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Polybrominated Diphenyl Ether (PBDE) Levels in an Expanded Market Basket Survey of United States (U.S) Food and Estimated PBDE Dietary Intake by Age and Gender

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Abbreviations and definitions

ng/kg: nanogram per kilogram ($1X10^{-9}$ g/kg)

PBDEs: Polybrominated diphenyl ethers

PCB: Polychlorinated biphenyls

pg/g: picogram per gram ($1X10^{-12}$g/g)

pg/kg: picogram per kilogram ($1X10^{-12}$g/kg)

ppt: parts per trillion

ww: wet weight or whole weight

Outline

Abstract

Background and objectives:

This study expands a previously reported U.S. market basket survey of food for polybrominated diphenyl ether (PBDE) levels with a larger sample size of 62 individual analyses for 13 congeners. In addition, it estimates levels of PBDE intake from food by gender and age for the U.S. general population.

Results and Discussion:

In food samples, total PBDEs varied from 7.9 pg/g, or parts per trillion (ppt), in milk to 3,726 pg/g in canned sardines. Fish were found to be highest in PBDEs with mean 1120 pg/g, median 616 pg/g and range from 11.14 to 3726 pg/g. This was followed by meat with mean 383 pg/g, median 190 pg/g and range from 39 to 1426 pg/g; and dairy products with mean 116 pg/g, median 32.2 pg/g and range from 7.9 to 683 pg/g. However, using estimates for food consumption, meat accounted for the highest U.S. dietary PBDE intake, followed by dairy and fish with almost equal contributions, except for nursing infants. Women had lower dietary intake of PBDEs than did men on a body weight basis. PBDE intake from food was estimated at 307 ng/kg-day for nursing infants, and varied from 2 ng/kg-day at age 2-5 for both males and females to 0.9 ng/kg-day in adult women.

Conclusion:

Dietary exposure alone does not appear to account for the very high body burdens measured. It is suggested that the indoor environment (dust, air) may play an important role in PBDE body burdens in addition to food.

Introduction

Polybrominated diphenyl ethers (PBDEs) are persistent and bioaccumulative flame retardants which are of concern because they are ubiquitous in the U.S., are potentially toxic, and have been found at rapidly rising levels in humans during the past few decades (Birnbaum and Staskal 2004; Hites 2004; Schecter et al. 2005b; Sjödin et al. 2004; Webster et al. 2005). The high level of PBDE contamination in the U.S. population and food is cause for concern since these compounds are chemically similar to PCBs, and have been shown in laboratory animal studies to be toxic in a number of ways. These include cancer in high dose studies (NTP 1986), reproductive and developmental toxicity (Stoker et al. 2004), endocrine disruption (Hallgren and Darnerud 2002), and central nervous system effects (Eriksson et al. 2002; Viberg et al. 2003). PBDEs can be found in some textiles, electronics, (e.g. computers and television sets), plastics, and furniture such as sofas, chairs and mattresses. Unlike dioxins and PCBs, these chemicals are primarily indoor pollutants and are found at high levels in household vacuum dust and other home and workplace environmental samples (Schecter et al. 2005a; Stapleton et al. 2005).

Very high levels of PBDEs have recently been found in U.S. milk (Schecter et al. 2003, Schecter et. al 2005b), blood (Mazdai et al. 2003; Morland et al. 2005; Schecter et al. 2005b; Schecter et al. 2004; Sjödin et al. 2004), food (Schecter et al. 2004) and adipose tissue (Johnson-Restrepo et al. 2005; She et al. 2002). U.S. blood and milk concentrations were 10-20 fold higher than the levels found in Europe (Bocio et al. 2003; Meironyte et al. 1999; Norén and Meironyté 2000; Ohta et al. 2002). Whereas levels of dioxins, dibenzofurans and PCBs in human tissues are declining, PBDEs have been increasing substantially in blood levels in the U.S. during the past two to three decades (Schecter et al. 2005b; Sjödin et al. 2004).

The penta BDE and octa BDE commercial PBDE mixtures are no longer being produced or sold in the U.S., while deca BDE continues to be manufactured and sold in the U.S., as well as worldwide. Furthermore, because these compounds are persistent in the environment, reservoir sources are likely to be present for substantial periods of time. These reservoir sources may continue to contaminate food and dust, both of which are believed to contribute substantially to human intake of these compounds (Birnbaum and Staskal 2004; Jones-Otazo et al. 2005; Webster et al. 2005).

Even though studies have begun to estimate PBDE intake from ingestion and inhalation, the amount and percent of intake from food in the U.S. general population has not been well characterized nor have the amounts of intake from dust ingestion and inhalation been well defined (Jones-Otazo et al. 2005; Stapleton et al. 2005; Webster et al. 2005). The present study expands and complements our previous U.S. market basket survey and also estimates dietary PBDE exposure by age and gender from birth through age 60 plus years. The food sample size is approximately twice the size of the earlier study and includes previously unpublished congener data from that study (Schecter et al. 2004). For the first time, this paper characterizes the U.S. population’s PBDE intake from food.

Methods

Food samples were purchased during 2003 and 2004 in Dallas, Texas, from three large supermarkets representing national chains. Commonly eaten food types were chosen and national or store brands purchased whenever possible. Items were frozen and shipped on dry ice to Eurofin-ERGO Laboratory for analysis. The laboratory measured 13 PBDE congeners (BDE-17, BDE-28, BDE-47, BDE-66, BDE-77, BDE-85, BDE-99, BDE-100, BDE-138, BDE-153, BDE-154, BDE-183, and BDE-209) in 62 food samples by gas chromatography - isotope dilution high resolution mass spectrometry. For quality control purposes, one laboratory blank and a quality control pool for each block of samples were run. Quantification was done only if the sample level was at least twice the blank level. For the analysis of major food types like fish, meat, cooked egg, cheese, ice-cream and sausage samples, a total of 5 – 200 g tissue was homogenized and mixed with sodium sulfate. Before column extraction a mixture of internal 13-C labeled standards was added to the sample. With column extraction of lipids, a mixture of cyclohexane and dichloromethane was applied. After solvent evaporation gravimetric lipid determination was performed. The quality control pools used were fish oil and human milk. Details of the analytical procedure have been described elsewhere (Päpke et al. 2004; Schecter et al. 2004). In this paper, we used half detection limit to estimate levels of congeners below the detection limit whereas previously we calculated them as equal to zero (Schecter et al. 2004).

The mean PBDE concentrations in our food samples, in combination with others' food consumption estimates, were used to estimate PBDE intake for several age and gender groups in the U.S. population. Nursing was assumed to be the only source of food for nursing infants and calculation of their intake was based on the assumption that the daily consumption of human milk is 800 grams (Dewey et al. 1999; Kent et al. 1999; Neville et al. 1988); milk PBDE levels were primarily levels previously reported (Schecter et al. 2005b; Schecter et al. 2003; Schecter et al. 2005b), (Schecter, AJ, unpublished data). To calculate PBDE intake relative to body weight, an average weight of 7 kg was estimated for nursing infants (CDC 2000). For other population groups, the median amount consumed each day for each of several categories of food was obtained from the USDA dietary intake survey (USDA 1999a and USDA 1999b) and from Smiciklas-Wright et al. (2003). These intake estimates were multiplied by the mean PBDE concentration of our sample foods in each category to obtain a PBDE intake estimate for a "typical" man or woman (one whose food intake is at the 50th percentile) for each age group.

Results

Tables 1 through 4 show the PBDE levels in pg/g (ppt) in U.S. food products reported on a whole weight basis. Of the 18 meat samples analyzed (Table 1), total PBDE levels varied from 39 ppt wet weight in a bacon sample to 1,426 ppt in one pork sausage sample. Considerable variation in levels can be noted, even between samples of the same type of meat such as bacon, ground pork, and pork sausage. BDE-209 (Deca BDE), the major remaining congener in commercial production, was detected in 8 of the 18 meat samples and, when detected, ranged from 9.7 in one ground beef sample to 245 ppt in ground turkey. Compared to meat products in Spain (10 – 172 ppt) and Japan (6.25 – 63.6 ppt) the level of PBDE contamination was higher in the U.S. (Bocio et al. 2003; Ohta et al. 2002). Of the 24 fish samples analyzed (Table 2), total PBDE concentration ranged from 11 to 3,726 ppt. These values though slightly higher, are comparable with fish in Spain that had PBDE concentration of 88 – 1019 ppt and that in Japan with 17.7 – 1720 ppt (Bocio et al. 2003; Ohta et al. 2002). As with meat, considerable variation was found between samples of the same type of fish. Farm grown salmon and other fish tend to have higher PBDE concentrations than wild fish. Unfortunately, it is not always clear from the store label whether salmon or other fish were farm grown since mislabeling appears to be common (Burros 2005). BDE-209 was found in 10 of the 24 fish samples, ranging from 4.9 in a canned tuna sample to 1,269 ppt in a catfish sample. Of 15 dairy products analyzed (Table 3), the total PBDE concentration varied from 7.9 ppt in both cows' whole and nonfat milk, to 683 ppt in cream cheese. BDE-209 was measured in 7 of the 15 dairy samples and, in these 7 samples, varied from 9.1 in lowfat yogurt to 481 ppt in cream cheese. Again, this was considerably higher than Spain (6 – 34 ppt) (Bocio et al. 2003). Of the 5 types of miscellaneous food products analyzed (Table 4), eggs was lowest at 85 and calf liver highest at 2,835 ppt total PBDEs. BDE-209 was found in all of the miscellaneous samples except margarine and varied from 10.3 in eggs to 288 ppt in calf liver.

When PBDEs are expressed on a lipid basis, fish are still the highest, followed by meat and dairy products. Table 5 presents the PBDE levels for the various food types analyzed indicating the minimum, mean, median, and maximum levels, on a lipid basis as well as on a wet weight basis. While these lipid normalized values reflect animal or fish body burdens of PBDE, they do not provide data useful in calculating dietary intake.

Table 6 and Figure 1 present estimates of dietary intake of PBDEs subdivided by food types for the U.S. population. In all age groups greater than one year, total PBDE intake from meat is significantly higher than from any other food. As shown in Table 6, the highest dietary intake values are in nursing infants (307 ng/kg body weight) of PBDEs per day, which compares to 1.0 or 0.9 ng/kg/day at ages 60 plus for men and women, respectively; much higher than Swedish values of 0.63 and 0.58 ng/kg,day respectively (Lind et al, 2002).

Discussion

This larger U.S. market basket survey confirms that PBDE contamination levels in U.S. food are currently higher than previously published studies in other countries (Bocio et al. 2003; Huwe et al. 2005; Ohta et al. 2002). Fish are highest in PBDE contamination on a whole weight basis, followed by dairy and meat. Meat is the major source of PBDEs in the U.S. diet after nursing ends, followed by dairy and fish, unlike some other countries where fish intake predominates (Bocio et al, 2003; Darnerud et al. 2001; Ohta et al. 2002). Men, with larger daily intakes of food, have a larger dietary intake of PBDEs than do women.

As was found by other publications reporting PBDE values in food, a large variation exists in levels even for the same type of food (Huwe and Larsen, 2005). Even though this study is the largest U.S. PBDE food survey, these new data cannot claim to be a representative sampling of the U.S. diet. Like other published surveys from other countries, the sample size needs to be increased and the samples need to be representative of the diet(s) of the country. Until this is done, uncertainty in estimates of food levels will exist and as a result, intake estimates will be somewhat imprecise.

The comparatively higher food levels cannot however be the only explanation for the 10-20 fold higher levels in blood and milk from the U.S. general population compared to European and Canadian levels (Bocio et al. 2003; Mazdai et al. 2003; Meironyte et al. 1999; Morland et al, 2005; Norén and Meironyté 2000; Ohta et al. 2002). Our total daily PBDE intake from dietary sources for adults is only 0.9 - 1.2 ng/kg body weight which compares to Spain's 1.2 – 1.4 ng/kg/day (Bocio et al 2003) and ~ 1.5ng/kg/day for U.K assuming average adult weight of 70 kgs (Harrad et al, 2004), but higher than Sweden's 0.58 – 0.63 ng/kg/day (Lind et al, 2002). Although there is a great deal of uncertainty on half lives, assuming a maximum half-life of two years (Geyer et al. 2004; Thuresson et al. 2006) and an American body composition of approximately 25% adipose tissue, PBDE intake from food would lead to a steady-state body burden of less than 10 ppb lipid. Given that the median lipid adjusted levels in the U.S. from recent blood, milk, and adipose specimens exceed 30 ppb lipid, and the top 5% of the population is 10-100 times greater, it appears unlikely that diet is the sole or even major source of exposure to PBDEs. This is in direct contrast to the situation with PCBs and dioxins in which more than 95% of the exposure of the general population comes from food (US EPA 2004).

This suggests that other routes of intake might be more significant for PBDEs than is the case for dioxins and PCBs.

The trends in dietary intake of PBDEs show a decreased intake per kg body weight with age, with the highest dietary intake in pg/kg body weight during nursing in the first year of life, 307 ng/kg of body weight. This is due to the high level of PBDEs in human milk; (median 1,056 pg/g on a wet weight basis), assuming that human milk was the only food consumed. Children aged 2 – 5 years have higher PBDE dietary intake per kg body weight than do older persons because of higher food intake per kg body weight.

Congeners 47, 99, 100, 153 and 154, and in some cases 209, are major contributors in both food concentration and dietary intake estimates. This reflects the previously reported findings on the congener distribution in human blood (Schecter et al. 2005b).

Similar to dioxins and PCBs, human breast milk is a major source of daily exposure for infants to PBDEs. Based on lactational exposure to dioxins, the body burden of the infant does not exceed 3-5 times that of the mother despite the 50-100 times greater daily intake (Abraham et al. 1996; Lorber and Phillips 2002). A similar situation may exist for PBDE exposure of nursing infants in which case, human milk can be a significant route of exposure for babies. We join Wu et al. (2005) in suggesting that routes of exposure such as house dust ingestion and inhalation are also likely important pathways of PBDE intake in addition to food for children as well as adults

Extrapolating from rodent studies, MacDonald (2005) hypothesizes that health risks are possible for more highly exposed persons in the U.S. general population. Although the health effects of the levels reported here are not clear, it seems reasonable from a public health standpoint to reduce the levels of these chemicals in the environment.

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Table 1: PBDE levels in U.S. meat products. (N = 18 individual meat products analyzed). pg/g (ppt) wet wt.

		PBDE congener													
	lipid %	17	28	47	66	77	85	99	100	138	153	154	183	209	PBDE Total[a]
Bacon A	52.3	n.d.(5.2)	n.d.(7.1)	n.d.(78.8)	n.d.(5.2)	n.d.(5.2)	n.d.(5.2)	n.d.(28.8)	n.d.(6.8)	n.d.(5.2)	n.d.(5.2)	n.d.(5.2)	n.d.(5.2)	n.d.(166.6)	165
Bacon B	43.4	n.d.(0.4)	n.d.(2.1)	n.d.(19.9)	n.d.(0.4)	n.d.(0.2)	n.a.	n.d.(15.6)	n.d.(2.8)	n.d.(0.4)	n.d.(1.1)	n.d.(0.9)	n.d.(1.7)	n.d.(32.8)	39[b]
Bacon C	35.3	0.7	n.d.(2.0)	30.1	n.a.	n.a.	1.4	16.8	4.8	n.d.(0.7)	4.5	2.8	14.3	28.4	105[b]
Beef (ground) A	30.7	n.d.(3.1)	59.7	87.5	n.d.(3.1)	n.d.(3.1)	n.d.(3.1)	35.5	6.2	n.d.(3.1)	6.8	4.6	n.d.(4.2)	n.d.(95.7)	258
Beef (ground) B	13.6	0.2	n.d.(0.7)	23.4	0.5	n.a.	n.a.	32.3	4.5	0.4	4.7	2.5	n.a.	9.7	79[b]
Beef tenderloin	13.7	n.d.(1.4)	n.d.(1.5)	35.1	n.d.(1.4)	n.a.	1.7	40.3	6.9	n.d.(1.4)	4.9	3.7	3.8	n.d.(11.1)	105
Chicken breast	4.9	n.d.(0.04)	0.5	60.5	n.a.	n.a.	n.a.	128	17.1	2.2	12.0	10.8	3.2	48.5	283[b]
Duck	75.1	n.d.(0.5)	n.d.(3.0)	286	2.7	n.d.(0.3)	15.2	609	122	7.3	52.3	42.9	31.6	113	1283[b]
Ground chicken	7.3	n.d.(0.7)	n.d.(1.5)	11.0	n.d.(0.7)	n.a.	n.d.(0.7)	18.9	4.6	n.d.(0.7)	4.1	2.6	5.8	80	129
Ground lamb	19.7	n.d.(2.0)	n.d.(2.1)	n.d.(23.0)	n.d.(2.0)	n.d.(2.0)	3.2	56.8	16.8	n.d.(2.0)	9.6	6.3	n.d.(2.0)	n.d.(150.6)	186
Ground pork	21.5	n.d.(2.2)	n.d.(3.5)	53.8	n.d.(2.2)	n.a.	3.1	74.2	12.9	4.3	18.7	15.0	19.9	n.d.(31.3)	221
Ground turkey	11.1	0.2	n.d.(0.5)	98	0.8	n.d.(0.1)	n.a.	217	54.4	3.9	32.9	24.1	36.8	245	713[b]
Pork	8.9	0.1	n.d.(0.5)	6.9	n.a.	n.a.	n.a.	16.3	1.8	0.2	1.0	1.2	1.3	11.7	41[b]
Pork sausage A	23.7	n.d.(1.3)	n.d.(6.9)	387	n.d.(1.0)	n.d.(0.3)	16.8	688	74.5	5.6	81.6	55.3	14.6	49.7	1378[b]
Pork sausage B	24.4	n.d.(2.4)	n.d.(3.4)	39.4	n.d.(2.4)	n.d.(2.4)	2.6	71.6	8.3	n.d.(2.4)	22.0	13.7	10.7	n.d.(139)	244
Sausage A	26.2	n.d.(2.6)	n.d.(5.5)	n.d.(34.8)	n.d.(2.6)	n.a.	3.1	40.1	6.4	n.d.(2.6)	5.9	4.9	6.9	n.d.(51.0)	1426
Sausage B	28.5	n.d.(2.9)	n.d.(3.2)	94.1	n.d.(3.5)	n.d.(2.9)	n.d.(2.9)	43.7	8.3	n.d.(2.9)	8.5	9.2	n.d.(2.9)	n.d.(41.7)	195
Wieners	32.9	n.d.(0.3)	n.d.(1.5)	386	1.4	n.d.(0.2)	11.1	703	53.9	7.2	106	49.8	14.3	n.d.(28.7)	1348[b]
Mean	26.3	0.76	4.59	93.2	1.19	0.83	4.93	157	22.7	2.33	21.1	14	10.1	53.3	383
Median	24.1	0.66	1.03	39.4	1.08	0.57	2.62	42	7.57	1.37	7.68	5.63	5.83	38.1	190
Min	4.87	0.02	0.24	6.93	0.21	0.06	0.36	7.79	1.39	0.16	0.53	0.44	0.86	5.53	39
Max	75.1	2.62	59.7	387	2.74	2.62	16.8	703	121	7.28	106	55.3	36.8	245	1426

n.d = not detected. The numbers in parentheses are the detection limits. Total PBDE levels and statistics for each congener were calculated by assuming that non-detected concentrations were one-half the detection limit.

n.a = data not available. For calculation purposes these were treated as zero

[a] Totals rounded to the nearest whole number for hundreds and 1 decimal place for tens

[b] Previously published data (Schecter et al. 2004)

Table 2: PBDE levels of U.S. fish. (N = 24 individual fish products analyzed). pg/g (ppt) wet wt.

		PBDE congener													
	lipid %	17	28	47	66	77	85	99	100	138	153	154	183	209	PBDE Total[a]
Canned tuna A	0.3	0.1	0.6	5.1	0.2	n.a.	0.2	3.2	0.6	n.d.(0.0)	0.3	0.2	1.1	4.9	16.6
Canned tuna B	0.5	n.d.(0.1)	0.2	2.1	0.2	n.a.	n.d.(0.1)	1.1	0.4	n.d.(0.1)	0.2	0.3	2.1	8.8	15.5
Catfish A	11.1	4.6	6.4	372	4.3	n.a.	n.a.	589	116	5.1	37.1	39.6	7.3	1269	2450[b]
Catfish B	5..3	4.6	5.1	438	13.5	n.d.(0.1)	41.6	834	102	7.9	49.9	45.8	4.9	n.d.(15.9)	1547[b]
Catfish C	5.2	2.2	3.7	137	0.7	n.d.(0.5)	11.7	184	39.5	n.d.(2.7)	15.8	15.2	n.d.(1.6)	n.d.(49.4)	437
Catfish Fillet (Farm)	5.7	1.1	3.7	197	6.3	n.a.	16.4	282	53.0	n.d.(4.1)	18.4	21.3	3.8	22.7	627
Halibut	0.2	0.6	4.1	76.6	2.8	n.a.	n.d.(0.1)	10.6	12.4	n.d.(0.1)	1.1	2.6	1.8	11.4	124
Herring	9.1	4.1	56.3	2072	69.4	3.6	n.d.(0.9)	267	221	n.d.(0.9)	29.3	69.9	2.5	n.d.(26.4)	2809
Mahi mahi	0.5	0.6	n.d.(2.0)	24.1	2.0	n.a.	0.6	13.0	5.1	n.d.(0.8)	1.4	4.9	4.3	n.d.(16.6)	66
Salmon A	8.0	79.2	92.6	1222	30.6	n.d.(0.2)	n.a.	93.2	348	n.d.(0.2)	27.7	98.8	1.4	n.d.(9.0)	1999[b]
Salmon B	13.9	118	142	2081	59.1	n.d.(0.1)	n.a.	147	353	n.d.(0.2)	36.6	142	n.d.(1.2)	n.d.(7.0)	3082[b]
Salmon C	10.3	18.4	49.4	1103	35.3	n.d.(0.1)	n.d.(0.1)	239	217	n.d.(0.1)	18.3	45.1	n.d.(1.3)	n.d.(11.2)	1732[b]
Salmon D	6.3	1.4	5.2	94.7	5.2	n.d.(0.9)	n.d.(0.6)	15.4	7.1	n.d.(0.6)	1.4	5.0	n.d.(0.8)	n.d.(9.1)	141
Salmon E	12.3	1.7	20.4	356	n.d.(2.1)	n.d.(1.2)	n.d.(1.2)	84.4	84.2	n.d.(1.2)	10.1	29.8	n.d.(1.4)	n.d.(29.2)	605
Salmon Fillet (Farm)	7.4	11.1	50.5	1000	63.1	n.a.	7.9	410	210	n.d.(1.4)	37.4	104	3.7	20.5	1919
Salmon Fillet (Farm)	6.9	2.3	27.9	517	24.3	n.a.	n.d.(0.7)	168	115	n.d.(0.7)	16.0	35.8	1.7	681	1590
Sardines	9.6	3.3	53.6	2748	85.6	n.d.(5.0)	n.d.(1.0)	358	257	n.d.(1.0)	51.9	139	n.d.(3.2)	n.d.(51.4)	3726
Shark	0.4	1.1	29.8	784	29.5	0.3	n.a.	57.8	608	0.4	112	291	2.0	5.4	1920[b]
Shrimp	0.6	0.3	3.6	75.6	n.a.	n.a.	n.a.	9.4	14.3	n.d.(0.1)	1.2	2.6	0.2	n.d.(1.3)	108[b]
Tilapia	1.0	n.d.(0.1)	n.d.(0.7)	5.9	n.a.	n.a.	0.1	1.3	0.6	n.d.(0.1)	0.2	0.5	n.d.(0.2)	n.d.(4.0)	11[b]
Trout A	4.2	4.8	22.2	320	n.a.	n.a.	n.d.(0.2)	79.8	66.5	0.2	11.8	26.3	4.4	n.d.(26.7)	549[b]
Trout B	10.1	4.3	49.3	826	n.d.(5.6)	n.d.(1.0)	n.d.(1.0)	128	198	n.d.(1.0)	24.7	61.3	2.5	n.d.(42.9)	1319
Tuna	0.2	n.d.(0.1)	n.d.(1.0)	16.6	0.7	n.a.	n.d.(0.0)	n.d.(4.6)	2.9	n.d.(0.1)	n.d.(0.4)	n.d.(1.0)	0.5	23.4	48
Wild perch	1.2	n.d.(0.1)	0.7	10.2	0.4	n.a.	n.d.(0.1)	2.3	2.1	n.d.(0.1)	0.7	2.4	0.6	5.9	25
Mean	5.43	11.01	26.19	603	20.8	0.78	4.29	166	126	0.89	21	49.3	2.08	91.8	1120
Median	5.52	1.97	5.77	338	5.23	0.30	0.35	88.8	75.3	0.33	15.9	28.	1.68	10.1	616
Min	0.15	0.03	0.20	2.11	0.18	0.06	0.02	1.15	0.43	0.02	0.21	0.21	0.12	0.63	11.14
Max	13.9	118	142	2748	85.6	3.60	41.6	834	608	7.94	112	291	7.32	1269	3726

n.d = not detected. The numbers in parentheses are the detection limits. Total PBDE levels and statistics for each congener were calculated by assuming that non-detected concentrations were one-half the detection limit.

n.a = data not available. For calculation purposes these were treated as zero

[a] Totals rounded to the nearest whole number for hundreds and 1 decimal place for tens

[b] Previously published data (Schecter et al. 2004)

Table 3: PBDE levels of U.S. dairy products. (N = 15 individual dairy products analyzed). pg/g (ppt) wet wt.

	lipid %	PBDE congener 17	28	47	66	77	85	99	100	138	153	154	183	209	PBDE Total[a]
American cheese A	19.0	n.d.(1.9)	n.d.(1.9)	45.5	n.d.(1.9)	n.a.	n.d.(1.9)	34.9	5.91	n.d.(1.9)	3.67	2.67	2.09	14.6	114
American cheese B	11.6	n.d.(1.2)	n.d.(1.9)	28.2	0.80	n.a.	n.d.(1.2)	23.1	4.14	n.d.(1.2)	2.37	1.67	n.d.(1.2)	17.5	81.1
Gouda cheese	26.2	n.d.(2.6)	n.d.(3.0)	75.6	n.d.(2.6)	n.a.	5.52	57.4	12.2	n.d.(2.6)	8.27	4.76	1.6	n.d.(22.7)	182
Cottage cheese A	4.7	n.d.(0.5)	n.d.(1.5)	13.6	n.d.(0.5)	n.a.	n.d.(0.5)	14	2.63	n.d.(0.5)	1.39	1.01	n.d.(0.9)	n.d.(13.5)	41.5
Cottage cheese B	1.7	n.d.(0.2)	n.d.(1.3)	n.d.(6.9)	n.d.(0.2)	n.d.(0.2)	n.d.(0.2)	2.24	n.d.(0.4)	n.d.(0.2)	0.39	0.27	n.d.(0.3)	n.d.(4.2)	9.8
Cream cheese	39.2	0.4	n.d.(1.8)	97.8	1.57	n.d.(0.2)	n.a.	77.1	12.2	n.a.	5.96	2.84	n.d.(5.6)	481.4	683[b]
Milk (Cow's)	3.2	n.d.(0.3)	n.d.(0.3)	n.d.(5.6)	n.d.(0.5)	n.d.(0.3)	n.d.(0.3)	1.58	0.23	n.d.(0.32)	n.d.(0.3)	0.22	n.d.(0.3)	n.d.(3.5)	7.9
Evaporated milk A	6.6	n.d.(0.1)	n.d.(0.9)	15.8	n.a.	n.a.	n.a.	8.47	1.89	n.d.(0.2)	1.35	0.44	0.22	n.d.(1.9)	29.7[b]
Evaporated milk B	6.3	n.d.(0.1)	n.d.(0.9)	11.9	n.a.	n.a.	n.a.	12.6	2.27	0.20	1.91	0.80	n.d.(0.1)	n.d.(1.9)	31.1[b]
Goat milk	6.7	0.20	2.56	105	1.82	n.d.(0.07)	n.a.	97.9	27.3	n.a.	29	8.27	12.22	5.67	290[b]
Non fat milk	0	n.d.(0.0)	n.d.(0.6)	n.d.(3.8)	n.d.(0.1)	n.a.	n.d.(0.1)	n.d.(2.5)	n.d.(0.8)	n.d.(0.1)	n.d.(0.1)	n.d.(0.2)	n.d.(0.1)	n.d.(7.5)	7.9[b]
Infant milk formula A	3.4	n.d.(0.0)	n.d.(0.5)	n.d.(3.1)	n.d.(0.1)	n.a.	n.a.	12.3	1.10	0.27	1.41	1.08	0.20	14	32.2[b]
Infant milk formula B	3.2	n.d.(0.1)	n.d.(1.2)	n.d.(7.7)	n.d.(0.1)	n.a.	n.a.	n.d.(5.1)	n.d.(1.5)	n.d.(0.3)	n.d.(0.5)	n.d.(0.3)	0.40	16.5	25.4
Lowfat yogurt	1.3	0.2	0.9	9.05	0.24	n.d.(0.02)	n.a.	7.78	1.39	0.05	0.97	0.40	1.44	9.08	31.6[b]
Ice cream	19.9	n.d.(0.2)	n.d.(0.8)	60.5	n.d.(1.0)	n.d.(0.4)	n.a.	63.7	9.45	n.d.(0.4)	6.91	3.41	5.47	n.d.(41.2)	171[b]
Mean	10.2	0.29	0.79	31.8	0.61	0.10	1.08	27.8	5.48	0.33	4.27	1.87	1.86	40.5	116
Median	6.3	0.16	0.63	13.6	0.24	0.10	0.24	12.6	2.27	0.20	1.41	1.01	0.45	9.08	32.2
Min	0.0	0.02	0.16	1.54	0.03	0.01	0.05	1.26	0.22	0.04	0.06	0.08	0.05	0.94	7.91
Max	39.2	1.31	2.56	105	1.82	0.20	5.52	97.9	27.3	1.31	29.0	8.27	12.2	481	683

n.d = not detected. The numbers in parentheses are the detection limits. Total PBDE levels and statistics for each congener were calculated by assuming that non-detected concentrations were one-half the detection limit.
n.a = data not available. For calculation purposes these were treated as zero
[a] Totals rounded to the nearest whole number for hundreds and 1 decimal place for tens
[b] Previously published data (Schecter et al. 2004)

Table 4: PBDE levels of U.S. miscellaneous food products. (N = 5 individual product types analyzed). pg/g (ppt) wet wt.

		PBDE congener													
	lipid %	17	28	47	66	77	85	99	100	138	153	154	183	209	PBDE Total[a]
6 chicken eggs	11.5	0.14	0.20	22.5	0.24	0.03	1.52	36.6	5.93	0.58	3.63	2.56	0.68	10.32	85[b]
Butter	78.3	0.4	1.3	165	1.2	n.a.	n.a.	172	40.4	4.5	16.8	12.6	5.3	66.2	485[b]
Calf liver	6.4	0.1	0.4	9.0	n.a.	n.d 0.6	0.5	10.5	1.6	n.d 0.2	2.9	1.8	6.2	81.6	115[b]
Chicken liver	6.4	0.3	1.1	687	5.3	n.a.	27.2	1258	261	17.9	148	130	11.5	288	2835[b]
Margarine	83.3	n.d(0.7)	n.d (2)	n.d (12)	n.d (2.3)	n.d (1)	n.d (1.1)	n.d (7.2)	n.d (2)	n.d (1.4)	0.9	n.d (0.9)	n.d (2.6)	n.d (142)	88[b]

n.d = not detected. The numbers in parentheses are the detection limits. Total PBDE levels and statistics for each congener were calculated by assuming that non-detected concentrations were one-half the detection limit.

n.a = data not available. For calculation purposes these were treated as zero

[a] Totals rounded to the nearest whole number for hundreds and 1 decimal place for tens

[b] Previously published data (Schecter et al. 2004)

Table 5: Range of PBDE levels of the survey items. pg/g (ppt) wet wt.

		Lipid Based Concentration				Wet/Whole weight concentration			
	n	Min	Mean	Median	Max	Min	Mean	Median	Max
Human milk [a]	62	6,000	66,000	32,000	419,000	31	1,916	968	21,359
Meat									
Poultry	4	1,708	3,919	3,771	6,423	129	602	498	1283
Beef	3	581	729	766	840	79	147	105	258
Pork	2	461	744	744	1,028	41	131	131	221
Bacon	3	90	234	298	316	39	103	105	165
Processed meat	5	684	3,408	4,097	5,814	195	918	1348	1426
Dairy									
Ice cream	2	859	1,645	1,645	2,431	31.6	101.3	101.3	171
Milk	2	-	-	-	-	7.9	7.9	7.9	7.9
Cheese	6	577	866	697	883	9.8	185	97.6	683
Eggs	1	-	739	739	-	-	85	85	-
Fat									
Margarine	1	-	106	106	-	-	88	88	-
Butter	1	-	619	619	-	-	485	485	
Fish	24	1,100	37,319	17,408	480,000	11	1,119	616	3,726

[a] Schecter et al, 2005b, and Schecter A, unpublished data

Table 6: Daily PBDE dietary intake from food sources (pg/kg or parts per quadrillion body weight)

		Infant (0-1) Males and Females	2-5 Males and Females	6-11 Males and Females	12-19 Males	12-19 Females	20-39 Males	20-39 Females	40-59 Males	40-59 Females	>=60 Males	>=60 Females
	Body weight (kg)	*5*	*16*	*29*	*55*	*49*	*70*	*60*	*70*	*60*	*70*	*60*
Dairy	Ice Cream and Ice Milk	0	63	59	33	35	25	17	27	20	30	22
	Milk	0	191	113	61	42	29	27	29	25	30	28
	Total Cheese	0	173	121	118	83	90	62	56	46	37	28
	TOTAL DAIRY		427	293	212	160	144	106	112	91	97	78
Meat	Poultry	0	790	477	449	344	413	331	396	331	275	291
	Beef	0	211	177	187	126	168	93	134	88	95	74
	Pork	0	52	36	37	23	34	22	34	22	32	22
	Bacon	0	6	4	4	2	3	2	3	3	4	3
	Processed meat	0	780	476	334	215	300	164	244	153	178	120
	TOTAL MEAT		1839	1170	1011	710	918	612	811	597	584	510
Fish	Total Fish	0	280	232	163	137	160	149	208	187	224	243
Eggs	Total Eggs	0	69	38	31	24	27	21	30	23	32	26
Fat	Margarine	0	6	6	3	4	3	3	4	4	5	4
	Butter	0	30	17	9	10	14	8	7	8	14	8
	TOTAL FAT PRODUCTS		36	23	12	14	17	11	11	12	19	12
	Human milk	306,560	0	0	0	0	0	0	0	0	0	0
Sum PBDE intake per body wt.	(pg/kg-day ww)	306,560	2,652	1,755	1,429	1,045	1,264	900	1,172	912	957	869

Figure 1: Daily PBDE dietary intake of U.S. population by age and food group (as shown in Table 5) (pg/kg body weight)

Figure 1: Daily PBDE dietary intake of U.S. population by age and food group (as shown in Table 5) (pg/kg body weight)