INVESTIGATION INTO LEVELS OF DIOXINS, FURANS AND PCBs IN BATTERY, FREE RANGE, BARN AND ORGANIC EGGS

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Background

The Food Safety Authority of Ireland (FSAI) has a statutory responsibility to assure the safety of food consumed, distributed, produced and sold on the Irish market. The results of a targeted surveillance study on levels of dioxins, furans and polychlorinated biphenyls (PCBs) in battery, free-range, barn and organic eggs are presented here.

The study was undertaken against the background of increased awareness in the European Union of the possible health risks posed by dioxins, furans and polychlorinated biphenyls (PCBs) in the food chain, and builds on previous studies undertaken by FSAI into levels of these contaminants in milk, fish and fish oils.[1,2] The opportunity was taken at the same time to investigate the levels of a number of metals in these eggs, and results of the full study are available on the FSAI website.[3]

Study Design and Methodology

Egg samples (excluding retail samples) were provided by the officers of the Egg and Poultry Division of the Department of Agriculture and Food, while planning and co-ordination of the project and sampling of eggs at retail level was undertaken by FSAI staff. A total of 40 samples 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 5 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, in which the majority of eggs produced in Ireland are packed, 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 4 samples each were taken. 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. The low number of samples for the latter categories is due to the low production of these type eggs in Ireland.

Samples were analysed using established methodology[4] accredited to the ISO 17025 standard and to meet EU quality legislation for analysis of dioxins in food.[5]

Results and Discussion

Table 1 presents the levels of PCDD/Fs, dioxin-like PCBs and marker PCBs in all egg types taken together, and Table 2 splits the results into the four egg types separately. Table 3 presents the sum of the 7 marker PCBs in each egg type. 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 of 3 pg WHO-PCDD/F-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 10 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 4 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 1.43 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 7 different egg samples (analysed as pooled samples of between 2 and 5 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, with an upper-bound level of WHO-PCDD/F-TEQ in whole feed of 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 showed that environmental contamination of soil with dioxins was not 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 4 years.

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 2). 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 while PCB118 was the most abundant of the dioxin-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 ug/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 ug/kg fat respectively. The mean levels in 2 of the 3 remaining organic egg samples were in this range (2.99 and 3.40 ug/kg fat), while the third sample had a somewhat higher level of 10.35 ug/kg. These levels may be compared with the statutory limit of 200 ug/kg fat for the sum of the marker PCBs established for eggs in Belgium and France and the limit of 20 ug/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,[8] in which the congener found at the highest concentration was also PCB 180, at 134 ug/kg, followed by the congeners 153 and 138. Similar findings have been reported by other authors. The risk assessment to be carried out on non-dioxin-like PCBs by the European Food Safety Authority (EFSA) during 2004 will help to clarify the health significance of the levels of these chemicals in Irish eggs.

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 2001.[5] Table 4 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 5 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 upperbound level of 0.91ng WHO-TEQ /kg (pg/g) fat for all egg types together (Table 1, 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 4 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 (see Table 5). The 95th 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.[7] It can be

concluded that these levels of consumption of Irish eggs (mean and 95th percentile) containing typical levels of dioxins and dioxin-like PCBs does not present a risk to the health of the Irish population.

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. The low levels 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 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.

Table 1: Mean, median, minimum and maximum upper- and lowerbound 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 lowerbound)*	40	0.43	0.35	0.03	2.70
PCDD/F WHO TEQs *(ng/kg fat upperbound)*	40	0.49	0.39	0.10	2.70
Dioxin- like PCBs WHO TEQ *(ng/kg fat lowerbound*)	40	0.26	0.13	0.07	3.89
Dioxin- like PCBs WHO TEQ *(ng/kg fat upperbound)*	40	0.42	0.30	0.22	3.93
Total WHO TEQs *(ng/kg fat lowerbound)*	40	0.69	0.48	0.12	6.59
Total WHO TEQs *(ng/kg fat upperbound)*	40	0.91	0.70	0.37	6.63
∑ Marker PCBs *(μg/kg fat lowerbound*)*	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.*

Table 2: Mean, minimum and maximum upperbound levels of PCDD/Fs in Irish battery, free range, organic and barn eggs

	Sum of PCDD/F + dioxin-like PCBs				Sum of PCDD/F			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 3: Mean, minimum and maximum upperbound 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

Table 4: 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 5: Daily, weekly and monthly intake of dioxins and dioxin-like PCBs (pg TEQ) expressed as total intake and intake per kg body weight

	Daily intake	Weekly intake	Monthly intake	Daily intake	Weekly intake	Monthly intake
	pg TEQ dioxins + dioxin like PCBs			pg TEQ per kg/bw		
Mean	1.88	13.18	56.50	0.03	0.19	0.81
Median	1.40	9.83	42.12	0.02	0.14	0.60
Minimum	0.12	0.82	3.51	0.002	0.01	0.05
Maximum	12.09	84.64	362.76	0.17	1.21	5.18
97.5 Percentile	5.69	39.81	170.63	0.08	0.57	2.44

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