Dioxins and Dioxin-Like Compounds
In the U.S. Domestic Meat and Poultry Supply

INTRODUCTION

Between May 2002 and May 2003, the U.S. Department of Agriculture's (USDA) Food Safety and Inspection Service (FSIS) conducted a survey to gather information on dioxins, furans, and dioxin-like PCBs in U.S. meat and poultry products as part of a continuing effort to understand and characterize potential contaminants in the food supply. In this report, the dioxins, furans, and dioxin-like polychlorinated biphenyls (PCBs) included in the survey are referred to as dioxin-like compounds (DLCs).

DIOXIN

DLCs are a group of compounds that share a similar chemical structure and common characteristics such as exerting biological effects through a common receptor-mediated mechanism of action (Ah-receptor). Each compound in this group is referred to as a congener. DLCs almost always occur as mixtures of individual congeners.

Low levels of DLCs are ubiquitous in the environment. DLCs are released into the environment through natural processes, such as forest fires and volcanic eruptions, and through industrial processes, such as combustion or incineration of industrial waste, or chemical manufacturing. These compounds can remain in the environment for decades.

DLCs accumulate in the fatty tissues of food animals and the primary means of human exposure is believed to be through the consumption of animal fats in food. DLCs also accumulate in fatty tissue in the human body. Studies indicate that prolonged exposure to elevated levels of dioxin may have long term, adverse health effects.

Samples collected for analysis are adipose (fat) samples from carcasses. The percentage of carcass fat actually varies by species, thus all findings are converted to a 100% fat level. These results are referred to as fat-based or lipid-based results.

DLCs are not toxicologically equal. Toxic equivalency factors (TEFs) are used to characterize the relative potency of various DLC congeners. The most recent and generally accepted TEFs were developed by the World Health Organization (WHO) in 1998. Congener TEFs range from 0.0001 to 1.0. When parts per trillion (ppt) congener concentrations in a sample are weighted by TEFs and added together, the sample can then be characterized by a single value expressed in terms of parts per trillion Toxic Equivalents (ppt TEQ or TEQs). All TEQs presented in this document are based on the 1998 WHO TEFs.

PREVIOUS SURVEY- 1994-1996

In the mid-1990s, as a part of the Environmental Protection Agency's (EPA) dioxin reassessment, FSIS and EPA conducted a survey to gather information on DLCs in beef, pork, and poultry products. Samples were collected from 51 steer/heifer, 56 market hog, 41 young chicken, and 15 young turkey carcasses. Analyses showed that most

results were below 2.0 ppt TEQ on a fat basis. Two of 41 young chicken samples had highly elevated levels of DLCs (25-31 ppt TEQ) compared to a mean of 0.76 ppt TEQ in the remaining 39 birds. FSIS, EPA, and the Food and Drug Administration (FDA), took immediate action and identified ball clay, an anti-caking agent added to animal feed, as the cause of elevated DLC levels in the two young chickens. FDA subsequently banned the use of ball clay in animal feeds.

The two ball clay-tainted samples were clearly outliers, possibly diminishing the usefulness of calculating a mean, though they were part of a random sample. To simplify the issue of whether to include or exclude the two samples, FSIS chose to present both the median and mean results, with and without the two samples, as shown in Table 1. In Table 1, the median TEQ values for young chickens are essentially the same, with or without the two ball clay-tainted samples (0.48 vs. 0.49). The mean TEQ values however are very different (0.76 vs. 2.10).

(Table 1 includes the 1994-1996 data for only the slaughter classes and congeners that were also used in the more recent survey. The 1994-1996 survey included several samples from other slaughter classes and analyses for additional PCB congeners that were not included in the 2002-2003 survey.)

Table 1
Median and Mean TEQs for Dioxins/Furans, Dioxin-like PCBs, and Total DLCs
1994-1996 Survey

Slaughter Class	Number Of Samples	Dioxins/ Furans Median	DLCs Median	Dioxins/ Furans Mean	DLCs Mean
Market Hogs	56	1.19	1.22	1.44	1.47
Steers-Heifers	51	0.79	1.08	1.03	1.38
Young Chickens	39 (41)	0.48 (0.49)	0.63 (.66)	0.76 (2.10)	0.94 (2.28)
Young Turkeys	15	0.64	1.07	1.09	1.53

Note: Results expressed in parts per trillion (ppt). Data from the 1994-1996 survey were background subtracted. All results reported on a lipid basis. All Non-Detects = LOD/2. Results within parenthesis include the two ball clay-tainted samples.

LATEST SURVEY- 2002-2003

After the survey in the 1990s, FSIS decided to conduct periodic surveys of DLCs in meat and poultry products in order to update and expand information. Seventeen toxic dioxins and furans, and three dioxin-like PCBs were analyzed in samples collected from 510 market hog, steer/heifer, young chicken, or young turkey carcasses processed in federally inspected slaughter establishments. (Refer to Table 2 for a list of the congeners analyzed in this study.)

The 2002–2003 survey was conducted under the FSIS National Residue Program (NRP). Under the NRP, FSIS conducts testing for residues from pesticides, animal drugs, natural contaminants, and potentially dangerous chemicals. Samples are collected for monitoring, surveillance, enforcement, and exploratory projects testing. The survey was an exploratory project under the NRP because it was initiated outside of the monitoring planning process described in the FSIS Blue Book (i.e., annual plan for the NRP).

The survey was directed by the Dioxin Survey Oversight Committee, an interagency group that included participants from FSIS, FDA, EPA, and the USDA's Agricultural Research Service (ARS). The committee examined survey data on a monthly basis and made recommendations to a second interagency committee, the Dioxin Investigation Management Committee, about sample results that warranted further investigation. All survey samples were analyzed at the ARS laboratory in Fargo, ND. The method, high resolution gas chromatography/high resolution mass spectrometry, is based on EPA Method 1613. A complete description of the method is included here.

Samples were randomly chosen during the survey. The initial sampling was based on the most up-to-date production information available for a 12-month period prior to the start of the survey. The sampling frame was updated quarterly with the latest production figures from all active federally inspected slaughter establishments. The number of samples collected from each plant during the course of the survey was proportional to the plant's production volume of that slaughter category. Therefore, the resulting samples are expected to be representative of the population of inspected and passed carcasses from federally inspected establishments. The 510 survey samples include 139 beef carcasses (55 heifers, 83 steers, 1 not sexed), 136 market hog carcasses (56 gilts, 72 barrows, 8 not sexed), 151 young chicken carcasses, and 84 young turkey carcasses.

Survey Results

Survey results are presented on a lipid basis. FSIS elected to report DLC levels on a lipid basis because 1) residue levels of fat-soluble compounds are often reported on a lipid basis; and 2) knowing the residue level in fat will enable risk assessors to estimate the DLC exposure to individuals for a range of diets of varying fat content. Each sample has an analytical result for each of the 20 DLCs analyzed as a part of the survey.

When summarizing results from a DLC survey, it is necessary to decide how to handle findings for the samples that are below the analytical Limit of Detection (LOD). Analysis results for each congener that is below the LOD are referred to as non-detects (ND). Because DLCs are ubiquitous in the environment, it is unlikely that actual levels in non-detect samples are zero. It may be that the non-detects are clustered near zero, clustered near the LOD, randomly distributed, or evenly spread between zero and the LOD.

In this report, FSIS is presenting results with all non-detects equal to one-half the LOD (LOD/2). Data calculated with non-detects equal to zero are also available upon request along with other more detailed data. For purposes of calculating mean levels,

one-half the LOD is the same as assuming that the non-detects are evenly spread between zero and the LOD. FSIS recognizes that results have also been reported using a value of zero for the non-detects, or other values such as the LOD divided by the square root of 2. Presenting data as ND= LOD/2, however, is a standard practice and a widely used approach.

The results from the 2002–2003 survey are presented in Tables 2 through 7.

- Table 2 includes the mean concentrations for DLCs by congener for each slaughter class. The table also includes the 1998 WHO TEFs.

- Table 3 includes the mean, median, minimum, and maximum TEQ values by slaughter class. TEQ values are provided for dioxins/furans, dioxin-like PCBs, and the combined DLCs.

- Tables 4 through 7 provide the ppt TEQ results for all 510 individual samples. These tables list the ppt TEQ values for dioxins/furans, dioxin-like PCBs, and the combined DLCs. The state where the animal was produced is also listed for each of the samples. Results are presented on a lipid basis and use the value of LOD/2 for all non-detects. The results are not background subtracted.
    - Table 4: Market hog samples
    - Table 5: Steer/heifer samples
    - Table 6: Young chicken samples
    - Table 7: Young turkey samples

Additional data from the 2002-2003 survey, including data with ND=0 and the congener make up of samples, as well as data from the 1994-1996 survey, are available by contacting the FSIS Congressional and Public Affairs Office at (202) 720-9113.

COMPARING RESULTS: (2002–2003) and (1994–1996)

Comparisons between the two surveys are complicated by changes in the equipment, methods, and procedures used. As Table 8 indicates, there were changes in the LODs from survey to survey. In general, LODs were lower in the 2002-2003 survey than those in the 1994-1996 survey. When LODs were not lower in the recent survey, it was typically for congeners with low TEFs. These differences can be partially attributed to variations in background levels at the laboratories used to analyze samples, as well as variations in the methodology used to calculate the LODs.

The 1994–1996 results were background subtracted and the 2002–2003 results were not. The lack of background subtraction in the 2002-2003 survey was estimated to add less than 13% to the average TEQ for each slaughter class.

Table 8 also includes a TEQ value for the 20 congener LODs. This value would be the TEQ of a sample where all 20 congeners were present at the exact level of

detection. These values were included since they provide a measure of how the LODs have changed.

There was also a considerable change in the percentage of non-detects in the two surveys. The percentage of non-detects is a function of both the LODs and the actual levels of compounds present in the samples. The 2002-2003 survey included 510 samples, each analyzed for the 20 separate congeners. This provided approximately 10,200 results. For DLCs, the term "percentage of non-detects," can be used in two ways, either to describe (1) the percentage of samples where individual results of analyses for each of the congeners was below the LODs, resulting in a ND for the entire sample; or (2) as a percentage of the total of all sample analyses below the LOD. Data could also reflect the percentages of samples that were below the LOD for a specific compound.

Table 8
Limits of Detection

Congener	All Slaughter Classes 2002-2003	Steers/Heifers 1994	Market Hogs 1995	Chickens 1996	Turkeys 1996
2378-TCDD	0.062	0.063	0.180	0.061	0.058
12378-PeCDD	0.032	0.630	0.900	0.304	0.292
123478-HxCDD	0.033	0.630	0.900	0.304	0.292
123678-HxCDD	0.032	0.630	0.900	0.304	0.292
123789-HxCDD	0.046	0.630	0.900	0.304	0.292
1234678-HpCDD	0.237	0.630	0.900	0.304	0.292
OCDD	2.725	3.379	1.799	0.609	0.583
2378-TCDF	0.049	0.063	0.180	0.061	0.058
12378-PeCDF	0.038	0.630	0.900	0.304	0.292
23478-PeCDF	0.065	0.630	0.900	0.304	0.292
123478-HxCDF	0.110	0.630	0.900	0.304	0.292
123678-HxCDF	0.133	0.630	0.900	0.304	0.292
234678-HxCDF	0.034	0.630	0.900	0.304	0.292
123789-HxCDF	0.042	0.630	0.900	0.304	0.292
1234678-HpCDF	0.261	0.630	0.900	0.304	0.292
1234789-HpCDF	0.029	0.630	0.900	0.304	0.292
OCDF	0.151	3.379	1.799	0.609	0.583
PCB-77	10.992	1.260	2.699	0.974	0.933
PCB-126	0.158	0.378	0.360	0.122	0.110
PCB-169	0.101	0.252	0.180	0.097	0.093
TEQ	0.200	1.547	2.288	0.774	0.742

Note: Results expressed in parts per trillion (ppt).

For steers and heifers, the 2002-2003 survey data are likely to be more reflective of actual environmental conditions for DLCs relative to the previous survey because there

has been a substantial decline in the number of non-detects, due in large part to the improved limit of detection. In other words, in the recent survey, many more samples produced measurable results, where many more sample results had to be estimated in the previous survey. For just the 17 dioxins, the earlier study found 15 of 51 steer/heifers samples (29.4 %) below the LODs for all congeners. For 2002-2003, there were no such steer/heifer samples. The 29.4 % of steer/heifer samples corresponds with previously published data showing 18 of 63 beef samples (28.6 percent) had no detectable dioxins. The 63 results included both 51 steer/heifer samples and 12 other bovine samples (bulls, beef cows, and dairy cows). (These details are provided to avoid any confusion with data reported in the EPA's October 2002 draft dioxin reassessment.) Substantial changes in the percentage of non-detects, either by sample or total results, complicates comparisons between the surveys.

Even with these limitations, FSIS recognizes the interest in comparing the survey results. For that reason, FSIS is presenting what the Agency believes is the most meaningful comparison. Table 9 shows the mean ppt TEQs for the two surveys, using the mean for young chickens without the two outliers. The table also includes data on the 75th percentile, representing the level that 75% of sample TEQs are at or below.

Table 9
Mean and 75th Percentile TEQs for DLCs
1994-1996 and 2002-2003 Surveys

Slaughter Class	1994-1996 Mean TEQ	2002-2003 Mean TEQ	1994-1996 75th Percentile TEQ	2002-2003 75th Percentile TEQ
Market Hogs	1.47	0.28	1.49	0.30
Steers-Heifers	1.38	0.93	1.51	1.06
Young Chickens	0.94	0.33	0.95	0.35
Young Turkeys	1.53	0.63	1.92	0.75

Note: Results expressed in parts per trillion (ppt). Data from the 1994-1996 survey were background subtracted. Data from the 2002-2003 survey were not background subtracted. All results reported on a lipid basis. All Non-Detects = LOD/2. The percentile of sample n from a total sample population N was derived from the formula: percentile of sample n = n/ [N+1] If the 75th percentile lay between two samples, the value for the 75th percentile was obtained by extrapolation.

Comparisons between slaughter classes within the surveys (e.g., market hogs compared to young chickens) are more problematic. Animals within the different slaughter classes vary in age, body type, and body composition. Different slaughter classes are raised under different conditions.

The ability to compare percentage decrease between different slaughter classes is also complicated by different LODs for the different animals. The LODs varied across slaughter class in the 1994–1996 survey. Within the 1994-1996 survey, market hogs (sampled in 1995) had the highest LOD. Both steers/heifers (1994) and market hogs had LODs considerably higher than the LODs for poultry (1996). In that survey, when examining the percentage of non-detects for the individual congener analyses, market hogs had the highest (82%), and poultry had the lowest (chickens at 55% and turkeys at

51%). FSIS believes that the varying percentages of non-detects is at least somewhat due to the differing LODs. The same holds true for comparisons between surveys since the LODs were lower in the 2002-2003 survey. But, at the same time, because the LODs varied considerably in the 1994-1996 survey, the proportional decrease in the LODs also varies between slaughter classes. All data presented here are based on non-detects = LOD/2.

The following factors support the conclusion that a comparison between the two surveys is meaningful:

- All results below the LOD are set at LOD/2. (This is the same as assuming that unknown values are evenly spread between zero and the LOD.)
- All TEQs were calculated based on the 1998 WHO TEFs.
- All values are presented on a lipid basis because the percentage of fat in the actual samples varied across slaughter class even though all samples were "fat" samples.
- Both surveys include samples randomly selected from federally inspected establishments. Sampling was weighted by production volume so that results are expected to be representative of the population of carcasses produced during the surveys.

The following factors illustrate persisting limitations in comparing the data:

- LODs used in the 2002-2003 survey were generally lower than those used in the 1994-1996 survey.
- The 1994–1996 results were background subtracted and the 2002–2003 results were not. If the 1994-1996 data were available in the same format as the 2002-2003 data (i.e. not background subtracted), the findings would be higher than the numbers presented in this report.
- Samples were analyzed in different laboratories using different equipment and sample preparation and analysis methods.
- There were considerable differences in the percentage of non-detected congeners.

Table 2. Mean Concentrations for DLCs (in ppt) by Congener for Each Slaughter Class (Includes 1998 WHO TEFs)

Congener	Market Hogs	Steers/ Heifers	Young Chickens	Young Turkeys	TEF
2378TCDD	0.039	0.064	0.042	0.059	1.00
12378PeCDD	0.035	0.236	0.062	0.174	1.00
123478HxCDD	0.078	0.308	0.049	0.101	0.10
123678HxCDD	0.197	1.639	0.270	0.378	0.10
123789HxCDD	0.036	0.325	0.064	0.047	0.10
1234678HpCDD	1.415	4.163	1.396	0.358	0.01
OCDD	13.774	7.023	6.368	3.774	0.0001
2378TCDF	0.037	0.039	0.083	0.181	0.10
12378PeCDF	0.031	0.029	0.067	0.105	0.05
23478PeCDF	0.115	0.203	0.092	0.201	0.50
123478HxCDF	0.212	0.473	0.117	0.131	0.10
123678HxCDF	0.160	0.299	0.109	0.105	0.10
234678HxCDF	0.088	0.240	0.059	0.054	0.10
123789HxCDF	0.028	0.025	0.025	0.023	0.10
1234678HpCDF	0.766	0.911	0.270	0.170	0.01
1234789HpCDF	0.055	0.053	0.024	0.018	0.01
OCDF	0.707	0.305	0.243	0.226	0.0001
PCB-77	9.209	7.954	9.586	7.910	0.0001
PCB-126	0.307	1.344	0.780	1.791	0.10
PCB-169	0.301	0.323	0.390	0.790	0.01

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. All Non-Detects = LOD/2.

Table 3. Mean, Median, Minimum and Maximum TEQ Values for Dioxins/Furans, Dioxin-like PCBs, and Total DLCs by Slaughter Class

Slaughter Class (Number of samples)		TEQ Dioxins/ Furans	TEQ PCBs	Total TEQ DLCs
Market Hogs (136)				
	mean	0.24	0.03	0.28
	median	0.15	0.02	0.18
	min	0.10	0.01	0.11
	max	4.18	0.32	4.50
Steers-Heifers (139)				
	mean	0.79	0.14	0.93
	median	0.43	0.12	0.56
	min	0.15	0.03	0.21
	max	6.07	1.21	6.12
Young Chickens (151)				
	mean	0.25	0.08	0.33
	median	0.16	0.06	0.25
	min	0.10	0.02	0.13
	max	1.88	0.59	1.90
Young Turkeys (84)				
	mean	0.45	0.19	0.63
	median	0.37	0.16	0.55
	min	0.12	0.03	0.16
	max	1.40	0.78	1.88

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. All Non-Detects = LOD/2. The mean TEQ for all 20 DLCs may not equal the sum of the mean TEQs for dioxins/furans and PCBs due to rounding. The median, minimum, and maximum TEQ for all 20 DLCs is not expected to be the sum of the medians, minimums, and maximums for dioxins/furans and PCBs since the levels of dioxins/furans and PCBs in product samples can be independent of each other.

Table 4. TEQ Values for the 136 Market Hog Samples

	Producer State	TEQ Dioxins/ Furans	TEQ PCBs	Total TEQ DLCs
1	IA	4.181	0.318	4.498
2	IA	2.299	0.145	2.445
3	IN	1.097	0.012	1.108
4	WI	0.548	0.028	0.576
5	IA	0.559	0.010	0.570
6	NC	0.443	0.080	0.524
7	IA	0.374	0.122	0.497
8	NC	0.433	0.057	0.490
9	MN	0.421	0.047	0.467
10	OK	0.245	0.213	0.458
11	IA	0.356	0.072	0.427
12	NC	0.384	0.037	0.421
13	SD	0.364	0.049	0.414
14	SD	0.395	0.010	0.405
15	OH	0.385	0.010	0.395
16	MO	0.374	0.011	0.385
17	NC	0.251	0.127	0.378
18	IA	0.326	0.045	0.371
19	IA	0.152	0.215	0.366
20	MO	0.351	0.012	0.364
21	IN	0.306	0.057	0.363
22	IA	0.303	0.060	0.363
23	MN	0.282	0.078	0.360
24	NC	0.314	0.022	0.336
25	IL	0.307	0.029	0.336
26	NE	0.317	0.014	0.331
27	OK	0.251	0.080	0.330
28	NC	0.281	0.038	0.319
29	IA	0.295	0.021	0.316
30	IA	0.254	0.057	0.311
31	MN	0.268	0.040	0.309
32	IA	0.270	0.038	0.308
33	NC	0.293	0.012	0.305
34	KS	0.273	0.031	0.303
35	IA	0.179	0.119	0.298
36	IA	0.274	0.014	0.287
37	IA	0.249	0.033	0.282
38	MN	0.164	0.115	0.279
39	OK	0.220	0.056	0.276
40	MO	0.249	0.010	0.259

41	OK	0.218	0.038	0.256
42	MN	0.218	0.030	0.248
43	IN	0.209	0.036	0.244
44	MO	0.203	0.040	0.242
45	OK	0.163	0.079	0.241
46	TX	0.192	0.049	0.241
47	MO	0.230	0.010	0.240
48	NE	0.195	0.037	0.232
49	MN	0.187	0.041	0.228
50	IA	0.199	0.028	0.227
51	UT	0.185	0.040	0.225
52	IA	0.212	0.011	0.222
53	IA	0.207	0.010	0.218
54	MN	0.178	0.038	0.217
55	NC	0.188	0.025	0.213
56	IA	0.197	0.016	0.213
57	AZ	0.121	0.086	0.207
58	OK	0.142	0.063	0.206
59	NC	0.167	0.036	0.203
60	MN	0.188	0.014	0.202
61	OH	0.170	0.031	0.200
62	IN	0.182	0.015	0.197
63	IA	0.141	0.055	0.195
64	MN	0.170	0.021	0.191
65	MN	0.142	0.044	0.185
66	IN	0.156	0.028	0.184
67	IA	0.161	0.022	0.183
68	IA	0.167	0.016	0.183
69	IA	0.167	0.013	0.180
70	PA	0.141	0.037	0.178
71	UT	0.142	0.034	0.176
72	NC	0.145	0.030	0.174
73	IA	0.140	0.033	0.173
74	IL	0.160	0.011	0.171
75	NC	0.159	0.012	0.171
76	NC	0.136	0.035	0.171
77	MN	0.152	0.014	0.166
78	NE	0.132	0.034	0.166
79	NC	0.155	0.011	0.166
80	IL	0.135	0.030	0.166
81	IA	0.144	0.020	0.164
82	IL	0.153	0.011	0.164
83	NC	0.126	0.037	0.163
84	GA	0.152	0.010	0.162
85	MN	0.138	0.021	0.159
86	NC	0.128	0.030	0.158

87	NC	0.127	0.029	0.157
88	IA	0.127	0.029	0.157
89	NC	0.129	0.026	0.155
90	IN	0.121	0.032	0.154
91	IN	0.125	0.028	0.153
92	NC	0.124	0.026	0.150
93	MN	0.136	0.012	0.148
94	NC	0.137	0.011	0.148
95	IA	0.134	0.012	0.146
96	IA	0.133	0.012	0.145
97	ND	0.111	0.034	0.144
98	IA	0.121	0.022	0.143
99	-	0.130	0.012	0.142
100	NC	0.120	0.023	0.142
101	NC	0.114	0.026	0.140
102	IA	0.128	0.012	0.140
103	MI	0.116	0.023	0.139
104	MB*	0.129	0.010	0.139
105	MI	0.111	0.026	0.137
106	IA	0.125	0.012	0.137
107	KY	0.123	0.012	0.135
108	NE	0.121	0.013	0.133
109	NC	0.118	0.012	0.130
110	MI	0.118	0.011	0.129
111	NC	0.117	0.011	0.128
112	IA	0.117	0.011	0.128
113	NE	0.116	0.012	0.128
114	MI	0.106	0.022	0.128
115	IA	0.118	0.010	0.128
116	IA	0.117	0.011	0.128
117	MB*	0.097	0.030	0.128
118	NC	0.114	0.011	0.125
119	MB*	0.112	0.013	0.125
120	IL	0.112	0.011	0.122
121	ND	0.102	0.019	0.121
122	IN	0.110	0.011	0.121
123	SD	0.110	0.011	0.121
124	IL	0.109	0.011	0.120
125	KY	0.106	0.010	0.117
126	MN	0.107	0.010	0.117
127	IA	0.105	0.010	0.116
128	MN	0.105	0.010	0.115
129	TX	0.103	0.010	0.113
130	MT	0.102	0.010	0.113
131	NC	0.101	0.012	0.112
132	NE	0.102	0.010	0.112

133	AR	0.100	0.010	0.111
134	MN	0.100	0.010	0.110
135	MO	0.100	0.010	0.110
136	MB*	0.096	0.010	0.106

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. The mean TEQ for all 20 DLCs may not equal the sum of the mean TEQs for dioxins/furans and PCBs due to rounding. A "-" indicates that producer state information is not available.

* Animal raised in Manitoba, Canada, and slaughtered in the U.S.

Table 5. TEQ Values Summary for the 139 Steer/Heifer Samples

	Producer State	TEQ Dioxins/ Furans	TEQ PCBs	Total TEQ DLCs
1	ND	6.067	0.058	6.124
2	ME	5.131	0.119	5.251
3	KS	3.475	0.090	3.565
4	OK	3.105	0.284	3.388
5	WI	3.359	0.027	3.387
6	NE	2.706	0.039	2.745
7	IL	2.597	0.107	2.704
8	KS	2.369	0.208	2.578
9	ID	2.248	0.179	2.426
10	TX	2.238	0.101	2.339
11	WI	2.088	0.174	2.262
12	NE	1.042	1.210	2.251
13	TX	2.041	0.132	2.173
14	IA	1.977	0.154	2.131
15	NE	2.004	0.062	2.066
16	KS	1.715	0.192	1.907
17	OH	1.599	0.252	1.851
18	IA	1.666	0.185	1.851
19	KS	1.550	0.230	1.780
20	KS	1.444	0.229	1.673
21	KS	1.455	0.126	1.580
22	IN	1.450	0.120	1.570
23	KS	1.402	0.129	1.531
24	IA	1.410	0.105	1.515
25	CO	1.399	0.078	1.477
26	MO	1.352	0.100	1.453
27	TX	1.120	0.328	1.448
28	OK	1.306	0.125	1.431
29	CO	1.290	0.096	1.386
30	CO	1.258	0.075	1.333
31	KS	0.867	0.402	1.270
32	IA	0.959	0.173	1.133
33	NE	0.970	0.139	1.109
34	KS	0.697	0.384	1.080
35	NE	0.995	0.064	1.059
36	TX	0.901	0.149	1.050
37	SD	0.922	0.118	1.040
38	CO	0.935	0.087	1.022
39	KS	0.811	0.170	0.981
40	CO	0.837	0.117	0.954
41	-	0.810	0.128	0.938
42	KS	0.767	0.157	0.924

43	SD	0.769	0.130	0.899
44	IA	0.803	0.072	0.875
45	NE	0.804	0.055	0.858
46	TX	0.635	0.173	0.809
47	CA	0.496	0.310	0.806
48	KS	0.635	0.162	0.797
49	SD	0.699	0.094	0.794
50	ID	0.278	0.507	0.785
51	ON*	0.534	0.245	0.779
52	IA	0.605	0.153	0.758
53	TX	0.636	0.116	0.752
54	IA	0.675	0.071	0.746
55	NE	0.558	0.176	0.734
56	NE	0.620	0.106	0.726
57	NV	0.523	0.156	0.678
58	IA	0.487	0.166	0.652
59	CO	0.543	0.106	0.650
60	TX	0.447	0.188	0.635
61	MN	0.537	0.084	0.622
62	CO	0.495	0.124	0.619
63	CA	0.319	0.297	0.615
64	KS	0.385	0.227	0.611
65	OK	0.379	0.225	0.604
66	TX	0.434	0.161	0.595
67	TX	0.352	0.221	0.573
68	TX	0.445	0.127	0.573
69	IA	0.414	0.152	0.566
70	MN	0.484	0.075	0.559
71	TX	0.428	0.128	0.555
72	NE	0.460	0.095	0.555
73	NE	0.468	0.083	0.552
74	NE	0.499	0.050	0.550
75	TX	0.442	0.106	0.548
76	TX	0.344	0.204	0.547
77	AB**	0.460	0.080	0.541
78	NE	0.421	0.117	0.538
79	CO	0.357	0.166	0.522
80	CA	0.337	0.171	0.508
81	TX	0.408	0.094	0.502
82	NE	0.421	0.068	0.489
83	TX	0.315	0.173	0.488
84	KS	0.364	0.121	0.485
85	TX	0.369	0.113	0.482
86	OR	0.368	0.109	0.477
87	KS	0.375	0.099	0.474
88	KS	0.312	0.159	0.470

89	CO	0.397	0.072	0.469
90	KS	0.352	0.115	0.467
91	TX	0.308	0.159	0.467
92	NE	0.356	0.109	0.465
93	OK	0.262	0.202	0.465
94	TX	0.339	0.125	0.464
95	KS	0.380	0.081	0.461
96	KS	0.246	0.213	0.458
97	NE	0.308	0.148	0.456
98	KS	0.255	0.200	0.454
99	SD	0.372	0.081	0.453
100	TX	0.273	0.175	0.447
101	KS	0.304	0.137	0.440
102	IL	0.356	0.080	0.436
103	KS	0.315	0.121	0.436
104	KS	0.324	0.105	0.428
105	OK	0.305	0.121	0.426
106	KS	0.318	0.102	0.420
107	TX	0.299	0.118	0.417
108	OK	0.295	0.109	0.405
109	NE	0.315	0.088	0.403
110	ON*	0.248	0.139	0.387
111	IA	0.268	0.111	0.379
112	WA	0.253	0.118	0.371
113	TX	0.269	0.093	0.362
114	CO	0.294	0.059	0.352
115	CA	0.221	0.126	0.347
116	KS	0.283	0.055	0.338
117	KS	0.224	0.110	0.334
118	CO	0.261	0.072	0.333
119	NE	0.226	0.103	0.329
120	TX	0.244	0.072	0.317
121	NE	0.267	0.045	0.312
122	AB**	0.261	0.049	0.310
123	NE	0.240	0.069	0.309
124	IA	0.262	0.047	0.309
125	NE	0.203	0.097	0.300
126	TX	0.174	0.120	0.294
127	KS	0.161	0.125	0.286
128	NE	0.218	0.063	0.281
129	CO	0.246	0.032	0.278
130	TX	0.211	0.065	0.276
131	KS	0.180	0.092	0.272
132	NE	0.190	0.073	0.263
133	KY	0.182	0.072	0.254
134	SD	0.217	0.036	0.253

135	NE	0.178	0.073	0.251
136	NE	0.175	0.067	0.241
137	OR	0.151	0.076	0.227
138	CO	0.159	0.062	0.221
139	ID	0.164	0.045	0.210

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. The mean TEQ for all 20 DLCs may not equal the sum of the mean TEQs for dioxins/furans and PCBs due to rounding. A "-" indicates that producer state information is not available.

* Animal raised in Ontario, Canada, and slaughtered in the U.S.
** Animal raised in Alberta, Canada, and slaughtered in the U.S.

Table 6. TEQ Values for the 151 Young Chicken Samples

	Producer State	TEQ Dioxins/ Furans	TEQ PCBs	Total TEQ DLCs
1	AR	1.876	0.025	1.901
2	MD	1.652	0.079	1.731
3	AR	1.516	0.200	1.716
4	TX	1.079	0.312	1.390
5	NC	0.692	0.526	1.217
6	AL	0.544	0.376	0.920
7	CA	0.322	0.592	0.914
8	MS	0.672	0.168	0.840
9	AL	0.712	0.078	0.790
10	MS	0.633	0.115	0.748
11	OK	0.606	0.132	0.738
12	MS	0.565	0.161	0.726
13	MN	0.520	0.114	0.634
14	GA	0.536	0.034	0.569
15	AR	0.500	0.052	0.553
16	AR	0.475	0.072	0.547
17	-	0.256	0.284	0.540
18	GA	0.482	0.056	0.538
19	MD	0.471	0.061	0.533
20	AR	0.496	0.024	0.519
21	NC	0.444	0.056	0.499
22	AR	0.377	0.092	0.469
23	MS	0.363	0.100	0.463
24	AR	0.375	0.087	0.461
25	AL	0.400	0.047	0.448
26	TX	0.356	0.087	0.443
27	MS	0.388	0.053	0.441
28	VA	0.127	0.300	0.428
29	FL	0.313	0.104	0.417
30	TN	0.361	0.051	0.412
31	CA	0.226	0.185	0.411
32	MS	0.321	0.087	0.408
33	MO	0.217	0.184	0.401
34	LA	0.277	0.107	0.384
35	NC	0.190	0.191	0.382
36	MD	0.119	0.262	0.381
37	AL	0.307	0.049	0.356
38	GA	0.200	0.152	0.352
39	VA	0.150	0.200	0.350
40	AR	0.235	0.110	0.345
41	VA	0.175	0.168	0.344

42	-	0.204	0.139	0.343
43	CA	0.266	0.060	0.326
44	GA	0.295	0.030	0.324
45	AL	0.290	0.031	0.321
46	-	0.177	0.140	0.317
47	LA	0.111	0.204	0.315
48	MS	0.286	0.025	0.311
49	VA	0.224	0.086	0.310
50	AR	0.119	0.190	0.310
51	NC	0.207	0.094	0.301
52	MS	0.217	0.078	0.295
53	SC	0.230	0.065	0.295
54	NC	0.231	0.059	0.291
55	AL	0.233	0.054	0.288
56	AL	0.116	0.164	0.280
57	AR	0.179	0.101	0.280
58	GA	0.238	0.040	0.278
59	GA	0.171	0.107	0.278
60	AL	0.252	0.020	0.272
61	NC	0.235	0.037	0.272
62	TN	0.140	0.127	0.268
63	CA	0.197	0.070	0.267
64	AL	0.202	0.062	0.264
65	MS	0.228	0.035	0.262
66	NC	0.118	0.142	0.260
67	AR	0.156	0.103	0.259
68	GA	0.226	0.032	0.258
69	DE	0.165	0.090	0.255
70	AL	0.207	0.048	0.255
71	GA	0.164	0.089	0.253
72	OK	0.206	0.048	0.253
73	CA	0.194	0.059	0.253
74	GA	0.153	0.099	0.252
75	TX	0.182	0.070	0.252
76	AR	0.223	0.025	0.248
77	GA	0.198	0.050	0.248
78	MD	0.152	0.091	0.243
79	AL	0.212	0.029	0.241
80	TN	0.160	0.079	0.239
81	GA	0.208	0.030	0.237
82	GA	0.193	0.042	0.235
83	NC	0.201	0.033	0.234
84	NC	0.194	0.040	0.233
85	TX	0.197	0.036	0.232
86	-	0.112	0.120	0.232
87	MD	0.111	0.118	0.229

88	MS	0.183	0.039	0.222
89	MS	0.109	0.109	0.218
90	TX	0.181	0.033	0.214
91	PA	0.164	0.050	0.214
92	GA	0.142	0.071	0.213
93	AL	0.136	0.071	0.207
94	LA	0.117	0.089	0.207
95	KY	0.118	0.084	0.202
96	VA	0.150	0.051	0.201
97	AR	0.117	0.082	0.198
98	TN	0.144	0.053	0.197
99	NC	0.107	0.089	0.196
100	VA	0.113	0.082	0.195
101	GA	0.150	0.043	0.193
102	MS	0.164	0.025	0.189
103	VA	0.138	0.051	0.189
104	KY	0.126	0.062	0.188
105	NC	0.110	0.077	0.187
106	GA	0.115	0.072	0.186
107	MS	0.148	0.037	0.185
108	GA	0.113	0.071	0.185
109	OK	0.144	0.040	0.184
110	TX	0.126	0.059	0.184
111	AR	0.153	0.031	0.184
112	VA	0.139	0.043	0.182
113	NC	0.115	0.066	0.180
114	GA	0.140	0.040	0.180
115	TX	0.150	0.029	0.179
116	MS	0.158	0.021	0.178
117	AR	0.150	0.027	0.177
118	AL	0.113	0.063	0.176
119	-	0.130	0.043	0.174
120	AL	0.118	0.055	0.173
121	GA	0.107	0.064	0.171
122	MD	0.118	0.052	0.170
123	TX	0.143	0.026	0.169
124	SC	0.135	0.032	0.167
125	OK	0.137	0.030	0.167
126	DE	0.119	0.046	0.165
127	OK	0.125	0.040	0.165
128	GA	0.113	0.049	0.162
129	GA	0.105	0.057	0.162
130	OK	0.129	0.033	0.162
131	MO	0.115	0.041	0.156
132	GA	0.116	0.037	0.153
133	TX	0.112	0.040	0.152

134	AR	0.112	0.038	0.150
135	TX	0.118	0.027	0.146
136	SC	0.116	0.029	0.145
137	AR	0.121	0.023	0.144
138	VA	0.115	0.029	0.144
139	AL	0.104	0.039	0.144
140	FL	0.105	0.034	0.139
141	AR	0.110	0.027	0.136
142	OK	0.113	0.023	0.135
143	AR	0.108	0.027	0.135
144	AR	0.114	0.021	0.135
145	AR	0.112	0.023	0.135
146	KY	0.108	0.025	0.134
147	NC	0.105	0.027	0.132
148	MS	0.111	0.020	0.131
149	AR	0.107	0.024	0.131
150	AR	0.106	0.024	0.130
151	MO	0.109	0.020	0.129

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. The mean TEQ for all 20 DLCs may not equal the sum of the mean TEQs for dioxins/furans and PCBs due to rounding. A "-" indicates that producer state information is not available.

Table 7. TEQ Values for the 84 Young Turkeys Samples

	Producer State	TEQ Dioxins/ Furans	TEQ PCBs	Total TEQ DLCs
1	IA	1.402	0.480	1.882
2	MN	1.098	0.228	1.326
3	MN	1.136	0.176	1.313
4	IA	1.115	0.190	1.305
5	CA	0.894	0.313	1.207
6	MN	1.110	0.093	1.203
7	MN	0.558	0.631	1.189
8	NC	0.929	0.178	1.107
9	CA	0.326	0.781	1.106
10	CA	0.629	0.401	1.029
11	MN	0.648	0.381	1.029
12	MN	0.810	0.211	1.021
13	CA	0.611	0.363	0.974
14	NC	0.650	0.315	0.965
15	IN	0.422	0.527	0.949
16	IA	0.656	0.218	0.875
17	MO	0.616	0.209	0.824
18	IA	0.530	0.288	0.818
19	NC	0.658	0.115	0.773
20	-	0.626	0.145	0.771
21	MN	0.502	0.254	0.756
22	NC	0.516	0.213	0.729
23	VA	0.333	0.370	0.704
24	WI	0.533	0.152	0.684
25	WI	0.509	0.168	0.677
26	MO	0.553	0.118	0.671
27	MN	0.552	0.119	0.671
28	OH	0.531	0.137	0.668
29	OH	0.544	0.123	0.668
30	OH	0.491	0.170	0.662
31	NC	0.323	0.331	0.654
32	MO	0.507	0.138	0.645
33	IN	0.488	0.157	0.645
34	IN	0.494	0.129	0.623
35	NC	0.470	0.142	0.611
36	AR	0.312	0.295	0.607
37	SC	0.445	0.140	0.585
38	TX	0.263	0.311	0.575
39	TX	0.274	0.296	0.570
40	MN	0.410	0.157	0.567
41	MN	0.398	0.160	0.557

42	CA	0.368	0.182	0.551
43	NC	0.460	0.087	0.547
44	VA	0.378	0.167	0.546
45	PA	0.366	0.157	0.524
46	NC	0.393	0.130	0.523
47	AR	0.303	0.218	0.521
48	VA	0.323	0.197	0.520
49	IN	0.388	0.130	0.518
50	AR	0.413	0.094	0.507
51	NC	0.368	0.131	0.499
52	TX	0.285	0.205	0.489
53	VA	0.298	0.189	0.487
54	NC	0.299	0.186	0.485
55	NC	0.307	0.167	0.474
56	WI	0.288	0.183	0.471
57	NC	0.394	0.069	0.464
58	MO	0.322	0.137	0.459
59	NC	0.307	0.147	0.454
60	VA	0.354	0.099	0.454
61	MN	0.357	0.090	0.448
62	AR	0.233	0.196	0.429
63	VA	0.284	0.136	0.419
64	NC	0.338	0.081	0.419
65	NC	0.322	0.097	0.419
66	SC	0.295	0.115	0.409
67	AR	0.166	0.240	0.406
68	AR	0.256	0.140	0.396
69	MO	0.315	0.073	0.389
70	AR	0.265	0.110	0.375
71	IA	0.299	0.073	0.373
72	MO	0.230	0.136	0.367
73	MN	0.277	0.087	0.364
74	VA	0.250	0.106	0.356
75	SC	0.284	0.072	0.355
76	MI	0.270	0.085	0.355
77	NC	0.284	0.066	0.350
78	MN	0.136	0.212	0.349
79	MO	0.183	0.158	0.340
80	MO	0.243	0.087	0.330
81	-	0.292	0.028	0.320
82	AR	0.205	0.062	0.268
83	AR	0.162	0.087	0.248
84	CA	0.123	0.034	0.157

Note: Results expressed in parts per trillion (ppt). Data were not background subtracted. All results reported on a lipid basis. The mean TEQ for all 20 DLCs may not equal the

sum of the mean TEQs for dioxins/furans and PCBs due to rounding. A "-" indicates that producer state information is not available.

Analytical Method (Based on EPA Method 1613)

FSIS collected 250g adipose tissue samples from carcasses. For poultry, each sample was a composite of three birds from the flock. Samples were frozen and shipped in sealed boxes to the USDA Agricultural Research Service Biosciences Research Laboratory in Fargo, ND for analysis. Samples remained frozen at -60° C until analysis. Prior to analysis, each sample was removed from the ultracold freezer, thawed at room temperature for 1 hour, and the entire sample was homogenized by grinding at room temperature in a blender (Waring Model 700B) using a 250ml mini-container blender jar. A 5 g sub-sample was spiked with a mixture of 15 ^{13}C-labeled PCDD/Fs and 3 ^{13}C-labeled co-planar PCBs (500 pg of each tetra- to hepta- congener, 1000 pg of each octa-congener, and 500 pg of each PCB) and dispersed in methylene chloride (20 mL) using a Tissumizer (Ultra-Turrax T25-S1; Janke & Kunkel, IKA Labortechnik) The sample was gravity-filtered through anhydrous sodium sulfate (20 g) to dry. An aliquot of the dissolved fat solution was removed for gravimetric lipid determination. The remainder of the sample was solvent-exchanged into hexane 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 concentrated into 10uL of dodecane containing the internal standards (500 pg each of ^{13}C-labeled 1,2,3,4,-TCDD, 1,2,3,7,8,9-HxCDD, and 3,3',4,5'-TeCB). A 2 uL aliquot was analyzed for 17 PCDD/Fs and PCBs-77, 126, and 189 according to EPA Method 1613 ("Tetra- through octa-chlorinated dioxins and furans by isotope dilution HRGC/HRMS") on a Micromass AutoSpec Ultima high resolution mass spectrometer (HRMS) coupled to an Agilent 6890 gas chromatogram. Chromatographic separation was accomplished using a 60 m x 0.32 mm id J&W DB-5MS capillary column (Chrom Tech, Inc., Apple Valley, MN). 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. At 0.1 pg TCDD, a S/N > 20 was expected from the instrument. 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.

The known spiked samples were required to be within 25% of the actual value and have a coefficient of variance <35%. Coefficients of variance (CVs) for spiked samples in the survey were under 15% for all congeners except PCB-77, which had a CV < 25%. The recoveries of ^{13}C-surrogates were allowed to range from 25–150%, but actually averaged 70–90% for each congener during the survey.

Data were not background-subtracted, but each blank was evaluated to determine if laboratory contamination was elevated. When elevated levels were found in the blanks and samples, another sub-sample was taken and re-analyzed. The lack of background subtraction was estimated to add less than 13% to the average toxic equivalents (TEQs) (total TEQ with non-detects equal to one-half the limit of detection [ND= LOD/2]) for each slaughter class.

TEQs were calculated from the data using the 1998 World Health Organization (WHO) toxic equivalency factors (TEFs) and setting non-detects equal to ½ the method detection limit or limit of detection. The LOD was determined as the mean of the method blanks + 2 standard deviations when congeners were present in the blanks, or as 2 standard deviations calculated from nine replicate low-level spikes when a congener was not generally detected in the blank.