Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Bisphenol A and BPA Alternatives in Selected Canned Foods - April 1, 2020 to March 21, 2021

Food chemistry - Targeted surveys - Final report

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.

Bisphenol A (BPA) is a chemical used to make Bisphenol A diglycidyl ether (BADGE) epoxy resins and hard plastic containers[1]. Its use in the food industry is common, as BADGE epoxy resins are often coated on the inside of cans to prevent direct contact between the food and the metal. These compounds can migrate into food, particularly at elevated temperatures (for example, in hot-filled or heat-processed canned foods) [2,3].

To prevent these adverse health effects of these componds[4,5,6,7], some manufacturers have turned to BPA alternatives such as Bisphenol F (BPF) and Bisphenol S (BPS)[8]. Limited data is available concerning the use of BPA alternatives in canned and bottled foods, therefore they were included in this survey.

A total of 402 samples were collected from retail stores in 11 major cities across Canada. The samples collected included canned: fish, fruit, meat, pie filling, vegetables and vegetable products. BPA was detected in 163 (41%) survey samples, BADGE in 17 (4%), BPS in 7 (2%) and BPF was found in 2 (0.5%) samples in this survey. BPF was not found in canned vegetables or vegetable products, and neither BPF or BPS were detected in canned fruit or pie filling.

BPA was detected at similar average and maximum levels in canned meat, fish products, vegetables and vegetable products. Average and maximum levels of BPA detected in canned fruit and pie filling products were also comparable. In general, detected levels of BPA were relatively higher in canned meat, fish and vegetables, compared with canned fruit and pie filling. The results from this survey were comparable to those found in previous surveys and in literature sources.

The levels of BPA, BADGE, BPF and BPS observed in this survey were evaluated by Health Canada (HC) who determined that none of the samples would pose an unacceptable human health concern, therefore there were no recalls resulting from this survey.

What are targeted surveys

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 did we conduct this survey

The main objectives of this targeted survey were to generate baseline surveillance data on the prevalence of BPA, BADGE and its alternatives in foods on the Canadian retail market, and to compare the prevalence of these compounds in foods targeted in this survey with that of similar products in previous targeted surveys and in scientific literature. BPA is an industrial chemical used to make BADGE epoxy resins and clear hard plastic known as polycarbonate. It can be found in many items including tableware, storage containers, and food packaging. BADGE epoxy resins are also used as protective linings on the inside of metal containers and metal lids to prevent the corrosion of the metal and subsequent contamination of foods and beverages by dissolved metals. However, as a result of these liners, chemical components of food packaging like epoxy resins and polycarbonate come in contact with food. Residues of BPA can then migrate from the liners into the food, especially at elevated temperatures (such as in hot-fill or heat-processed canned foods)[1,2,3].

The negative health effects of BPA are well-documented. Exposure at high levels has been shown to be associated with infertility, breast cancer, prostate cancer[4], and some evidence suggests that it can also contribute towards heart problems, liver problems and diabetes[5]. BPA is a known endocrine disrupting chemical (EDC) that can contribute to the development of various diseases such as reproductive dysfunction[9]. It is also a nervous system disruptor that impacts hormone function[10]. The International Agency for Research on Cancer (IARC) has found some evidence of BADGE's carcinogenic effects in animals, although there is not enough evidence to conclude that it is carcinogenic in humans[6]. Current studies suggest that BADGE may also be an endocrine disruptor, but further evidence is needed for conclusive

corroboration[11,12]. HC has stated that the health risk associated with BADGE is considered moderate based on available toxicological information[7].

Due to these adverse health effects, manufacturers have supported initiatives to reduce BPA exposure from food packaging applications, including development of alternative materials. In addition to BPA, this targeted survey tested for 2 BPA alternatives: BPF and BPS . These compounds are generally considered to be safer than BPA, although their toxicity is not well-known and some evidence suggests exposure to these compounds can have adverse health effects[8]. Limited data is available on the extent of their usage by manufacturers, which is why the CFIA considered it important to include these compounds in this survey.

What did we sample

A variety of domestic and imported canned products including: fish, fruit, meat, pie filling, and vegetable products were sampled between April 1, 2020 and March 31, 2021. Samples of products were collected from local/regional retail locations located in 11 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

- Atlantic (Halifax, Moncton)
- Quebec (Montreal, Quebec City)
- Ontario (Ottawa, Toronto) and
- West (Calgary, Saskatoon, Vancouver, Victoria, Winnipeg)

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.

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
Canned fish	8	90	3	101
Canned fruit	0	50	2	52
Canned meat	20	55	25	100
Canned pie filling	0	49	0	49
Canned vegetables and vegetable products	19	73	8	100
Total	**47**	**317**	**38**	**402**

[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 were samples analyzed and assessed

Samples were analyzed by an ISO/IEC 17025 accredited food testing laboratory under contract with the Government of Canada. The results are based on the food products as sold and not necessarily as they would be consumed.

In the absence Maximum Limits (MLs) for BPA and BADGE, BPF and BPS, levels were assessed by HC on a case-by-case basis using the most current scientific data.

What were the survey results

The number of samples surveyed that contained detected levels of BPA and analogues BADGE, BPF and BPS varied by product type. Of the 402 samples tested, 163 (41%) had detected levels of BPA, 17 (4%) had detected levels of BADGE, 2 (0.5%) had detected levels of BPF, and 7 samples (2 %) contained BPS. BADGE, BPF and BPS were detected in canned meat, fish and vegetable products but not in any of the 101 fruit and pie filling samples surveyed.

Of the 100 meat samples included in the survey, 42 contained BPA, 1 chicken sample of unknown origin contained BPF, and 5 imported corned beef samples contained BPS.

There were 101 canned fish samples tested, 39 of which had detected levels of BPA, 1 imported herring sample contained BPF, and 1 imported mackerel sample contained BPS.

The survey also analyzed 100 canned vegetables and vegetable products, 163 (41%) of which contained BPA, 1 (1%) imported vegetable product contained BADGE and 1 (1%) imported vegetable product contained BPS.

BPA was detected in 15 (29%) of the 52 canned fruit samples surveyed, as well as in 16 (33%) of the 49 pie filling samples tested. All of the canned fruit and pie filling samples that contained BPA were imported products. None of the canned fruit or pie filling samples tested contained BADGE, BPF or BPS.

Bisphenol A (BPA)

Table 2 below, illustrates the range of BPA concentrations detected in the survey samples by type. The BPA detection rate between canned meat, fish and vegetable product categories was comparable at 42%, 39%, and 51% respectively, as were the average levels at 43.5, 43.8 and 55.9 ppb. The highest level of BPA detected in canned meat was in an imported corned beef sample at 479 ppb, while the highest level detected in fish was in an imported sardine sample at 395 ppb, and the highest level detected in vegetables was 151 ppb in an imported vegetable product.

Canned fruit and pie filling contained lower average levels of 6.1 and 2.1 ppb respectively. Levels of BPA ranged from 1.4 to 21.4 ppb in canned fruit and 1.1 to 7.1 ppb in canned pie filling. All 31 canned fruit and pie filling samples that contained BPA were imported products.

Table 2. Results of Bisphenol A testing in canned fish, fruit, meat, pie filling and vegetable products in ppb

Product type	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average[b]
Canned fish	101	39 (39)	0.91	395	43.8
Canned fruit	52	15 (29)	1.4	21.4	6.1
Canned meat	100	42 (42)	1.2	479	43.5
Canned pie filling	49	16 (33)	1.1	7.1	2.1
Canned vegetables and vegetable products	100	51 (51)	0.96	151	55.9
Total	**402**	**163 (41)**	**0.91**	**479**	**40.0**

[b] Only positive results were used to calculate averages

Bisphenol A diglycidyl ether (BADGE)

Table 3 below, illustrates the range of BADGE concentrations detected in the survey samples by product type. Only 17 (4%) of the 402 canned products tested in this survey reported detected levels of BADGE, 11 of which were meat, 5 of which were fish, and 1 of which was a vegetable product. The majority (14) of the samples that contained BADGE were imported products.

The average concentration of BADGE detected across all commodities was 141 ppb, with the lowest and highest levels detected in fish, ranging from 3.6 ppb to 1580 ppb. The highest level of BADGE was detected in an imported sardine sample while the second highest was detected in an imported mackerel sample at 51 ppb. The concentration levels of BADGE detected in meat products, ranged from 6.5 ppb to 372 ppb, with the highest level detected in imported luncheon meat. The vegetable sample containing BADGE was an imported vegetable product.

Of the 17 samples that contained BADGE, 8 also contained BPA, all of which were imported canned meat and fish samples. Of the 101 canned fruit and pie filling samples analysed, none tested positive for BADGE.

Table 3. Positive results of BADGE testing in canned fish, meat, and vegetable products in ppb

Product type	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average[c]
Canned fish	101	5 (5)	3.6	1580	330
Canned meat	100	11 (11)	6.5	372	66.1
Canned vegetables and vegetable products	100	1 (1)	14.0	14.0	14.0

[c] Only positive results were used to calculate averages

BPF and BPS Analogues

Table 4 below, illustrates the range of BPF detected in the survey samples by product type. Of the 101 canned fish and 100 meat samples tested, 1 chicken product of unknown origin and 1 imported herring sample tested positive for BPF. No canned vegetable products, fruit or pie filling samples contained BPF. Only 2 (0.5%) of the 402 samples surveyed contained BPF.

Table 4. Positive results of BPF testing in canned fish and meat products in ppb

Product type	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average[d]
Canned fish	101	1 (1)	94.8	94.8	94.8
Canned meat	100	1 (1)	19.6	19.6	19.6

[d] Only positive results were used to calculate averages

Table 5 illustrates the range of BPS detected in the survey samples by product type. Of the total canned fish samples tested, 1 imported mackerel sample contained BPS. Of the total meat samples tested, 5 imported corned beef products tested positive for BPS as well as BPA. Of the total canned vegetable samples surveyed 1 imported product contained BPS. No canned fruit or pie filling samples contained BPS. Only 2% of the 402 samples surveyed contained BPS, none of which were domestic products.

Table 5. Positive results of BPS testing in canned fish, meat and vegetables and vegetable products in ppb

Product type	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average[e]
Canned fish	101	1 (1)	46.0	46.0	46.0
Canned meat	100	5 (5)	0.96	191	52.1
Canned vegetables and vegetable products	100	1 (1)	0.98	0.98	0.98

[e] Only positive results were used to calculate averages

What do the survey results mean

Current survey data was compared with previous years and scientific publications, where BPA and its analogues were analyzed in similar commodities. All CFIA surveys and literature studies focused on chemical contaminants in foods available in Canadian markets only, including a study in canned fish published in the Journal of Food Protection[14] and HC's Total Diet Studies[15] food surveillance program. Overall, BPA levels detected were comparable to previous CFIA surveys and studies in literature as noted in Table 6[14,15,].

Table 6. Minimum, maximum and average concentration of BPA in canned fish/seafood, fruit, meat, pie filling, and vegetables/products across various studies in ppb

Product type	Study	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average[f]
Canned fish	CFIA survey, 2020	101	39 (39)	0.91	395	43.8[f]
Canned fish/seafood	CFIA survey, 2017	237	159 (67)	1.3	1480	54.7[f]
Canned fish	Cao et al., 2015	52	52 (100)	0.96	265	28.0[f]
Canned fish	HC, 2008 to 2012	5	5 (100)	5.9	109	57.4
Canned fruit	CFIA survey, 2020	52	15 (29)	1.4	21.4	6.1[f]
Canned fruit	CFIA survey, 2016	50	34 (68)	2.0	1160	62.1[f]
Canned fruit	CFIA survey, 2013	38	19 (50)	1.0	53.6	6.7[f]
Canned fruit	CFIA survey, 2012	73	1 (1)	N/D[h]	8.6	N/A[i]
Canned meat	CFIA survey, 2020	100	42 (42)	1.2	479	43.5[f]
Canned meat	CFIA survey, 2017	231	170 (74)	1.2	407	35.6[f]
Canned meat	HC, 2008 to 2012	5	4 (80)	10.0	18.0	10.0
Canned pie filling	CFIA survey, 2020	49	16 (33)	1.1	7.1	2.1[f]
Canned pie filling	CFIA, survey, 2018	98	62 (63)	0.97[g]	101[g]	11.2[f,,g]

Canned pie filling	CFIA survey, 2016	20	16 (80)	8.5	2240	281.4[f]
Canned pie filling	CFIA survey, 2013	20	8 (40)	3.4	47.3	22.3[f]
Canned vegetables/products	CFIA survey, 2020	100	51 (51)	0.96	151	55.9[f]
Canned vegetables	CFIA survey, 2016	72	58 (81)	5.3	751	139[f]
Canned vegetables	CFIA survey, 2013	70	59 (84)	1.1	565	31.8[f]
Canned vegetables	CFIA survey, 2012	141	30 (21)	5.5	103	34.0[f]

[f] Only positive results were used to calculate the average BPA levels

[g] In 2018 to 2019 new improved detection method was used

[h] Not detected (N/D) at or above the minimum detection level

[i] Average not available (N/A) as only one value was obtained

The maximum level of BPA detected in canned fish/seafood products in 2017 was detected in an imported sardine sample at 1480ppb and varied significantly from the maximum level observed in 2020 in an imported sardine product at 395 ppb. However, the highest level detected in 2017 was significantly elevated compared with all other canned fish/seafood samples tested in that survey. Overall, average levels of BPA detected in canned fish products were consistent across studies and survey years. Rates of detection of BADGE in canned fish/seafood were also similar between surveys. In 2020, BADGE was detected in 5% of 101 canned fish samples and in 2017, 8% of 237 canned fish/seafood samples contained BADGE. In 2020, only 1 canned fish sample contained BPF and 1 contained BPS, while none contained either in 2017.

The maximum level of BPA detected in canned fruit in the current survey was 21.4 ppb in an imported lychee in syrup product, which diverged from the maximum level detected of 1460 ppb in the 2016 survey in an imported organic pineapple sample in juice. However, the highest level detected in 2016 was elevated compared with other canned fruit samples tested within that survey. The average levels of BPA were lower than comparable surveys over the years. BADGE, BPF and BPS were not detected in any canned fruit samples in the 2020 and 2016 surveys. 2012 and 2013 surveys did not include BPF or BPS analogue testing.

The maximum and average levels of BPA detected in canned meat products in the current survey were similar to those found in previous years, and BPA detection rates appeared to decline over the period studied. Similarly, detection rates of BPF across the variety of canned meat products sampled, decreased from 29% in 2017, to 1% in 2020. BPS was found in 5 imported corned beef samples in 2020 and 1 imported corned beef sample in 2017.

The maximum and average levels of BPA in canned pie filling in the current survey were 7.1ppb and 2.1 ppb respectively and declined from previous years. The highest detected level of BPA was 2240ppb in an imported pumpkin pie filling product that was observed to be elevated compared with all other canned pie filling samples tested in that survey. Overall, the average levels detected in canned pie filling were comparable with other commodities surveyed ranging from 2.1 ppb to 281 ppb. Neither BADGE, BPF, or BPS were detected in any canned pie filling

samples in the current survey or the previous survey years of 2018 and 2016. Note that 2013 surveys did not include BPF or BPS analogue testing.

The average levels of BPA detected in canned vegetables and products were comparable across survey years as well as with other commodities. The highest maximum value was observed in 2016 at 751 ppb in an imported corn product followed by a corn sample at 565 ppb in 2013.

There are a wide range of factors that can affect BPA levels in foods. BPA research indicates that differences can be attributed to the specific type of product tested, sample size, or the composition of the internal polymeric can lining[16,17]. Processing temperature as well as the presence of sodium chloride, glucose, fats and vegetable oils have also been shown to influence the transfer of BPA from can linings into food[13,18,19]. A research study in canned vegetables also shows that migration of BPA is affected by food type, product brand, pH, fat and water content[20]. Therefore, some differences observed between maximum and average BPA levels between commodities and product types are expected, particularly due to the variation of sample numbers included in each study.

There are no regulations in Canada for BPA or BADGE levels in food. All levels of BPA and BADGE found in the products tested in this survey were evaluated by HC who determined that none of the samples would pose an unacceptable human health concern, therefore there were no recalls resulting from this survey.

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