

Dioxin Analysis Results/Exposure Estimates

March 2004; Updated November 2007

Introduction

Dioxin and chemically-related compounds (referred to collectively as dioxin-like compounds or DLCs) are a group of environmental contaminants found throughout the world. Studies suggest that exposure to DLCs may lead to a variety of adverse health effects including reproductive and developmental problems, cardiovascular disease, increased diabetes, and increased cancer. Because DLCs tend to accumulate in the fat of food-producing animals, consumption of animal-derived foods (e.g., meat, poultry, eggs, fish, and dairy products) is considered to be the major route of human exposure to low levels of DLCs.

The Food and Drug Administration (FDA) has been concerned about DLCs and has been monitoring food and animal feed with the goal of identifying ways to reduce dietary exposure to these ubiquitous environmental contaminants. In 2000, FDA developed a **strategy for DLCs** ([/Food/FoodbornellnessContaminants/ChemicalContaminants/ucm077432.htm](http://www.fda.gov/Food/FoodbornellnessContaminants/ChemicalContaminants/ucm077432.htm)). The purpose of FDA's dioxin strategy, which significantly expanded FDA's Dioxin Monitoring Program, is to develop the science to support appropriate risk management actions. Specific goals for FDA's Dioxin Monitoring Program are to obtain baseline data for DLC levels in food and animal feed ingredients susceptible to DLC contamination, to determine opportunities for DLC reduction by identifying contamination sources that can be eliminated or significantly reduced and estimating dietary DLC exposure. As part of FDA's Dioxin Monitoring Program, FDA analyzes foods collected under its Total Diet Study (TDS) as well as additional non-TDS foods.

Collection of TDS Foods

The TDS is FDA's ongoing market basket survey of approximately 280 core foods in the U.S. food supply to determine levels of various pesticides residues, contaminants, and nutrients in foods and to estimate exposures of these substances in representative diets of specific age-sex groups in the U.S. Four market baskets are generally collected each year, once in each of four geographic regions of the U.S. (i.e., West, North Central, South, and Northeast). For each market basket, food samples are collected from grocery stores and fast food restaurants in three cities within the region, prepared table-ready (i.e., as they would be consumed), and composited for analysis (See **General notes about preparation of TDS foods prior to analysis**). Therefore, each data point reported for a TDS food represents a composite of three samples of a table-ready (i.e., cooked, if required by TDS recipes) food type.

FDA's Dioxin Monitoring Program analyzed selected TDS samples from one market basket each year in 2000, 2001, 2002, 2003 and 2004 to determine levels of polychlorinated dibenzo-*p*-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) congeners. Collection year and site for each market basket analyzed are listed in Table 1.

Table 1.

Collection year and site for FDA Total Diet Study market baskets analyzed by the Dioxin Monitoring Program

Collection Year	Collection Site
2000	Tucson, Arizona; San Diego, California; Brownsville, Texas
2001	Colorado Springs, Colorado; Oakland, California; Spokane, Washington
2002	Ventura County, California; San Jose, California; Yakima, Washington
2003	Albuquerque, New Mexico; Riverside-San Bernardino, California; Salem, Oregon
2004	Boston, Massachusetts; Syracuse, New York; Pittsburg, Pennsylvania

In 2000, TDS samples selected for dioxin monitoring represent only FDA regulated products; in 2001, 2002, 2003 and 2004 TDS samples analyzed for PCDD/PCDF congeners represent a broader range of TDS samples. In addition, the TDS food list was updated in 2003, which resulted in a number of changes to the list (e.g., some foods were deleted, some foods were added).

Collection of Non-TDS Foods

In addition to TDS food samples, FDA's Dioxin Monitoring Program involves the collection and analysis of additional non-TDS food samples to obtain more comprehensive data on baseline levels for DLCs in specific foods, as well as to identify and reduce pathways of DLC contamination. In addition, non-TDS samples are used to complement TDS findings by further estimating dietary DLC exposure from specific types of foods (e.g., species of fish). Non-TDS food samples collected and analyzed by FDA include dairy products, eggs, fats/oils, fruits/vegetables, grains/cereals, seafood (finfish/shellfish), tree nuts/peanuts, and dietary supplements. Samples were assigned and collected by one of ten FDA District Offices at retail, as domestic imports or at the grower for certain domestic aquaculture finfish samples (e.g., catfish, salmon, striped bass, tilapia, trout). Unlike TDS foods, non-TDS food samples were not prepared as consumed (i.e., cooked) prior to DLC analysis though only the edible portion was analyzed (See [General Notes about Preparation of Foods Prior to Analysis for Non-TDS Samples](#)).

Analytical Methods

Samples were analyzed by gas chromatography/high resolution mass spectroscopy (HRMS) or ion trap mass spectroscopy (ITMS) for PCDD/PCDF congeners as listed in Table 2. HRMS is the preferred method for high consumption-rate foods with very low or no expected DLC levels while ITMS is the preferred method for lower consumption-rate foods with higher expected DLC levels. In addition, HRMS is the preferred method for TDS samples. Data are presented as Toxicity Equivalents or TEQs which are used to estimate the relative toxicity of congeners. This equivalency method is based on summing the TEQs of DLC congeners measured in each sample. The TEQ is calculated by multiplying the concentration of each DLC congener by the corresponding 1998 World Health Organization Toxic Equivalency Factor or TEF listed in Table 2. The TEF of the most potent PCDD/PCDF congener called 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) is 1. Three TEQ values were generated for each DLC congener reported and for each sample, reflecting assignment of zero, half the limit of detection (LOD), or LOD values to congener non-detects. All results are expressed on a whole weight basis.

Table 2.
Toxicity Equivalency Factors (TEFs) for the polychlorinated dibenzo-*p*-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) congeners

Congener		TEF (1, 2, 3)
<i>Polychlorinated Dibenzodioxins</i>		
	2,3,7,8-TCDD	1

Congener		TEF
	1,2,3,7,8-PeCDD	1
	1,2,3,4,7,8-HxCDD	0.1
	1,2,3,6,7,8-HxCDD	0.1
	1,2,3,7,8,9-HxCDD	0.1
	1,2,3,4,6,7,8-HpCDD	0.01
	OCDD	0.0001 (0.0003)
<i>Polychlorinated Dibenzofurans</i>	2,3,7,8-TCDF	0.1
	1,2,3,7,8-PeCDF	0.05 (0.03)
	2,3,4,7,8-PeCDF	0.5 (0.3)
	1,2,3,4,7,8-HxCDF	0.1
	1,2,3,6,7,8-HxCDF	0.1
	1,2,3,7,8,9-HxCDF ⁽⁴⁾	0.1
	2,3,4,6,7,8-HxCDF ⁽⁴⁾	0.1
	1,2,3,4,6,7,8-HpCDF	0.01
	1,2,3,4,7,8,9-HpCDF	0.01
	OCDF	0.0001 (0.0003)

¹ van den Berg M, Birnbaum L, Bosveld AT, Brunstrom B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, Kubiak T, Larsen JC, van Leeuwen FX, Liem AK, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tyskind M, Younes M, Waern F, Zacharewski T. 1998. Toxic equivalency factors (TEF) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106: 775-792.

² Values in parentheses are TEFs that were established in 2005 by the World Health Organization (van den Berg M, Birnbaum L, Denison M, De Vito M, Farland W, Feeley M, Fiedler H, Hakansson H, Hanberg A, Haws L, Rose M, Safe S, Schrenk D, Tohyama C, Tritscher A, Tuomisto J, Tyskind M, Walker N, Peterson RE. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol Sci 93: 223-241) that replaced 1998 WHO-TEFs. For consistency with earlier estimates, 1998 WHO-TEFs were used to calculate TEQ for all samples.

³ In addition to TEFs for PCDDs and PCDFs, the World Health Organization has also established TEFs for dioxin-like PCBs (non-ortho substituted PCBs and mono-ortho substituted PCBs). Congeners analyzed and listed in Table 2 include only PCDDs and PCDFs but not dioxin-like PCBs.

⁴ Congener not included for samples analyzed by gas chromatography/ion trap mass spectroscopy.

Analytical Results

Each results file is a compressed, tab-delimited text file that can be downloaded, decompressed (double-click the file or use a program like Stuffit Expander), and imported by database or spreadsheet software. **For best viewing** and data manipulation, the text files should be saved and then opened from a database or spreadsheet program such as Microsoft Excel, Corel QuattroPro and Lotus 1-2-3.

A. TDS Foods

Summary PCDD/PCDF concentration results for TDS foods:

[2000 PCDD/PCDF Summary File \(/downloads/Food/FoodborneIllnessContaminants/UCM190942.zip\)](#) for TDS Foods

[2001 PCDD/PCDF Summary File \(/downloads/Food/FoodborneIllnessContaminants/UCM190936.zip\)](#) for TDS Foods

[2002 PCDD/PCDF Summary File \(/downloads/Food/FoodborneIllnessContaminants/UCM190938.zip\)](#) for TDS Foods

[2003 PCDD/PCDF Summary File \(/downloads/Food/FoodborneIllnessContaminants/UCM190940.zip\)](#) for TDS Foods

[2004 PCDD/PCDF Summary File \(/downloads/Food/FoodborneIllnessContaminants/UCM190944.zip\)](#) for TDS Foods

Congener specific PCDD/PCDF concentration results for TDS foods:

[2000 PCDD/PCDF Congener File \(/downloads/Food/FoodborneIllnessContaminants/UCM190946.zip\)](#) for TDS Foods

[2001 PCDD/PCDF Congener File \(/downloads/Food/FoodborneIllnessContaminants/UCM190950.zip\)](#) for TDS Foods

[2002 PCDD/PCDF Congener File \(/downloads/Food/FoodborneIllnessContaminants/UCM190952.zip\)](#) for TDS Foods

[2003 PCDD/PCDF Congener File \(/downloads/Food/FoodborneIllnessContaminants/UCM190953.zip\)](#) for TDS Foods

[2004 PCDD/PCDF Congener File \(/downloads/Food/FoodborneIllnessContaminants/UCM190954.zip\)](#) for TDS Foods

B. Non-TDS Foods

Summary and congener specific PCDD/PCDF concentration results for non-TDS foods:

[Non-TDS Foods Analyzed for PCDD/PCDFs in 2001-2003](#)

[\(/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm077465.htm\)](#)

Exposure Estimate Results

A. TDS Foods

[2001-2004 PCDD/PCDF Exposure Estimates](#)

[\(/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm077498.htm\)](#) from TDS Samples

B. Non-TDS Foods

PCDD/PCDF Exposure Estimates from Non-TDS Foods Analyzed in 2001-2003
(/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm077478.htm)

General Notes About Preparation of Foods Prior to Analysis:

A. TDS Foods

Added fat:

Unless noted in the food description, fat was not added to foods after cooking (e.g., cooked vegetables, breads and rolls, pancakes, cooked cereals/grains).

Eggs:

Fried and scrambled eggs: were cooked in vegetable oil.

Meats:

Cooked meats: cooking fat/pan drippings were drained and excess fat trimmed.

Pan-cooked meats: were cooked in vegetable oil.

Brown gravy: was prepared with meat drippings.

Poultry:

Fried chicken: included light and dark meat, skin was included.

Roasted: included light meat only, skin was included.

Turkey breast: light meat only, skin was removed.

Fish:

Pan-cooked fish: was cooked in vegetable oil.

Canned tuna: oil was drained.

Vegetables:

Mashed potatoes: were prepared from package using whole milk and margarine.

Cream soups:

Tomato soup: was prepared with water.

Clam chowder: was prepared with whole milk.

Desserts:

Chocolate pudding: was prepared with whole milk.

B. Non-TDS Foods

Eggs:

Shells were removed.

Fruits/Vegetables:

Avocado, banana, and onion were peeled.

Seafood:

For finfish except catfish and basa, skin was included when available (i.e., bluefish, salmon, striped bass, trout). For shellfish, shells were removed.