs found in Irish eggs is not clear, pending the outcome of the risk assessment to be carried out on these chemicals by EFSA.

These findings for levels of dioxins, furans and PCBs in eggs are in line with previous FSAI surveys in dairy products and fish where background levels were also found to be generally low. This can be attributed to the relative absence of manufacturing industry in Ireland in the past, compared with more industrialised EU countries. Although Ireland's manufacturing base has increased in recent decades, this has been primarily in the fine chemical/pharmaceutical sector which has been subject to quite stringent emission controls. In contrast, a number of countries including the Netherlands and the United Kingdom have reported relatively high dioxin levels in eggs in the past, particularly in free-range eggs. The latter finding has been attributed to foraging of the chickens on dioxin-contaminated land.

Metallic and other elements

As shown in Table 10, levels for the toxic elements lead, cadmium, mercury, tin and arsenic were all found to be close to or below the limit of quantification, confirming the low level of occurrence of these contaminants in Irish eggs.

Eggs are a good source of zinc and levels found (10.4 – 14.5, average 12.4 mg/kg) are within the norm. The levels of selenium found in these egg samples suggest that they are comparatively selenium-enriched. Egg selenium content can be easily increased when organic selenium is included in the poultry feed. This technology has been developed to address nutrient requirements for maintaining good health throughout life since research in recent years has indicated that Se deficiency is a problem in many regions of the world. Consumption of 1 egg weighing 63 g (upper medium/lower large sized egg) can supply approximately 47% of the recommended daily intake (RDA) or Population Reference Intake (PRI) of selenium for adults. Copper was found to be present at expected levels, contributing 3.4% to the daily required amount per egg.

Currently no intake recommendations exist for chromium. However, the UK Committee on Medical Aspects of Food and Nutrition Policy (COMA, now Scientific Advisory Committee on Nutrition (SACN)) suggested that an adequate level of intake for trivalent chromium lies above 0.025 mg/day for adults The US National Research Council (NRC) specify an Estimated Safe and Adequate Daily Dietary Intake (ESADDI) of 0.05 – 0.2 mg/day for adults. Using the latter as guideline, an egg would contribute between 1 to 4% to the suggested adequate intake (Table 17).

Table 17: PRI (%) based on consuming one average weight egg (~63g)

	Amount (mg) per 63g egg	PRI (mg/d) Male adult (M)	PRI (mg/d) Female adult (F)	% PRI (M)	% PRI (F)
Zinc	0.78	9.5	7	8.2	11.1
Selenium	0.026	0.055	0.055	47.3	47.3
Copper	0.037	1.1	1.1	3.4	3.4
Chromium	0.002	n/a			

Conclusions

This study has demonstrated that levels of dioxins and furans in Irish eggs are in general well below the legal limit of 3 pg WHO-PCDD/F-TEQ/g fat. Levels of dioxin-like PCBs are similarly low, as are levels of the marker or indicator PCBs 28, 52, 101, 118, 138, 153, and 180.

The results of the study are in line with those from previous FSAI studies on dioxin levels in milk and fish and confirm that dioxin levels in these foods are relatively low compared with similar products from more industrialised countries in the European Union. FSAI is very pleased to report these results and to note that Irish produce readily complies with the new limits for dioxins which became legally binding on July 1, 2002. These findings support the interpretation that exposure of the Irish population to dioxins in food is lower than the European average, a conclusion which will be reassuring to Irish consumers. The somewhat higher dioxin levels found in organic eggs from one producer may possibly be attributed to the age of the birds. FSAI therefore advises that organic egg producers should not keep their birds beyond the normal age of maximum egg production, in order to avoid the gradual build up of dioxins (from the feed) in the birds with age.

Similarly, the levels of the toxic metals lead, cadmium, mercury, tin and arsenic detected confirmed the very low level of occurrence of these contaminants in Irish eggs. The levels of the nutrient elements copper and zinc were within the norms reported for eggs in the literature, while the levels of selenium suggest that eggs make an important contribution to the daily intake of this important trace element.

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