

## Dioxins in U.S. Fast Food

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### **Introduction**

In recent years, food products have been identified as the primary source of non-occupational human exposure to polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)<sup>(1,2)</sup>. It is therefore surprising that very limited data are available on the levels of these compounds in various food products from various regions. More comprehensive data on the levels of PCDDs, PCDFs and the dioxin-like coplanar polychlorinated biphenyls (PCBs) are needed to estimate dietary exposures to this class of compounds in terms of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalents (TEQs). These data are also needed to identify food products with higher TEQs, which will result in greater dietary exposures to these compounds.

The present study reports for the first time the TEQ content in three kinds of popular U.S. fast food, McDonald's Big Mac, Pizza Hut's Personal Pan Pizza Supreme, and Original Recipe Kentucky Fried Chicken (KFC). The daily TEQ dose from the consumption of this fast food was also estimated and compared with the recently proposed cancer risk-specific dose estimate of 0.01 pg TEQ/kg body weight /day for 75 years (U.S. EPA, 1994)<sup>(3)</sup>. This risk-specific daily dose estimate is a lifetime dose which results in a plausible upper bound cancer risk of  $1 \times 10^{-6}$  (one additional cancer in one million exposed), although this risk may be less, and may even be zero, for some members of the population.

### **Methods**

Samples were ground and homogenized three times. One hundred grams of each sample were taken and mixed with approximately 300-g of pre-cleaned sodium sulfate, then the sample was split and placed into two Soxhlet extractors. The sample was fortified with <sup>13</sup>C-labeled analogs consistent with EPA Method 8290 and extracted for 16 hours with 1:1 dichloromethane / hexane. After extraction the solvent was removed and the lipid was re-dissolved in 200 mL of hexane and

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slurried for 2 hours in 100-g of acidified silica gel. The extract was then eluted through an acidified silica gel column, a neutral alumina column, and an AX-21/Celite 545 carbon column. The final toluene extract was reduced in volume to 10 uL with <sup>13</sup>C-labeled recovery standards added. The extract was analyzed on a VG70-250S at a resolution of 10,000. A 60-m DB-5 GC/MS column was used to provide chromatographic resolution between 2,3,7,8-TCDD and all other TCDD isomers. Method 8290 analysis criteria were met.

## Results

The results from food samples are presented on a whole (or wet) weight basis, in order to be more representative of the way food is purchased and consumed.

Table 1. Dioxins, dibenzofurans and dioxin TEQs in U.S. fast food (ppt, wet weight)				
Compound	TEF	Big Mac	PIZZA	KFC
2,3,7,8-TCDD	1	U(.0249)(a)	U(.0249)	U(.025)
1,2,3,7,8-PeCDD	0.5	U(.125)	U(.124)	U(.125)
1,2,3,4,7,8-HxCDD	0.1	U(.125)	U(.124)	U(.125)
1,2,3,6,7,8-HxCDD	0.1	0.22	0.149	U(.13 EMPC)
1,2,3,7,8,9-HxCDD	0.1	U(.125)	U(.124)	U(.125)
1,2,3,4,6,7,8-HpCDD	0.01	0.862	0.936	0.454
OCDD	0.001	1.59	4.04	2.55
2,3,7,8-TCDF	0.1	U(.07 EMPC)(b)	U(.0847 EMPC)	0.0734
2,3,4,7,8-PeCDF	0.5	U(.125)	U(.124)	U(.125)
1,2,3,7,8-PeCDF	0.05	U(.125)	U(.124)	U(.125)
1,2,3,4,7,8-HxCDF	0.1	U(.125)	U(.124)	U(.125)
1,2,3,6,7,8-HxCDF	0.1	U(.143 EMPC)	U(.22 EMPC)	U(.349 EMPC)
2,3,4,6,7,8-HxCDF	0.1	U(.125)	U(.124)	U(.125)
1,2,3,7,8,9-HxCDF	0.1	U(.125)	U(.124)	U(.432 EMPC)
1,2,3,4,6,7,8-HpCDF	0.01	U(.486 EMPC)	U(.823 EMPC)	U(.125)
1,2,3,4,7,8,9-HpCDF	0.01	U(.125)	U(.124)	U(.135 EMPC)
OCDF	0.001	U(.249)	U(.249)	0.385
Total PCDDs-min(c)		2.672	5.125	3.004
Total PCDDs-max(d)		3.072	5.522	3.534
Total PCDFs-min		0	0	0.458
Total PCDFs-max		1.698	2.121	1.999
PCDDs and PCDFs-min		2.67	5.125	3.462
PCDDs and PCDFs-max		4.77	7.643	5.53
I-TEQs-min		0.03	0.03	0.01
I-TEQs-max		0.28	0.29	0.31

(a)-Undetected, with the curve based detection limit in pg/g.

(b)-Undetected due to an interference. An estimated maximum possible concentration (EMPC) is given as the detection limit.

(c)-Calculated using a value of zero for undetected compounds.

(d)-Calculated using the detection limit value for undetected compounds.

Table 1 presents congener-specific data for three kinds of fast food. Total PCDDs and PCDFs range from 2.67 to 4.77 pg/g for Big Mac, 5.12 to 7.64 pg/g for Pizza, and 3.46 to 5.53 pg/g for KFC. Total dioxin TEQs are 0.03-0.28 pg/g for Big Mac, 0.03-0.29 pg/g for Pizza, and 0.01-0.31 pg/g for KFC respectively.

Age group	Food group	Consumption rate (g/day)*	Mean PCDD and PCDF concentration range in food (pg/TEQ/g)		Daily TEQ intake (pg)		Average body weight (kg)	Daily TEQ intake (pg/kg) from each group	
			Low(a)	High(b)	Low(a)	High(b)		Low(a)	High(b)
Adult	BIG MAC	184	0.03	0.28	5.53	51.6	65	0.085	0.794
	PIZZA**	340	0.03	0.29	10.21	98.66	65	0.157	1.518
	KFC***	326	0.01	0.31	3.26	101.07	65	0.050	1.555
Children	BIG MAC	184	0.03	0.28	5.53	51.6	20	0.276	2.580
	PIZZA	340	0.03	0.29	10.21	98.66	20	0.510	4.933
	KFC	326	0.01	0.31	3.26	101.07	20	0.163	5.054

\*Consumption rate=weight of a single serving

\*\*One Pizza Hut Personal Pan Pizza Supreme

\*\*\*Kentucky Fried Chicken: 3 pieces mixed

(a)-Low TEQ values were calculated using a value of zero for undetected compounds

(b)-High TEQ values were calculated using the detection limit value for undetected compounds

Table 2 estimates the daily intake of dioxin TEQs from three kinds of popular U.S. fast food, a Big Mac, Pizza Hut's Personal Pan Pizza, and three pieces of mixed Original Recipe Kentucky Fried Chicken. The method of estimating the daily intake of dioxin TEQs from these fast food is to multiply the PCDD/Fs concentrations found in each type of food by the weight of one serving size, which we assume represents the amount that an average person would consume each day. The low TEQ values were calculated based on using only the congeners which were detected, and the high TEQ values were based on assigning the level of detection limits for congeners which were not detected. The daily dioxin TEQ intake per kilogram body weight per day is calculated based on the assumption of 65 kg average body weight for adults and 20 kg for 6-year old children. Daily TEQ intake for adults from these fast food ranges from 0.05 to 1.555 pg/kg/day. Children would have a higher daily TEQ per kilogram than adults: 0.276-2.58 pg/kg from Big Mac, 0.51-4.93 pg/kg from Pizza and 0.163-5.05 pg/kg from KFC.

Table 3 presents a summary of our previous study of dietary exposure to polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) from various U.S. food groups for comparison. The average daily intake of dioxin toxic equivalents (TEQ/kg) is calculated assuming an average of 65 kg body weight for adults. The average daily TEQ intake from various beef products ranges from 3.52 to 132 pg, pork ranges from 0.84 to 8.40 pg, poultry from one sample contributes 0.93 pg, fish ranges from 0.36 to 2.34 pg, milk contributes 10.16 pg, and other dairy products range from 2.20 to 38.50 pg. The dioxin TEQs in these samples provide an average total dietary intake ranging from 0.3 to 3.0 pg TEQ/kg body weight/day for an adult in the U.S.<sup>(1)</sup>

Table 4 and Table 5 show the ratios of dioxin TEQ intake from fast food and general diet<sup>(1)</sup> to the cancer risk-specific dose (0.01 pg TEQ/kg body weight/day) proposed by U.S. EPA for adults

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and 6-year old children respectively. For adults, the average daily dioxin TEQ intake from fast foods range about 5-156 fold greater than the EPA cancer risk-specific dose. Whereas for 6-year old children the ratios for three kinds of fast foods range from 16 to 505.

Table 3. Calculated PCDD and PCDF TEQ from Various Food Groups for the U.S. Adult General Population\*

Food Group	Consumption Rate (g/day)**	Range of PCDD/F TEQ in Food (wet weight; pg/g)		Daily Human Intake			
				Range Total TEQ (pg)		Range TEQ/kg B/W (pg)***	
		LOW	HIGH	LOW	HIGH	LOW	HIGH
Beef	88	0.04	1.50	3.52	132.00	0.054	2.031
Pork	28	0.03	0.30	0.84	8.40	0.013	0.129
Poultry	31	0.03	0.03	0.93	0.93	0.014	0.014
Fish	18	0.02	0.13	0.36	2.34	0.006	0.036
Milk	254	0.04	0.04	10.16	10.16	0.156	0.156
Other Dairy Products	55	0.04	0.70	2.20	38.50	0.034	0.592
Fruits & Vegetables	283	---	---	---	---	---	---
		Total Range		18.0	192.3	0.3	3.0

\* Copied from Ref 1

\*\*Consumption rates from Yang and Nelson(ref 4)

\*\*\* Assuming a 65 kg adult weight

Table 4. Ratios of Dioxin TEQ Intake from Fast Food and General Diet to U.S. EPA Cancer Risk-Specific Dose\* for Adults

	Ratio to EPA Proposed Dose		
	Low	Mean	High
Big Mac	8.5	43.95	79.4
Pizza	15.7	83.75	151.8
KFC	5.0	80.25	155.5
General U.S. Diet (Table 3)	30	165	300

\*U.S. EPA Cancer Risk-Specific Dose of 0.01 pg TEQ/kg/day = Dose Resulting in an upper bound excess cancer risk of 1 case in one million (Ref 3)

Table 5. Ratios of Dioxin TEQ Intake from Fast Food and General Diet to U.S. EPA Cancer Risk-Specific Dose\* for 6-Year Old Children

	Ratio to EPA Proposed Dose		
	Low	Mean	High
Big Mac	27.6	142.8	258
Pizza	51	275	493
KFC	16.3	283.4	505
General U.S. Diet (Ref 1)	100	1400	2700

\*U.S. EPA Cancer Risk-Specific Dose of 0.01 pg TEQ/ kg/day = Dose Resulting in an upper bound excess cancer risk of 1 case in one million (Ref 3)

## **Discussion**

Compared with our earlier study of dioxins in general food groups, the total TEQ concentration in each of the three fast foods is similar to that found earlier in general food groups, thus, one serving of the three fast foods contribute a similar relative dioxin intake.

Based on the unit cancer risk estimate for TCDD of  $1 \times 10^{-4}$  (pg/kg day) currently proposed by U.S. EPA (1994), a lifetime average daily dose (LADD) of 0.01 pg TEQ/kg body weight/day would result in a maximum of 1 excess cancer case in one million. This risk-specific dose estimate represents a plausible upper bound on risk based on the evaluation of animal and human data.

The total dioxin TEQ intake from general U.S. diet ranges from 30 to 300 fold greater than the U.S. EPA proposed value. According to the data we present in Table 2, even the lowest figure of 0.05 pg TEQ/kg body weight/day for adults exceeds the U.S. EPA cancer risk-specific dose of 0.01 pg TEQ/kg/day. For an adult, the daily dioxin TEQs intake from Big Mac ranges from 8.5 to 79 fold greater than the EPA proposed value, 15.7 to 152 fold from Pizza and 5 to 156 fold from three pieces of KFC. At a LADD of 5.05 pg TEQ/kg/day from three pieces of KFC for a 6-year old child, the risk level, if daily for a lifetime, would be  $5.05 \times 10^{-4}$  or 505 excess cancers in a population of 1,000,000. In addition, the dioxin TEQ intake from a Big Mac and a personal Pan Pizza are as much as 258 and 493 fold higher, respectively than 0.01 pg TEQ/kg BW/day. Since the dietary habits and lower body weight of children may cause them to have relatively higher intake of PCDDs and PCDFs than adults at a crucial time when their physical and mental capabilities are developing, these results may be of more medical significance in children than in adults. However, these cancer risk estimates are upper bound or maximal risk and it is also possible that the risk is much less, or even zero. Further studies need to be done to fully characterize the levels of dioxin like chemicals in American food so as to provide more reliable dietary based exposure assessment.

## **References**

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