A Survey of PCDD/Fs and Co-planar PCBs in the US Meat and Poultry Supply in 2002-2003

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Introduction

Periodic surveys of the food supply for dioxins and dioxin-like compounds are a useful tool to measure changes in dioxin levels in the environment and to update predictions of human exposure to these toxic compounds from dietary components. In the mid-1990s, the US Department of Agriculture together with the US Environmental Protection Agency conducted a survey of dioxins in beef,[1] pork,[2] and poultry[3] from slaughtering facilities across the US. A similar survey has been conducted to obtain statistically-valid information about current levels of dioxins in domestically-produced meat and poultry, to further investigate any unusual findings, and to compare these new results with those from the previous survey.

Materials and Methods

Adipose tissue samples were collected by federal inspectors from slaughtering facilities across the US on a weekly basis from May 2002–May 2003. The number of samples collected from each facility was proportional to the plant's production volume for that species. The samples covered four animal classes: beef (heifers and steers), pork (gilts and barrows), chicken, and turkey. The inspectors collected approximately 250 g of back fat from the cattle, belly fat from the hogs, or abdominal fat from the young chickens and turkeys. The poultry samples were composites from three birds in the same flock. The samples were frozen and shipped in sealed boxes to the USDA Biosciences Research Laboratory for analysis.

The samples remained frozen until the time of analysis. Prior to analysis, each sample was thawed and homogenized. A 5 g sub-sample was spiked with a mixture of 15 ^{13}C-labeled PCDD/Fs and 3 ^{13}C-labeled coplanar PCBs and purified on a Power Prep instrument (Fluid Management Systems, Waltham, MA) for automated dioxin cleanup using jumbo triphasic silica, regular triphasic silica, basic alumina, and carbon cartridges. The recovered dioxin-containing fraction was analyzed for 17 PCDD/Fs and PCBs-77, 126, and 189 according to EPA Method 1613 (modified to include the PCBs). A five-point calibration curve covering the following ranges was used for quantitation: 0.1–40 pg TCDD/F, 0.5–200 pg penta- to hepta- congeners, 1.0–400 pg OCDD/F, and 0.5–200 pg

PCBs. A blank and a known spiked sample were analyzed with each set of eight survey samples to provide on-going quality assurance for the method.

Toxic equivalency values (TEQs) were calculated from the data using the 1998 WHO toxic equivalency factors (TEFs) and setting non-detects equal to zero or ½ the detection limit. The detection limit (DL) was calculated as the mean concentration in the blanks + 2 standard deviations to give a 95% confidence level. For congeners not detected in the blanks, 2 standard deviations of a low level spike were used to calculate the DL. These low-level spikes also validated that the reported limits of detection were reasonable. The data were not background subtracted.

Results and Discussion

In total, 510 samples were collected and analyzed for this survey. The distribution of samples between and among each slaughter class represented the typical production of meat and poultry in the US food supply. Approximately ten samples, covering each class, were collected every week to give a final tally of 139 beef samples (55 heifers, 83 steers, 1 not sexed), 136 market hogs (56 gilts, 72 barrows, 8 not sexed), 151 young chickens, and 84 young turkeys.

One of the objectives of this survey was to obtain the best estimate of the levels of dioxins, furans, and coplanar PCBs in each animal class. Because the overall TEQ of the blanks was low (0.05 ppt), the background was not subtracted resulting in conservatively higher values than if background subtraction was employed. Table 1 summarizes the data by slaughter class. Beef cattle had the highest level of dioxin/furan TEQ and total TEQ of any class. The higher dioxin level observed in beef cattle most likely reflects the longer period of time it takes these animals to reach a marketable weight (approximately 2 years) and, therefore, more time to accumulate dioxins from the environment and diet. Hogs had the lowest TEQs on a lipid weight basis due, perhaps, to the larger amount of body lipid (approximately 30% body fat). A large lipid pool may dilute the dioxins that are absorbed by the animal. Turkeys had the highest levels of coplanar PCBs on average. Turkeys and chickens also appeared to have higher levels of TCDF and 1,2,3,7,8-PeCDF than beef and hogs which may reflect a difference in the metabolizing capabilities of poultry, a dietary input difference, or some other unknown factor.

Three congeners (1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF, and PCB-126) contributed 45–70% to the total TEQ in each animal class. Individually these three congeners represented 11–28% of the total TEQ. Another congener that contributed significantly to the beef total TEQ was 1,2,3,6,7,8-HxCDD (18%). Coplanar PCBs accounted for 15% and 13% of the total TEQ in beef and hogs, respectively. Chickens and turkeys had a somewhat greater contribution with 25% and 30% of the total TEQ coming from coplanar PCBs, respectively.

Almost 92% of the samples (468/510) had total TEQs < 1.0 ppt (nd=DL/2), and 97% were < 2.0 ppt. Seventeen samples were found with TEQs between 2 and 6 ppt, including eight steers, seven heifers, and two barrows. These fifteen beef animals originated from ten different states across the country and had no discernable connection. Both of the barrows, however, had been raised in Iowa under the same management coordination and practices (including common feed and feed supplements), were collected within a one month period, and showed similar congener patterns as illustrated in Figure 1. Further investigation revealed that a dioxin-contaminated mineral supplement had been used in the swine feed and was the likely source of the elevated PCDD/Fs in these two hogs.

Another objective of this survey was to compare the current results to the results of previous surveys conducted in the mid 1990s in order to determine whether and how much the levels of PCDD/Fs and coplanar-PCBs had changed. Due to differences in laboratories, instrumental capabilities, cleanup methods, and decision criteria, the comparison is not straight forward. The limits of detection from the earlier survey were determined in a different manner than in the current survey and were set at up to 20-times higher for some congeners. Simplistically, comparison of the average TEQs where nd=0 may give some indication if levels have declined. Because DLs were set at higher values in the earlier survey and blanks were subtracted, more non-detects should be found than in the current survey if actual levels are similar; therefore, averages from the previous survey should be lower when nd=0. In fact, the average TEQs in the current survey were 50–60% lower for hogs, chickens, and turkeys. This strongly suggests a decrease in dioxin levels in these products in the last ten years. For beef, the average TEQ increased by 30%, but this most likely reflects the high number of non-detects in the earlier survey (78%) and requires a more rigorous evaluation of the two data sets before any comparison can be made.

References

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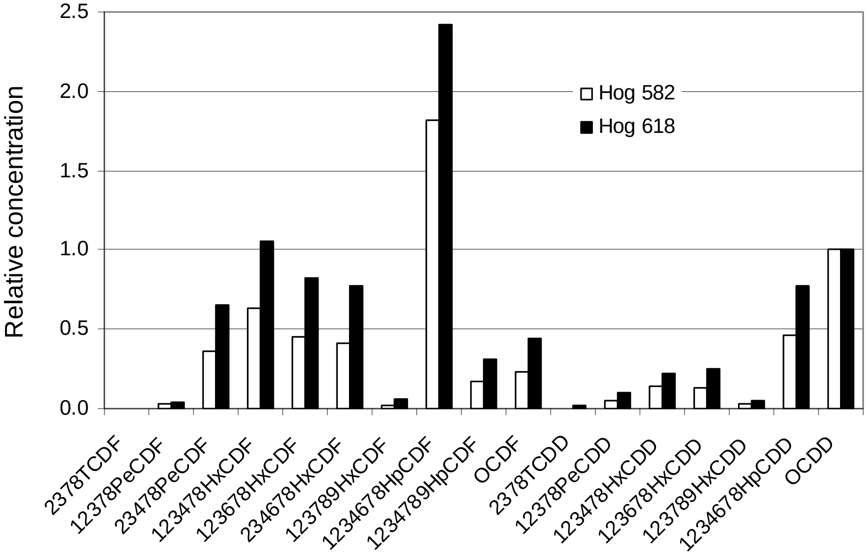

Figure 1. PCDD/F congener profile for two hogs with TEQs over 2 pg/g lipid. Congener concentrations are normalized to OCDD.

Table 1. Average levels of seventeen PCDD/Fs, three co-planar PCBs, and TEQs in method blanks and each slaughter class. Blanks and detection limits (DL) were converted to pg/g lipid (ppt) using the average lipid percent value from the survey. Sample levels are reported in pg/g lipid (ppt) with nd=DL/2 and nd=0 in parentheses. Detection limits are calculated as the mean levels in the blanks + 2 x standard deviations (95% confidence level).

Congener	**Blanks/DL n=33**	**Beef n=139**	**Market Hogs n=136**	**Young Chickens n=151**	**Turkeys n=84**
2378-TCDD	0.00/0.07	0.06 (0.04)	0.04 (0.00)	0.04 (0.01)	0.06 (0.03)
12378-PeCDD	0.00/0.04	0.24 (0.24)	0.04 (0.02)	0.0 (0.05)	0.17 (0.17)
123478-HxCDD	0.00/0.04	0.31 (0.31)	0.08 (0.07)	0.05 (0.04)	0.10 (0.10)
123678-HxCDD	0.01/0.04	1.64 (1.64)	0.20 (0.20)	0.27 (0.27)	0.38 (0.38)
123789-HxCDD	0.01/0.05	0.33 (0.32)	0.04 (0.01)	0.06 (0.05)	0.05 (0.03)
1234678-HpCDD	0.14/0.27	4.16 (4.16)	1.42 (1.40)	1.40 (1.39)	0.36 (0.31)
OCDD	1.12/3.14	7.02 (6.12)	13.77 (12.80)	6.37 (5.47)	3.77 (2.51)
2378-TCDF	0.02/0.06	0.04 (0.01)	0.04 (0.01)	0.08 (0.07)	0.18 (0.18)
12378-PeCDF	0.02/0.04	0.03 (0.01)	0.03 (0.01)	0.07 (0.06)	0.11 (0.10)
23478-PeCDF	0.04/0.08	0.20 (0.20)	0.12 (0.09)	0.09 (0.07)	0.20 (0.20)
123478-HxCDF	0.05/0.13	0.47 (0.46)	0.21 (0.17)	0.12 (0.07)	0.13 (0.10)
123678-HxCDF	0.05/0.15	0.30 (0.26)	0.16 (0.09)	0.11 (0.05)	0.11 (0.05)
234678-HxCDF	0.02/0.04	0.24 (0.24)	0.09 (0.08)	0.06 (0.05)	0.05 (0.05)
123789-HxCDF	0.00/0.05	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.02 (0.00)
1234678-HpCDF	0.10/0.30	0.91 (0.84)	0.77 (0.66)	0.27 (0.15)	0.17 (0.04)
1234789-HpCDF	0.01/0.03	0.05 (0.04)	0.06 (0.04)	0.02 (0.01)	0.02 (0.00)
OCDF	0.07/0.17	0.31 (0.25)	0.71 (0.64)	0.24 (0.18)	0.23 (0.16)
PCB-77	6.74/12.68	7.95 (2.61)	9.21 (4.16)	9.59 (5.01)	7.91 (3.21)
PCB-126	0.10/0.18	1.34 (1.34)	0.31 (0.26)	0.78 (0.78)	1.79 (1.79)
PCB-169	0.00/0.12	0.32 (0.32)	0.30 (0.28)	0.39 (0.37)	0.79 (0.79)
TEQ D/F	0.04/0.21	0.79 (0.75)	0.24 (0.16)	0.25 (0.18)	0.45 (0.41)
TEQ PCB	0.01/0.02	0.14 (0.14)	0.04 (0.03)	0.08 (0.08)	0.19 (0.19)
Total TEQ	**0.05/0.23**	**0.93 (0.89)**	**0.28 (0.19)**	**0.33 (0.26)**	**0.64 (0.59)**
TEQ Range	**0.01–0.10**	**0.21–6.12 (0.13–6.12)**	**0.11–4.50 (0.00–4.50)**	**0.13–1.90 (0.03–1.86)**	**0.16–1.88 (0.06–1.88)**

Trade names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.