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

Dioxins and dioxin-like compounds in dairy products – April 1, 2019, to March 31, 2021

Food chemistry – Targeted surveys – Final report

Canada

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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.

Dioxins and dioxin-like compounds are chemical contaminants found in the environment and consequently in food products. These compounds are separated into 3 groups of chemicals with toxicological and chemical similarities. These groups are polychlorinated dibenzo-p-dioxins (also known as dioxins or PCDDs), polychlorinated dibenzofurans (PCDFs or furans) and polychlorinated biphenyls (dioxin-like PCBs or DL-PCBs). Dioxins and dioxin-like compounds are found mainly in dairy products, animal tissues/fats and eggs[1,2,3]. They can also be found in products made from oily plants due to their accumulation in soil and on plant surfaces[2]. These compounds accumulate in the liver and fat tissues of humans through consumption of food products containing dioxins and dioxin-like compounds[1,3,4,5,6]. Dioxins and dioxin-like compounds are associated with various health effects such as skin disorders (for example, chloracne), liver and thyroid problems, impairment of the endocrine, nervous, reproductive and immune systems, developmental effects and certain types of cancers[3,4,6]. The type and occurrence of these health effects typically depend on the level and duration of exposure. The best method of minimizing dietary exposure to dioxins and dioxin-like compounds is prevention and reduction of contamination in foods and animal feeds[2,3,7]. This survey focused on cheese, cream, kefir, and milk available on the Canadian retail market.

A total of 296 samples were collected from retail stores in Canada between April 2019 and March 2021. Dioxins and/or dioxin-like compounds were found in 96% of samples tested. This large proportion of positive samples is expected, given the widespread presence and persistence of dioxins and dioxin-like compounds in the environment. These compounds accumulate in fatty tissues of all species, which leads to an increase in concentration in the fatty tissues of organisms further up the food chain. In this survey, the highest proportion of samples with detected levels of dioxin and dioxin-like compounds was found in cheese and cream (99%), and the lowest proportion of samples with detected levels was in kefir (87%).

There are no Canadian regulations for total levels of dioxins and dioxin-like compounds in dairy products, however the levels observed in this survey were evaluated by Health Canada's Bureau of Chemical Safety and none of the samples were determined to pose a safety concern to human health.

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

There are over 400 different structural forms of dioxins and dioxin-like compounds. The compounds are separated into three groups of chemicals with toxicological and chemical similarities. These groups are dioxins (also known as polychlorinated dibenzo-p-dioxins or PCDDs), polychlorinated dibenzofurans (PCDFs or furans) and polychlorinated biphenyls (dioxin-like PCBs or DL-PCBs). Only some of these compounds are of concern to human health; 29 of these (also known as targeted congeners) are the focus of this report[2].

Dioxins and furans are mainly formed as by-products of industrial processes (manufacturing of chemicals, pulp and paper bleaching processes, exhaust emissions and incineration, etc.), but can also occur naturally (such as through volcanic activity or forest fires)[3]. These contaminants are not deliberately manufactured. PCBs are also man-made and often contain furan contaminants. PCBs were historically used in many industrial applications (such as for their electrical insulating properties), but their production is now banned globally. PCBs are still present in certain types of electrical equipment and, despite strict controls on handling, storage and disposal of existing PCBs, accidental release into the environment is still possible. When released into the environment, dioxins, furans, and PCBs can be transported long distances from their source[2,3,6].

The primary exposure to dioxins and dioxin-like compounds is through the consumption of foods of animal origin. These pollutants enter the livestock food chain through foraging and animal feed contamination and accumulate in the fatty tissues of the livestock[1,2]. They then enter the human food chain through the consumption of contaminated foods of animal origin, particularly higher fat foods, such as dairy products, meat, and some fish and shellfish[4].

Dioxins and dioxin-like compounds are associated with various health effects such as skin disorders (for example, chloracne), liver and thyroid problems, impairment of the endocrine, nervous, reproductive and immune systems, developmental effects and certain types of cancers[3,4,6]. The type and occurrence of these health effects typically depend on the level and duration of exposure.

In food, dioxins and dioxin-like compounds are found mainly in dairy products, animal tissues/fats and eggs[1,2,3,4]. They can also be found in products made from oily plants due to their accumulation in soil and on plant surfaces[2]. These compounds accumulate in the liver and fat tissues of humans through consumption of food products containing dioxins and dioxin-like compounds[1,3,4,5]. Dioxins and dioxin-like compounds are not destroyed by heating or cooking. The best method of minimizing dietary exposure to dioxins and dioxin-like compounds is prevention and reduction of contamination in foods and animal feeds[2,3,7]. This survey focused on cheese, cream, kefir, and milk available on the Canadian retail market.

What was sampled

A variety of domestic and imported cheese (including hard, ripened, soft, semi-soft, and goat cheeses), liquid cream and sour cream with fat content of at least 10% milk fat (M.F.), kefir (fermented milk beverage including full fat, skim, plain and flavored), and liquid milk (including skim, 1% M.F., 2% M.F., and whole/homogenized milk with 3.25% M.F.) were sampled between April 1, 2019, and March 31, 2021. Samples of products were collected from local/regional retail locations in 11 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

- Atlantic (Halifax and Moncton)
- Quebec (Montreal and Quebec City)
- Ontario (Toronto and Ottawa)
- West (Calgary, Saskatoon, Vancouver, Victoria, and 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
Cheese	78	28	14	120
Cream	66	1	0	67
Kefir	70	0	0	70
Milk	38	1	0	39
Total	**252**	**30**	**14**	**296**

Table note:

[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 ISO 17025 accredited food testing laboratories under contract with the Government of Canada and were reported as they were sold (not prepared according to directions prior to analysis). Although the detection methods often test for 35 or more compounds, only 29 of these (also known as targeted congeners) are the focus of this report[2]. The list of compounds reported as part of this survey are shown in Table A-1 in the Appendix of this report. The concentration of each dioxin or dioxin-like compound detected, reported as picograms per gram of sample (pg/g), is multiplied by its respective World Health Organization (WHO) 2005 consensus Toxic Equivalency Factors (TEFs)[8,9] to calculate the individual toxic equivalency (TEQ) concentration in picograms TEQ per gram of sample (pg TEQ/g). Refer to Table A-1 in the Appendix for the TEFs used in this survey. Each of the calculated individual TEQ concentrations are then added together to arrive at a total TEQ concentration, which is an estimate of the total relative potency of all the dioxins and dioxin-like compounds detected in the sample.

Consistent with international reporting practice, total TEQ results are calculated and reported in terms of both lower bound TEQ (LB TEQ) and upper bound TEQ (UB TEQ) levels of dioxin and dioxin-like compounds. This allows for interpretation of both a best-case (LB TEQ) and a more conservative, worst-case scenario (UB TEQ) estimate of the total TEQ of a sample. LB TEQ levels represent solely the sum of all detected congeners multiplied by their respective TEFs, and congeners not detected are given a value of zero. UB TEQ levels represent the sum of detected forms multiplied by their respective TEFs, plus the sum of the limit of detection (LOD) contributions for all congeners that were not detected, also multiplied by their relevant TEFs. This method of calculating the UB TEQ incorporates levels that may be present below the LOD but still contribute to the total toxicity value. The true TEQ value will be somewhere between the LB TEQ and UB TEQ levels. At very low concentrations, the LB TEQ and UB TEQ values can span a larger range due to measurement uncertainty at low toxicity levels, but the higher the concentrations of the congeners, the closer the LB TEQ and UB TEQ values will be. In an abundance of caution, most global guidance and regulations use the UB TEQ value for compliance[1,10,12,13].

There are no Canadian regulations for total TEQ of dioxin-like compounds (furans and PCBs) for dairy products[11]. In the absence of established tolerances or standards for dioxins in foods, elevated levels in specific foods may be assessed by Health Canada on a case-by-case basis using the most current scientific data available. Currently, Health Canada is using the Joint Expert Committee on Food Additives' (JEFCA) recommended tolerable monthly intake of 70 picograms of dioxins and dioxin-like compounds per kilogram of body weight per month to assess the safety of foods while they are updating their risk assessments for these compounds[6].

Results of the survey

Of the 296 samples analyzed in this survey, 96% (284 samples) contained dioxins and dioxin-like compounds. The range of levels found is presented in Table 2. Among the 4 product types analysed, the lowest average UB TEQ level was found in milk (0.0213 pg TEQ/g) and the highest average level was found in cheese (0.0719 pg TEQ/g).

Table 2. Levels of dioxins and dioxin-like compounds in dairy products

Product type	Total number of samples	Number of samples with detected levels (%)	LB TEQ Average value[b] (range[c]) (pg TEQ/g)	UB TEQ Average value[b] (range) (pg TEQ/g)
Cheese	120	119 (99)	0.0265 (<LOD to 0.170)	0.0709 (0.0078 to 0.433)
Cream	67	66 (99)	0.0248 (<LOD to 0.201)	0.0621 (0.0142 to 0.235)
Kefir	70	61 (87)	0.0024 (<LOD to 0.0269)	0.0954 (0.0109 to 0.246)
Milk	39	37 (95)	0.0045 (<LOD to 0.0751)	0.0213 (0.0006 to 0.135)
Total	**296**	**283 (96)**	**0.0180 (<LOD to 0.201)**	**0.0682 (0.0006 to 0.433)**

Table notes:

[b] Only positive results were used to calculate averages.
[c] <LOD = Below the Limit of Detection (dependant on the analyte, and analysis method).

Cheese

The cheese samples that were tested consisted of 120 samples from 23 types of cheese including a variety soft, semi-soft, hard, ripened, and fresh cheeses. Dioxins and dioxin-like compounds were found in 99% of the samples. The average UB TEQ for cheese was 0.0709 pg TEQ/g.

Cream

Dioxin and dioxin-like compounds were found in 66 of the 67 dairy cream samples surveyed, or 99% of samples. The cream products that were tested contained at least 10% M.F., such as half-and-half cream, table cream, coffee cream, cooking cream, whipping cream, and full-fat sour cream. The average UB TEQ found in cream was 0.0621 pg TEQ/g.

Kefir

The 70 kefir samples in this category included a variety of types of this fermented milk beverage, including organic, non-organic, plain, and flavoured beverages. Dioxins and dioxin-like compounds were detected in 87% (61) of the samples. Although kefir had the lowest rate of positive samples found in this survey, it had the highest average UB TEQ at 0.0954 pg TEQ/g.

Milk

This survey tested 39 samples of liquid milk including skim, 1% M.F., 2% M.F, and whole/homogenized milk (3.25% M.F.). There were detected levels of dioxins and dioxin-like compounds in 37 samples (95%). Milk had the lowest average UB TEQ level in this survey at 0.0213 pg TEQ/g.

What the survey results mean

In this survey, 96% of dairy samples contained detected levels of dioxins and dioxin-like compounds. Table 3 presents current survey data compared with other surveys where dioxins and dioxin-like compounds were analyzed in similar commodities, including previous CFIA targeted surveys[15,16], results from the CFIA's National Chemical Residue Monitoring Program (NCRMP)[21,22,23], and results from 4 international studies published between 2012 and 2016. The studies used for comparison are from the National Cheng Kung University in Taiwan[17] ("Taiwan 2016"), the French Agency for Food, Environmental and Occupational Health & Safety in France[18] ("France 2012"), and two studies from Universitat Rovira i Virgili in Catalonia, Spain: Perelló et al.[19] ("Spain 2012"), and Cano-Sancho et al.[20] ("Spain 2015").

The average LB TEQ levels of dioxins and dioxin-like compounds found in this survey are comparable to, or lower than, the levels found by CFIA in past years and lower than the levels reported by the studies from other countries. The UB TEQ levels are similar to the other surveys and studies that reported UB TEQ. Differences can likely be attributed to the types of samples tested in each survey period and/or the amount of environmental contamination present in different parts of the world[1,7,24]. Another possible cause is that the dioxin and dioxin-like compound contamination of the environment is decreasing after Canada and many other countries began implementing regulations to prevent emissions and monitor environmental levels of these contaminants in the 1990s[6,14].

The levels observed in this survey were evaluated by Health Canada's Bureau of Chemical Safety and none of the samples were determined to pose a safety concern to human health.

Table 3: Minimum, maximum, and average results of dioxins and dioxin-like compounds across various studies

Product type	Survey	Total number of samples	Number of samples with detected levels (%)	Average LB TEQ value[d]	Average UB TEQ value[d]
Cheese	**CFIA, 2019 to 2021**	**120**	**119 (99)**	**0.0265**	**0.0709**
Cheese	CFIA, 2014 to 2019	280	279 (99.6)	0.0355	0.152
Cheese	CFIA, 2012 to 2014[e]	403	403 (100)	0.0696[e]	0.128[e]
Cheese	Taiwan, 2016	7	NR[f]	0.126	NR[f]
Cheese	France, 2012	32	NR[f]	0.131	NR[f]

Product type	Survey	Total number of samples	Number of samples with detected levels (%)	Average LB TEQ value[d]	Average UB TEQ value[d]
Cream	**CFIA 2019 to 2021**	**67**	**66 (99)**	**0.0248**	**0.0621**
Cream	Taiwan (2016)	3	NR[f]	0.184	NR[f]
Cream desserts	France (2012)	22	NR[f]	0.0280	NR[f]
Kefir	**CFIA 2019 to 2021**	**70**	**61 (87)**	**0.0024**	**0.0954**
Yogurt beverages	CFIA 2014 to 2015	9	9 (100)	0.0018	0.0235
Fermented milk	Taiwan (2016)	**5**	NR[f]	0.0100	NR[f]
Yogurt	Taiwan (2016)	**10**	NR[f]	0.0230	NR[f]
Yogurt	Spain (2015)	**18**	18 (100)	0.0182	0.0182
Yogurt	Spain (2012)	**48**	NR[f]	0.0100	NR[f]
Milk[g]	**CFIA 2019 to 2021**	**39**	**37 (95)**	**0.0045**	**0.0213**
Raw milk[h]	NCRMP 2020	93	93 (100)	0.0058[e]	0.0144[e]
Raw milk[h]	NCRMP 2019	184	184 (100)	0.0059[e]	0.0150[e]
Raw milk[h]	NCRMP 2018	179	179 (100)	0.0077[e]	0.0177[e]
Milk[g]	Taiwan (2016)	205	NR[f]	0.0400	NR[f]
Milk[g]	France (2012)	38	NR[f]	0.0130	NR[f]

Table notes:

[d] Only positive TEQ results were used to calculate average.
[e] This CFIA report was originally reported in pg TEQ/g of fat; for comparison purposes, these results have been converted to pg TEQ/g of total sample.
[f] NR: Not reported.
[g] Milk refers to processed milk available for purchase in retail stores
[h] Raw milk refers to unpasteurized milk collected from dairy farms/plants before pasteurization and packaging.

How to access the survey data

The data will be accessible on the Open Government Portal.

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Appendix

Table A-1. Limits of detection and WHO Toxic Equivalency Factors (TEFs) for dioxins and dioxin-like compounds

Compound	Congener	LOD range[i] (pg/g)	TEF[j]
Dioxins	2,3,7,8-TCDD	0.01 to 0.013	1
	1,2,3,7,8-PeCDD	0.01 to 0.05	1
	1,2,3,4,7,8-HxCDD	0.01 to 0.1	0.1
	1,2,3,6,7,8-HxCDD	0.01 to 0.082	0.1
	1,2,3,7,8,9-HxCDD	0.009 to 0.064	0.1
	1,2,3,4,6,7,8-HpCDD	0.03 to 0.085	0.01
	1,2,3,4,6,7,8,9-OCDD (or OCDD)	0.017 to 0.31	0.0003
Furans	2,3,7,8-TCDF	0.01 to 0.013	0.1
	1,2,3,7,8-PeCDF	0.008 to 0.039	0.03
	2,3,4,7,8-PeCDF	0.008 to 0.06	0.3
	1,2,3,4,7,8-HxCDF	0.006 to 0.075	0.1
	1,2,3,6,7,8-HxCDF	0.006 to 0.075	0.1
	1,2,3,7,8,9-HxCDF	0.008 to 0.056	0.1
	2,3,4,6,7,8-HxCDF	0.008 to 0.05	0.1
	1,2,3,4,6,7,8-HpCDF	0.029 to 0.052	0.01
	1,2,3,4,7,8,9-HpCDF	0.04 to 0.085	0.01
	1,2,3,4,6,7,8,9-OCDF (or OCDF)	0.033 to 0.13	0.0003
Dioxin-like PCBs	3,3',4,4'-TeCB (PCB 77)	0.01 to 0.37	0.0001
	3,4, 4',5-TeCB (PCB 81)	0.02 to 0.26	0.0003
	2,3,3',4,4'-PeCB (PCB 105)	0.03 to 0.37	0.00003
	2,3,4,4',5-PeCB (PCB 114)	0.01 to 0.27	0.00003
	2,3',4,4',5-PeCB (PCB 118)	0.05 to 0.4	0.00003
	2',3,4,4',5-PeCB (PCB 123)	0.02 to 0.38	0.00003
	3,3',4,4',5-PeCB (PCB 126)	0.01 to 0.31	0.1
	2,3,3',4,4',5-HxCB (PCB 156)	0.02 to 0.39	0.00003
	2,3,3',4,4',5'-HxCB (PCB 157)	0.01 to 0.39	0.00003
	2,3',4,4',5,5'-HxCB (PCB 167)	0.01 to 0.22	0.00003
	3,3',4,4',5,5'-HxCB (PCB 169)	0.01 to 0.33	0.03
	2,3,3',4,4',5,5'-HpCB (PCB 189)	0.02 to 0.48	0.00003

Table notes:

[i] LOD: Method limit of detection depends on the analyte and analysis method.
[j] TEF: Toxic Equivalency Factor (2005 WHO TEF values)[8,9].