Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

Bisphenol A and BPA Alternatives in Canned Meat, Fish and Seafood - April 1, 2017 to March 31, 2018

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 468 samples were collected from retail stores in 6 cities across Canada. The samples collected included canned meat, fish and seafood. BPA was detected in 329 (70%) of survey samples and BADGE was detected in 72 (15%). BPF was detected in 68 (15%) of survey samples, while only one tested positive for BPS (0.002%). Neither BPF or BPS was detected in canned fish and seafood samples.

The average level of BPA detected in canned meat was 34.6 parts per billion (ppb), while the maximum level was 407 ppb. The average level detected in canned fish and seafood was 54.7 ppb, and the maximum BPA level was 1480 ppb. The results from this survey were comparable to those found in literature.

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 the use 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. This targeted survey also looked at the presence of 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 products including canned meat, fish and seafood were sampled between April 1, 2017 and March 31, 2018. Samples of products were collected from local/regional retail locations located in 6 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

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

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 meat	111	102	18	231
Canned fish and seafood	14	220	3	237
Total	**125**	**325**	**21**	**468**

[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, levels were assessed by HC on a case-by-case basis using the most current scientific data.

What were the survey results

Table 2 illustrates the range of BPA, BADGE, BPF and BPS concentrations detected in the survey samples by product type. Of the 468 samples tested, 329 (70%) had detected levels of BPA, 72 (15%), had detected levels of BADGE, 68 (15%) had detected levels of BPF and one sample (0.002%) contained BPS. No fish and seafood samples contained detected levels of BPF or BPS.

Table 2. Results of BPA and BPA alternatives testing in canned meat, fish and seafood in ppb

Product type	Number of samples	Analyte	Number of samples (%) with detected levels	Minimum	Maximum	Average[b]
Canned meat	231	BPA	170 (74)	1.20	407	35.6
Canned meat	231	BADGE	53 (23)	0.98	46.2	10.8
Canned meat	231	BPF	68 (29)	1.01	63.6	15.3
Canned meat	231	BPS	1 (0.004)	1.79	1.79	1.79
Canned fish and seafood	237	BPA	159 (67)	1.29	1480	54.7
Canned fish and seafood	237	BADGE	19 (8)	0.97	53.2	8.02
Canned fish and seafood	237	BPF	N/D[c]	N/D[c]	N/D[c]	N/D[c]
Canned fish and seafood	237	BPS	N/D[c]	N/D[c]	N/D[c]	N/D[c]
Total	**468**	**BPA**	**329 (70)**	**1.20**	**1480**	**44.8**

[b] Only positive results were used to calculate averages
[c] Not detected (N/D) at or above the minimum detection level of 0.90 ppb

Bisphenol A (BPA)

Within the canned meat and canned fish and seafood categories, 170 of 231 samples (74%) and 159 of 237 samples (67%) contained BPA respectively. Thus, the BPA detection rate between canned meat and fish and seafood product categories was observed to be comparable. The average detected BPA levels of 46.6 ppb for meat and 54.7 ppb for seafood were also similar. The highest level of BPA detected was 1480 ppb in an imported canned fish and seafood sample (sardine). The next highest level was detected at 567 ppb which is more comparable with the highest value detected in canned meat at 407 ppb.

Bisphenol A diglycidyl ether (BADGE)

In total, 72 (15%) of the 468 canned products tested in this survey reported detectable levels of BADGE, 53 (11%) of which were meat samples and 19 (4%) were fish and seafood. Of the 231 meat samples, 53 (23%) contained BADGE, as did 19 (8%) of the 237 canned fish and seafood samples tested. The average concentration of BADGE detected in tested products was 10.1 ppb, ranging from 0.97 to 53.2 ppb in fish and seafood and 0.98 to 46.2 ppb in meat. The majority (96%) of samples that contained BADGE (69 out of 72), also contained BPA.

Bisphenol F (BPF) and Bisphenol S (BPS)

BPF was detected in 68 (29%) of the 231 canned meat samples tested. Of the 237 canned fish and seafood samples tested, none contained BPF. All samples that contained BPF also contained BPA. BPS was detected in one canned meat sample at 1.79 ppb which is comparable to the minimum detection level of 0.9 ppb. No canned fish and seafood samples contained BPS.

What do the survey results mean

Current survey data was compared with a combined study of canned meat and fish and seafood products conducted by the European Union (EU) and other scientific publications, as neither BPA nor its analogues were analyzed in similar commodities in previous targeted surveys. Overall, BPA levels detected in the canned meat, fish and seafood products tested in the current survey were comparable to similar product found in literature (Table 3)[14,15,16,17]. Average BPA levels detected were also relatively consistent between the current survey and other studies for both product types, ranging from 24.4 ppb to 35.6 ppb for canned meat products and 28.0 ppb to 54.7 ppb for canned fish and seafood products.

There are a wide range of factors that can affect BPA levels in foods. BPA research asserts that differences can be attributed to the specific type of product tested, sample size, or the composition of the internal polymeric can lining[18,19]. 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[13,20,21]. A current research study in canned vegetables further evidences that migration of BPA is affected by food type, product brand, pH, fat and water content[22]. 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.

The studies in literature contained samples from a variety of markets and countries, while the current survey and HC's Total Diet Studies[17], food surveillance program focused on monitoring chemical contaminants in foods available in Canadian markets only. The canned fish samples tested in the HC study conducted between 2008 and 2012, contained average BPA sample concentration levels of 57.4 ppb, which is similar to the average level of BPA (54.7 ppb) in canned fish and seafood from the current survey. The average BPA level detected in canned

meat samples tested in the HC study was 10 ppb, which varied from the current survey average of 35.6 ppb and is not unexpected due to the fewer number of samples included in the study.

Table 3. Minimum, maximum and average concentration of BPA in canned meat, fish and seafood across various studies in ppb

Product type	Study	Number of samples	Number of samples (%) with detected levels	Minimum	Maximum	Average
Canned meat	CFIA survey, 2017	231	170 (74)	1.2	407	35.6[d]
Canned meat	EFSA, 2015	47	26 (55)	N/A	203	31.5
Canned meat	Lim et al., 2009	13	8 (62)	9.1	98.3	24.4
Canned meat	HC, 2008 to 2012	5	4 (80)	10	18	10
Canned fish	CFIA survey, 2017	237	159 (67)	1.3	1480	54.7[d]
Canned fish and seafood	EFSA, 2015	174	127 (73)	N/A	198	37.0
Canned fish	Cao et al., 2015	52	52 (100)	0.96	265	28.0[d]
Canned fish	HC, 2008 to 2012	5	5 (100)	5.9	109	57.4

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

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.

References

1. Bisphenol A (BPA). (2018). Canada. Health Canada.
2. Survey of Bisphenol A in Canned Food Products from Canadian Markets. (2010). Canada. Health Canada.
3. Munguia-Lopez, E.M., Soto-Valdez, H. (2001). Effect of Heat Processing and Storage Time on Migration of Bisphenol A (BPA) and Bisphenol A-Diglycidyl Ether (BADGE) to Aqueous Food Simulant from Mexican Can Coatings. *Journal for Agricultural and Food Chemistry*, 49(8), pp. 3666-3671.
4. Konieczna, A., Rachon, D., Rutkowska, A. (2015). Health risk of exposure to Bisphenol A (BPA). *Annals of the National Institute of Hygiene*, 66(1), pp. 5-11.
5. Depledge, M., Galloway, T.S., Henley, W.E., Lang, A.I., Melzer, D., Wallace, R.B. (2008). Association of Urinary Bisphenol A Concentration With Medical Disorders and Laboratory Abnormalities in Adults. JAMA, 300(11), pp. 1303-1310.
6. Re-evaluation of Some Organic Chemicals, Hydrazine and Hydrogen Peroxide. (1999). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, 71, pp. 1285-1289.
7. Draft Screening Assessment Epoxy Resins Group. (2018). Canada. Health Canada.
8. Lehmler, H.-J., Liu, B., Badogbe, M., Bao, W. (2018). Exposure to Bisphenol A, Bisphenol F, and Bisphenol S in U.S. Adults and Children: The National Health and Nutrition Examination Survey 2013–2014. *American Chemical Society Omega*, 3(6), pp. 6523-6532.
9. Li, L., Wang, Q., Zang, Y., Niu, Y., Yao, X., Liu, H. (2015). The Molecular Mechanism of Bisphenol A (BPA) as an Endocrine Disruptor by Interacting with Nuclear Receptors: Insights from Molecular Dynamic (MD) Simulations. *PLOS One*, (10)3, pp. 1-18.
10. Seralini, G-E., Jungers, G. (2021). Endocrine disruptors also function as nervous disruptors and can be renamed endocrine and nervous disruptors (ENDs). *Toxicology Reports*, 8(2021), pp. 1538-1557.
11. Hyoung, U-j., Yang, Y. J., Kwon, S. K., Yoo, J. H., Myoung, S. C., Kim, S. C., Hong, Y. P. (2007). Developmental Toxicity by Exposure to Bisphenol A Diglycidyl Ether during Gestation and Lactation Period in Sprague-dawley Male Rats. *Journal of Preventative Medicine and Public Health*, 40(2), pp. 155-161.
12. Wang, D., Zhao, H., Fei, X., Synder, S. A., Fang, M., Liu, M. (2021). A comprehensive review on the analytical method, occurrence, transformation and toxicity of a reactive pollutant : BADGE. *Environmental International*, 155(2021), pp 1-15.
13. Kang, J.-H., Kito, K., Kondo, F. (2003). Factors Influencing the Migration of Bisphenol A from Cans. *Journal of Food Protection*, 66(8), pp. 1444-1447.
14. European Food Safety Authority (EFSA). (2015). Scientific Opinion on the risks to public health related to the presence of Bisphenol A (BPA) in foodstuffs: Executive Summary. *EFSA Journal*, 13(1), pp. 1-621.
15. Lim, D. S., Kwack, S. J., Kim, K-B., Kim, H. S., Lee, B. M. (2009). Risk Assessment of Bisphenol A migrated from Canned Foods in Korea. *Journal of Toxicology and Environmental Health*, Part A, 72(21-22), pp.1327-1335.

16. Cao, X-L., Popovic, S. (2015). Bisphenol A and Three Other Bisphenol Analogues in Canned Fish Products from the Canadian Market 2014. Journal of Food Protection, 78(7), pp. 1402-1407.

17. Canadian Total Diet Study - Bisphenol A (BPA) 2008-2012, 2016 - Total Diet Study Bisphenol A (BPA) results 2008-2012, 2016. (2022). Canada. Health Canada.

18. Goodson, A., Summerfield, W., Cooper, I. (2002). Survey of Bisphenol A and Bisphenol F in canned foods. *Food Additives and Chemical Contaminants*, 19(8), pp. 796-802.

19. Goodson, A., Robin, H., Summerfield, W., Cooper, I. (2004). Migration of Bisphenol A from can coatings–effects of damage, storage conditions and heating. *Food Additives and Contaminants*, 21(10), pp. 1015-1026.

20. Summerfield, W., Goodson, A., Cooper, I. (1998). Survey of Bisphenol A diglycidyl ether (BADGE) in canned foods. *Food Additives and Chemical Contaminants*, 15(7), pp. 818-830.

21. Hammarling, L., Gustavsson, H., Svensson, K., Oskarsson, A. (2000). Migration of Bisphenol-A diglycidyl ether (BADGE) and its reaction products in canned foods. *Food Additives and Chemical Contaminants*, 17(11), pp. 937-943.

22. El Moussawi, S. N., Ouaini, R., Matta, J., Chebib, H., Cladiere, M., Camel, V. (2019). Simultaneous migration of Bisphenol compounds and trace metals in canned vegetable food. *Food Chemistry*, 288(2019), pp. 228-238.