



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Polybrominated diphenyl ether (PBDE) flame retardants in selected foods – April 1, 2013, to March 31, 2021

Food chemistry – Targeted surveys – Final report



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Summary

Targeted surveys provide information on potential food hazards and enhance the Canadian Food Inspection Agency's (CFIA's) routine monitoring programs. These surveys provide evidence regarding the safety of the food supply, identify potential emerging hazards, and contribute new information and data to food categories where it may be limited or non-existent. They are often used by the agency to focus surveillance on potential areas of higher risk. Surveys can also help to identify trends and provide information about how industry complies with Canadian regulations.

Polybrominated diphenyl ethers (PBDEs) are a group of man-made chemicals that were used as flame retardants in a wide variety of consumer products. In 2006, all PBDEs were designated as persistent organic pollutants (POPs) by the Government of Canada⁷, and they are included in the international Stockholm Convention on Persistent Organic Pollutants¹⁰. Internationally, the use of PBDEs has been restricted or banned and they are no longer used in the manufacture of most consumer products, but they remain in older products, such as electronics, furniture, and plastics². PBDEs are still found in the environment all over the world because, like other POPs, they are not easily broken down in the environment, have the ability to travel long distances through air, water and sediments, and can accumulate in fatty tissues of plants and animals, resulting in bioaccumulation up the food chain, including in humans^{1,3}. The main sources of PBDE exposure to humans appears to be through food, human breast milk, and dust³. Results from monitoring programs have shown that levels of PBDEs in the environment^{3,4}, food, and breast milk^{4,13} have been decreasing since their use was restricted, and it is expected that levels will continue to decline.

The main objective of this targeted survey was to provide baseline surveillance data regarding PBDE levels in grain and grain-based products, dairy and dairy-based products, fats and oils, fish and seafood, canned meats and poultry, coconut products, egg products, nuts, seeds, and nut or seed products on the Canadian retail market. These products were expected to have detectable levels of PBDEs as they contain fat, where these chemicals can accumulate.

PBDEs were detected in 99% of samples tested, with total detected PBDE levels ranging from 0.252 parts per trillion (ppt) to 5679 ppt. The detection rates within the product types ranged from 97% to 100%. Comparison of the survey results to published scientific literature showed that the levels of PBDEs in the sampled Canadian retail products are similar to those reported in a variety of scientific studies.

There are no regulations in Canada for PBDE levels in food, but Health Canada has set a lowest adverse effect level (LOAEL) of 2.22 milligram per kilogram of body weight (mg/kg-bw) per day³. All levels of PBDEs found in the products tested in this survey were evaluated by Health Canada and were deemed safe for consumption by Canadians.

What targeted surveys are

Targeted surveys are used by the CFIA to focus its surveillance activities on areas of highest health risk. The information gained from these surveys provides support for the allocation and prioritization of the agency's activities to areas of greater concern. Originally started as a project under the Food Safety Action Plan (FSAP), targeted surveys have been embedded in our regular surveillance activities since 2013. Targeted surveys are a valuable tool for generating information on certain hazards in foods, identifying and characterizing new and emerging hazards, informing trend analysis, prompting and refining health risk assessments, highlighting potential contamination issues, as well as assessing and promoting compliance with Canadian regulations.

Food safety is a shared responsibility. We work with federal, provincial, territorial, and municipal governments and provide regulatory oversight of the food industry to promote safe handling of foods throughout the food production chain. The food industry and retail sectors in Canada are responsible for the food they produce and sell, while individual consumers are responsible for the safe handling of the food they have in their possession.

Why the survey was conducted

The main objective of this targeted survey was to provide baseline surveillance data regarding PBDE levels in grain and grain-based products, dairy and dairy-based products, fats and oils, fish and seafood, canned meats and poultry, coconut products, egg products, nuts, seeds and nut or seed products on the Canadian retail market.

PBDEs are a group of flame-retardant chemicals that have been used globally since the 1970s in the production of textiles, plastics, furniture, mattresses, electronics and electrical components of consumer products^{1,2,3,4}. These structurally related compounds contain between 1 and 10 bromine atoms in various conformations, called congeners, and are commonly identified by their assigned BDE number^{2,4}. Although there are 209 possible congeners, only some were used in fire retardant formulations^{2,4,5,6}. The congeners of concern that are the focus of this report are listed in [Table A-1](#) of the Appendix of this report.

These flame retardants were used, and are found in the environment, as mixtures^{2,3,4}. Canada has never manufactured these mixtures^{7,14}, but they were imported and used in products manufactured in Canada and are present in products imported from other countries. Historically there were 3 mixtures of PBDEs that were commercially produced: PentaBDE, OctaBDE and DecaBDE^{3,4,13}. Globally, the more toxic PentaBDE and OctaBDE mixtures were gradually phased out starting in the late 1990s^{4,5,7,10}. By 2005 their manufacture was discontinued^{1,4,5} and their use was banned in Canada^{7,8}. The DecaBDE mixture continued to be used internationally, until North America and Europe began phasing out its use around 2009^{4,5,9}, and China began phasing it out in 2017 and will prohibit its use entirely by 2025^{10,11}. All PBDEs were added to the Canadian Environmental Protection Act's List of Toxic Substances in 2006⁷, and they are

included in the Stockholm Convention on Persistent Organic Pollutants, which has prohibited almost all uses of these flame retardants in over 180 countries since 2017¹⁰.

Although PBDEs are no longer used in most manufacturing, they remain in older materials and manufactured products. PBDEs are not chemically bonded into the products in which they are used and can be released into the air, contaminating indoor air and dust^{1.3.6.13}. Contamination of surface water, air, sewage, landfills, and soil occurs during the manufacture of the previously mentioned products, as well as when these products and their components are damaged, degraded, recycled, incinerated, or disposed. Soil contamination also occurs when contaminated processed sewage sludge is used as fertilizer for food production^{1.2.3.4.7}. Like other POPs, PBDEs are omnipresent throughout the world because they are not easily broken down in the environment, have the ability to travel long distances through air, water and sediments, and can accumulate in fatty tissues of plants and animals, resulting in bioaccumulation up the food chain, including in humans^{1.3.4.5.6}.

Studies in laboratory rodents have shown that high levels of PBDE exposure can affect the liver, thyroid, endocrine, and reproductive systems, and that prenatal exposure can cause neurodevelopmental problems^{3.5.6.13}. Studies on the health effects of PBDE exposure in humans is limited and cannot provide conclusive evidence of disease or adverse effects^{6.13}. Based on toxicological health risk assessments, Health Canada has set a LOAEL of 2.22 mg/kg-bw per day³ for total PBDE exposure in humans.

Adult exposure to PBDEs occurs through the consumption of food and through inhalation and exposure to indoor dust^{3.4.6.13}. Babies and young children are primarily exposed via breast milk and the mouthing of hard plastic toys that contain PBDEs^{3.4.13}. Studies have found detectable levels of PBDEs in fish, meat, poultry, eggs, dairy products, fats and oils, and grain products^{2.3.4.7.10.13.14}. Additionally, detectable levels have been reported in baby food and infant formula¹² and also in human breast milk^{1.2.4.13}. However, levels of PBDEs in the environment^{3.4.6.10.11.15}, food, and breast milk^{4.13.14} have been decreasing since their use was restricted, and it is expected that levels will continue to decline.

What was sampled

The CFIA sampled and analyzed 2811 products between April 1, 2013 and March 31, 2021, including grain-based foods, dairy products, fats and oils, nuts/seeds and nut/seed butters, egg products, fish and seafood samples, coconut products and canned meat and poultry. Samples of products were collected from local/regional retail locations in 6 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

- Atlantic (Halifax)
- Quebec (Montreal)
- Ontario (Toronto and Ottawa)
- West (Vancouver and Calgary)

The number of samples collected from these cities was in proportion to the relative population of the respective areas. The shelf life, storage conditions, and the cost of the food on the open market were not considered in this survey. Samples originated in at least 46 countries.

Table 1. Distribution of samples based on product type and origin

Product type	Number of domestic samples	Number of imported samples	Number of samples of unspecified ^a origin	Total number of samples
Coconut products	5	37	9	51
Dairy products	304	182	155	641
Egg products	181	18	42	241
Fats and oils	111	319	123	553
Fish and seafood	17	72	5	94
Grain products	275	384	239	898
Meat and poultry	32	16	0	48
Nuts and seeds	96	50	139	285
Total	1021	1078	712	2811

Table notes:

^a Unspecified refers to those samples for which the country of origin could not be assigned from the product label or available sample information.

How samples were analyzed and assessed

Samples were analyzed by an ISO/IEC 17025 accredited food testing laboratory under contract with the Government of Canada. The samples were tested as sold, which means the product was tested as is and not prepared according to package instructions.

The list of compounds reported as part of this survey are shown in [Table A-1](#) in the Appendix of this report. The levels of the individual compounds that were detected were added together to arrive at a total PBDE level in each sample.

Currently, there are no Canadian Maximum Levels (MLs) for PBDEs in food. All results in this survey were assessed by Health Canada and were deemed safe for consumption by Canadians.

Results of the survey

Of the 2811 samples analyzed in this survey, 99% (2793 samples) contained detectable levels of PBDEs. The range of levels found is presented in Table 2. Among the 8 product types in the survey, the highest levels were found in fats and oils, and the lowest were found in coconut products. [Table A-2](#) in the Appendix shows the frequency of detection and levels of each individual PBDE congener found in this survey. The levels found in each sample category in each year that they were tested is presented in Appendix [Table A-3](#).

Table 2. Levels of PBDEs in selected foods

Product type	Total number of samples	Number of samples with detectable levels (%)	Minimum level ^b (ppt)	Maximum level (ppt)	Average level ^c (ppt)
Coconut products	51	51 (100)	1.08	349	45.6
Dairy products	641	638 (99.5)	0.380	1640	79.3
Egg products	241	234 (97)	0.252	1653	69.6
Fats and oils	553	552 (99.8)	4.38	5002	414
Fish and seafood	94	94 (100)	1.07	5679	169
Grain products	898	891 (99)	0.295	2083	60.8
Meat and poultry	48	48 (100)	2.16	235	53.1
Nuts and seeds	285	285 (100)	0.765	3726	143
Total	2811	2793 (99)	0.252	5679	147

Table notes:

^b Minimum positive (non-zero) result.

^c Only positive results were used to calculate averages.

Coconut products

The coconut products that were tested consisted of 23 samples of coconut pieces or shredded coconut, 18 coconut milk, 7 coconut flour, and 3 coconut cream/coconut butter samples. Coconut oils containing 100% fat are not included in this category, rather they are included in the fats and oils category. PBDEs were found in all 51 samples tested. The average levels found in coconut products was 45.6 ppt, with the highest average levels found in shredded coconut (59.6 ppt), and the lowest average levels were found in coconut milk (9.23 ppt). Coconut products contained the lowest overall average level of all the products in this survey.

Dairy products

Samples in this category consisted of dairy products that are ready-to-eat and do not require cooking prior to use. This category included pure dairy items such as cheese, cream, and milk, as well as dairy-based products such as sauces, dips, salad dressings, puddings, frozen dairy desserts (ice cream and frozen yogurt), cheesecake, coffee creamers, and baked goods that contain a dairy-based filling (cream pies and high dairy-content muffins, cakes, and pastries). PBDEs were detected in 638 of the 641 samples (99.5%) and the average level found was 79.3 ppt. The categories with the highest average levels of PBDEs were dairy salad dressings (131 ppt) and baked goods with dairy filling (130 ppt), and lowest levels were found in milk (10.4 ppt).

Egg products

This survey tested a total of 241 samples of egg products, including 126 liquid egg products, 48 cooked, pickled or preserved eggs, 39 powdered egg products (powdered albumin and egg protein powders) and 28 samples of eggnog. Note that mayonnaise products, despite containing eggs, are primarily oil-based, and so are not included in this category but are included in the fats and oils category. There were detected levels of PBDEs in 234 samples of egg products (97%), with the lowest average level of 41.5 ppt found in eggnog, and the highest level of 175 ppt found in cooked, pickled or preserved eggs.

Fats and oils

This category consisted of 553 fat and oil samples from vegetable and animal sources. The average total PBDEs detected in all fat and oil samples was 414 ppt, which is the highest average level found among the 8 food categories analysed in this survey.

Fats and oils – vegetable oils

A total of 457 vegetable-based oils and shortenings were tested, plus 48 samples of vegetable oil-based mayonnaise that also contained eggs. PBDEs were found in 99.8% of the vegetable-based fat and oil samples and in all the mayonnaise samples. The lowest level was found in the 1 avocado oil sample that was tested (45.5 ppt). The lowest average levels were found in sunflower oil (149 ppt) and palm oil (174 ppt). The highest average levels were found in grapeseed oil (1140 ppt), peanut oil (1389 ppt) and walnut oil (2504 ppt). Mayonnaise samples had an average level of 228 ppt. The overall average level in vegetable-based oils was 433 ppt.

Fats and oils – animal fats

Animal fats consisted of 40 dairy butter samples and 8 samples of lard (pork fat). All animal-based fat samples contained detectable levels of PBDEs, and the overall average was 211 ppt. The average level of PBDEs found in butter (226 ppt) was higher than that of lard (136 ppt), but both were lower than the overall average of all fats and oils combined (414 ppt).

Grain products

This survey sampled 898 grain-based products in 4 categories: wheat products (335 samples), corn products (202 samples), oat products (198 samples), and rice products (163 samples). PBDEs were detected in 891 samples, or 99% of grain products. The average level found in all grain products was 60.8 ppt, with oat products having the lowest average levels (35.8 ppt), and rice products having the highest levels (115 ppt). The 4 subcategories are discussed in more detail below, and [Table A-4](#) in the Appendix shows the results of each grain type by year tested.

Grain products - wheat

A total of 335 wheat-based products were sampled in this survey, and PBDEs were found in 331 (99%) of samples. These ranged from all-wheat products, such as wheat bran, wheat flour, wheat germ, and whole grain wheat, to more processed products such as pasta, couscous, crackers, and baked goods (for example cookies, frozen waffles, cakes, pastries, and pies). The average level of PBDEs found in all wheat products was 47.5 ppt, with the lowest average level found in pasta (10.4 ppt) and the highest average level found in whole-grain wheat (68.1 ppt).

Grain products - corn

The corn products that were sampled contained no grain ingredients other than corn. PBDEs were found in 201 of the 202 products surveyed, or 99.5% of samples. Samples tested included 80 cornmeal, 57 corn flour, 31 corn starch, 24 corn chips or snacks (such as toasted corn), and 10 popping corn samples. The average level found in this category was 63.1 ppt, with the highest average levels found in corn chips/snacks (254 ppt) and the lowest average levels were found in corn starch (12.9 ppt).

Grain products - oat

Oat products had the lowest average levels of PBDEs found among the grain categories, with an average level of total PBDEs of 35.8 ppt. Sample types included whole or cut oats (94 samples), oatmeal (60 samples), oat bran (30 samples), and oat flour (14 samples). These samples did not contain any grains other than oats, but some were flavored, such as flavored instant oatmeal. PBDEs were found in 197 of the 198 samples tested (99.5%). Oat flour had the highest average level (60.7 ppt) and whole grain or cut oats had the lowest average level (30.1 ppt).

Grain products - rice

In the rice category there were 7 rice bran samples, 59 rice flour samples, and 96 whole rice grain samples. PBDEs were found in 162 of the 163 samples analysed (99.4%). The whole rice samples included long grain, short grain, basmati, jasmine, white, brown, black, red, and wild rice varieties, and all of the rice product samples contained no other grains, and no flavorings or other additives. The average level found was 115 ppt, with small differences in average levels found between the rice flour (123 ppt), rice grain (109 ppt), and rice bran (135 ppt) categories.

Fish and seafood

Fish and seafood samples included 49 canned and 45 refrigerated or frozen products that were not breaded or smoked, for a total of 94 fish and seafood samples. The canned samples included clam, escargot, herring, mackerel, salmon, sardines, shrimp, sprats, and tuna. The frozen or refrigerated samples included basa, bass, cod, crab, haddock, herring, lobster, mussels, pollock, salmon, shrimp, sole, squid, tilapia, and trout. PBDEs were found in 100% of fish and seafood samples with an average level of 170 ppt. Higher average levels of PBDEs were found in fattier species such as sardines (445 ppt) and herring (1422 ppt) samples, with the highest level found in a bass sample (5679 ppt). Lower average levels were found in leaner species such as sole (5.91 ppt), cod (9.59 ppt) and shrimp (6.30 ppt).

Meat and poultry

In this survey, 48 samples of meat and poultry that is packaged in cans, jars or pouches was tested. This included canned meats such as ham, turkey, corned beef and luncheon meats, plus hot dogs, and sausages. PBDEs were found in all meat and poultry samples tested. The overall average level found was 53.1 ppt, with canned ham having the lowest levels (10.2 ppt) and a canned turkey sample having the highest level (114 ppt).

Nuts, seeds, and nut/seed butters

Nuts, seeds, nut butters, and seed butters were sampled, and PBDEs were found in all 285 samples tested, with an average level of 143 ppt. There were 160 nuts, 72 nut butters, 52 seeds/soybeans, and 1 sesame seed butter (tahini) sample. Nuts and nut butters contained a higher average level (155 ppt) than seeds and tahini (89.3 ppt), and nut butters had higher average levels (244 ppt) than nut samples (116 ppt). Among the types of nuts and seeds, chestnuts had the lowest average level at 2.97 ppt, and cashews/cashew butter had the highest average levels at 451 ppt.

What the survey results mean

The main objective of this targeted survey was to generate baseline data regarding the levels of PBDEs in selected foods on the Canadian retail market. Of the 2811 samples tested, 2793 (99%) tested positive for PBDEs. Tables 3 through 10 present the results for each product type in this survey along with data from published surveys in similar products, namely the German Total Diet Study¹⁶ (Germany 2024), the Australia New Zealand Total Diet Study¹⁷ (FSANZ 2004), the Canadian Cancer Society¹⁸ (Canada 2018), the Hong Kong Baptist University¹⁹ (China 2011), the University of Ibadan in Nigeria²⁰ (Nigeria 2018), and the National Cheng Kung University in Taiwan²¹ (Taiwan 2017). The results from the current survey are bolded in each table to facilitate comparison.

The results from this survey are similar to the results found in these published surveys, except for nuts and seeds, which are higher than the published surveys. This can likely be attributed to differences in the types of samples tested.

Table 3. Minimum, maximum, and average levels of PBDEs in coconut products from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^d (ppt)	Maximum level (ppt)	Average level ^e (ppt)
CFIA (2013 to 2021)	Coconut products	51	1.08	349	45.6
FSANZ (2004)	Dried coconut	1	244	244	244
China (2011)	Coconut milk	3	10.4	32.8	16.3

Table notes:

^d Minimum positive (non-zero) result.

^e Only positive results were used to calculate averages.

Table 4. Minimum, maximum, and average levels of PBDEs in dairy products from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^f (ppt)	Maximum level (ppt)	Average level ^g (ppt)
CFIA (2013 to 2021)	Milk and dairy products	641	0.38	1640	79.3
Germany (2024)	Milk and dairy products	23	2.12	41.2	13.2
Canada (2018)	Milk and dairy products	82	4.10	37.3	20.7
Nigeria (2018)	Cheese, evaporated milk	12	4.01	11.4	7.24
Taiwan (2017)	Milk	58	14.8	3020	261
FSANZ (2004)	Milk and dairy products	9	83.6	469	121

Table notes:

^f Minimum positive (non-zero) result.

^g Only positive results were used to calculate averages.

Table 5. Minimum, maximum, and average levels of PBDEs in egg products from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^h (ppt)	Maximum level (ppt)	Average level ⁱ (ppt)
CFIA (2013 to 2021)	Egg products, eggnog	241	0.252	1653	69.6
Germany (2024)	Eggs and egg products	2	13.2	23.4	18
Canada (2018)	Whole eggs and egg yolks	33	110	714	414
Nigeria (2018)	Chicken eggs	18	1.51	13.7	5.22
Taiwan (2017)	Chicken and duck eggs	46	174	4345	960
FSANZ (2004)	Hard-boiled eggs	1	910	910	910

Table notes:

^h Minimum positive (non-zero) result.

ⁱ Only positive results were used to calculate averages.

Table 5. Minimum, maximum, and average levels of PBDEs in fats and oils from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^j (ppt)	Maximum level (ppt)	Average level ^k (ppt)
CFIA (2013 to 2021)	Vegetable oils, lard, butter	553	4.38	5002	414
Germany (2024)	Animal fats, vegetable oils	8	3.88	61.4	21.0
Canada (2018)	Animal fat, butter, vegetable oils	104	1.48	2062	123
Nigeria (2018)	Vegetable oils	40	2.92	30.5	16.7
Taiwan (2017)	Vegetable oils and animal fats	36	249	8868	1418
China (2011)	Vegetable, seed, and fish oils	10	<LOD ^l	287	40.8
FSANZ (2004)	Butter, canola oil, margarine	3	164	189	118

Table notes:

^j Minimum positive (non-zero) result.

^k Only positive results were used to calculate averages.

^l <LOD = less than the limit of detection.

Table 1. Minimum, maximum, and average levels of PBDEs in fish and seafood from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^m (ppt)	Maximum level (ppt)	Average level ⁿ (ppt)
CFIA (2013 to 2021)	Fish and seafood	94	1.07	5679	169
Germany (2024)	Fish, seafood, invertebrates	30	4.22	11122	782
Canada (2018)	Fish and shellfish	467	12.5	2496	555
Nigeria (2018)	Fish and crayfish	64	8.76	223	86.2
Taiwan (2017)	Fish and seafood	150	49.1	5877	657
FSANZ (2004)	Fish fillets and canned tuna	2	24.5	173	98.6

Table notes:

^m Minimum positive (non-zero) result.

ⁿ Only positive results were used to calculate averages.

Table 2. Minimum, maximum, and average levels of PBDEs in grain products from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^o (ppt)	Maximum level (ppt)	Average level ^p (ppt)
CFIA (2013 to 2021)	Grain-based pasta and crackers	898	0.295	2083	60.8
Germany (2024)	Grain and grain-based products	38	2.12	65.2	8.34
Canada (2018)	Cereal, grains, pasta, rice, baked goods	27	1.20	463	155
Nigeria (2018)	Rice	18	NR ^q	NR ^q	2.11
Taiwan (2017)	Rice and non-wheat grains	18	34.1	1433	297
FSANZ (2004)	White wheat bread	1	194	194	194

Table notes:

^o Minimum positive (non-zero) result.

^p Only positive results were used to calculate averages.

^q NR: Not reported

Table 3. Minimum, maximum, and average levels of PBDEs in meat and poultry from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^r (ppt)	Maximum level (ppt)	Average level ^s (ppt)
CFIA (2013 to 2021)	Canned meat and poultry	48	2.16	235	53.1
Germany (2024)	Meat, liver, edible offal	35	3.47	184	37.5
Canada (2018)	Chicken breast, chicken skin, goose liver	10	102	830	253
Nigeria (2018)	Beef and chicken	46	9.29	34.5	16.2
Taiwan (2017)	Beef, pork, mutton, poultry	162	66.4	10799	805
China (2011)	Beef, pork, lamb, caribou, deer, moose, poultry, liver, and processed meats	113	20.1	2821	152
FSANZ (2004)	Beef, pork, lamb, chicken, bacon, sausage, and liver	10	190	688	402

Table notes:

^r Minimum positive (non-zero) result.

^s Only positive results were used to calculate averages.

Table 4. Minimum, maximum, and average levels of PBDEs in nuts and seeds from CFIA surveys and scientific literature

Survey (year)	Sample types	Number of samples	Minimum level ^t (ppt)	Maximum level (ppt)	Average level ^u (ppt)
CFIA (2013 to 2021)	Nuts, seeds, nut butters, soybeans, and tahini	285	0.765	3726	143
Germany (2024)	Legumes, nuts, oilseeds, and spices	20	2.31	17.9	6.61
Canada (2018)	Nuts, seeds, peanut butter, and soybeans	12	32.1	193	82.3
China (2011)	Nuts and seeds	10	<LOD ^v	231	44.4
FSANZ (2004)	Peanut butter	1	125	125	125

Table notes:

^t Minimum positive (non-zero) result.

^u Only positive results were used to calculate averages.

^v <LOD = less than the limit of detection

How to access the survey data

The data will be accessible on the [Open Government Portal](#).

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Appendix

Table A-1. List of PBDE congeners and congener pairs analysed in this survey

PBDEs (abbreviation)	Full name
BDE-17/BDE-25	(2,2',4-Tribromodiphenyl ether) / (2,3',4-Tribromodiphenyl ether)
BDE-28/BDE-33	(2,4,4'-Tribromodiphenyl ether) / (2',3',4'-Tribromodiphenyl ether)
BDE-47	2,2',4,4'-Tetrabromodiphenyl ether
BDE-66	2,3',4,4'-Tetrabromodiphenyl ether
BDE-77	3,3',4,4'-Tetrabromodiphenyl ether
BDE-85	2,2',3,4,4'-Pentabromodiphenyl ether
BDE-99	2,2',4,4',5-Pentabromodiphenyl ether
BDE-100	2,2',4,4',6-Pentabromodiphenyl ether
BDE-138/BDE-166	(2,2',3,4,4',5'-Hexabromodiphenyl ether) / (2,3,4,4',5,6-Hexabromodiphenyl ether)
BDE-153	2,2',4,4',5,5'-Hexabromodiphenyl ether
BDE-154	2,2',4,4',5,6'-Hexabromodiphenyl ether
BDE-183	2,2',3,4,4',5',6-Heptabromodiphenyl ether
BDE-209	Decabromodiphenyl ether

Table A-2. Frequency, minimum, maximum, and average levels of individual PBDE/PBDE pairs in detected samples

PBDE	Number of positive samples (%)	Category with the highest proportion of positive samples (%)	Minimum level^v (ppt)	Maximum level (ppt)	Average level^w (ppt)	Category with highest average^w level (average, ppt)
BDE-17/ BDE-25	565 (20)	Dairy (17)	0.014	40.3	0.76	Fish/seafood (2.39)
BDE-28/ BDE-33	1258 (45)	Fats/oils (19)	0.021	133	1.24	Fish/seafood (6.39)
BDE-47	2687 (96)	Dairy (22)	0.167	3970	18.7	Fish/seafood (102)
BDE-66	668 (24)	Dairy (21)	0.012	68.7	1.28	Fish/seafood (5.24)
BDE-77	177 (6)	Fats/oils (21)	0.010	6.35	0.58	Fats/oils (1.37)
BDE-85	805 (29)	Dairy (20)	0.022	57.6	1.94	Nuts/seeds (4.39)
BDE-99	2640 (94)	Dairy (22)	0.128	1610	19.9	Fats/oils (41.0)
BDE-100	2292 (82)	Dairy (22) Fats/oils (22)	0.035	1070	5.32	Fish/seafood (27.0)
BDE-138/ BDE-166	116 (4)	Egg (15)	0.060	14.6	2.21	Nuts/seeds (7.10)
BDE-153	1038 (37)	Dairy (24)	0.052	137	4.29	Fats/oils (9.80)
BDE-154	1108 (39)	Dairy (22)	0.027	420	3.77	Fish/seafood (12.7)
BDE-183	1053 (37)	Fats/oils (27)	0.032	223	3.79	Fats/oils (7.40)
BDE-209	1626 (58)	Dairy (25)	0.840	4860	171	Fats/oils (518)

Table notes:

^v Minimum positive (non-zero) result.

^w Only positive results were used to calculate averages.

Table A-3. Levels of Total PBDEs in this survey by commodity and year sampled

Product type	Fiscal year sampled	Total number of samples	Number of samples with detected levels (%)	Minimum ^x level (ppt)	Maximum level (ppt)	Average ^y level (ppt)
Coconut products	2015	1	1 (100)	99.0	99.0	99.0
	2017	50	50 (100)	1.08	349	44.6
Dairy products	2013	99	99 (100)	5.04	1100	150
	2014	91	89 (98)	2.30	1640	147
	2016	151	151 (100)	1.05	821	63.1
	2020	300	299 (99.7)	0.380	632	43.9
Egg products	2015	47	47 (100)	0.252	481	38.8
	2020	194	187 (96)	0.798	1653	77.4
Fats and oils	2013	72	70 (100)	18.3	1937	596
	2014	58	57 (98)	16.3	3748	509
	2015	423	423 (100)	4.38	5002	370
Fish and seafood	2017	94	94 (100)	1.07	5679	169
Grain products	2013	311	310 (99.7)	0.769	1578	70.0
	2014	267	261 (98)	0.432	2083	65.5
	2016	320	320 (100)	0.295	1964	48.0
Meat and poultry	2017	48	48 (100)	2.16	235	53.1
Nuts and seeds	2017	285	285 (100)	0.765	3726	143

Table notes:

^x Minimum positive (non-zero) result.

^y Only positive results were used to calculate averages.

Table A-4. Levels of Total PBDEs in grain products by grain type and year

Product type	Fiscal year sampled	Total number of samples	Number of samples with detected levels (%)	Minimum^z level (ppt)	Maximum level (ppt)	Average^{aa} level (ppt)
Corn products	All years	202	201 (99.5)	0.432	1964	63.1
	2013	69	69 (100)	2.57	1578	62.1
	2014	61	60 (98)	0.432	182	29.5
	2016	72	72 (100)	0.433	1964	92.1
Oat products	All years	198	197 (99.5)	0.446	562	35.8
	2013	74	74 (100)	0.769	562	51.5
	2014	72	71 (99)	0.553	163	37.5
	2016	52	52 (100)	0.446	194	11.1
Rice products	All years	163	162 (99)	0.724	2083	115
	2013	69	69 (100)	4.12	1077	117
	2014	60	59 (98)	2.46	2083	151
	2016	34	34 (100)	0.724	643	50.3
Wheat products	All years	335	331 (99)	0.295	1639	47.5
	2013	99	98 (99)	1.85	537	56.3
	2014	74	71 (96)	1.09	1639	53.2
	2016	162	162 (100)	0.295	651	39.7

Table notes:

^z Minimum positive (non-zero) result.

^{aa} Only positive results were used to calculate averages.