



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Methylmercury and inorganic mercury in canned seafood – April 1, 2015, to March 31, 2016

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.

Mercury is a naturally occurring metal that can be present in the environment through natural sources such as volcanoes, soils, undersea vents, and mercury-rich geological zones. It can also be released through human activities like combustion and industrial processes (such as coal-fired power generation, mining, smelting, and waste incineration). The use of mercury in batteries, fluorescent tube lighting, thermometers, and other manufactured items is also a source of mercury release into the environment¹. Mercury is considered a global contaminant due to its toxicity, its ability to persist in the environment, and its ability to be transported long distances within the atmosphere. Exposure to methylmercury can cause harmful effects on the digestive, immune, and nervous systems, particularly in children and fetuses, whereas inorganic mercury is corrosive to skin and eyes, and toxic to kidneys^{2,3,4,5}.

This targeted survey generated baseline surveillance data on the levels of methylmercury and inorganic mercury in domestic and imported canned seafood products on the Canadian retail market. The CFIA sampled and analyzed 300 products, including 207 fish samples, 62 mollusk samples and 31 crustacean samples. Methylmercury was detected in 38% of samples and inorganic mercury was detected in 23% of samples tested. The levels of methylmercury and inorganic mercury in this targeted survey were comparable to those previously found in CFIA surveys and reported in literature.

Only 2 samples of the 50 canned albacore tuna samples analyzed in this survey contained methylmercury concentrations (0.74 and 0.67 ppm) that were above Health Canada's ML for total mercury in retail fish of 0.5 ppm. There are no regulations in Canada for mercury or methylmercury in the other products tested. Health Canada determined that none of the samples analyzed for metals in this survey posed a 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

Mercury contamination of the environment is often related to human activities, such as mining/smelting, burning of fossil fuels and other wastes, improper disposal of items containing mercury, as well as the industrial production of chemicals¹. Once mercury is dispersed in the environment, it does not readily break down and may be transported over long distances. When deposited in soils or water, it can accumulate in plants and be transferred to animals and humans that ingest these plants^{2,3,4}.

The adverse health effects of mercury depend on many factors, including the form of mercury ingested, the route of exposure (ingested, inhaled, absorbed through the skin), and the magnitude of the exposure. Acute (short-term) exposure can take the form of physical/visual disturbances, mental/cognitive disturbances and respiratory effects, kidney damage. Long-term exposures, either directly or prenatally, have been linked to decreased cognitive function, delays achieving physical milestones, blindness, and lack of muscle coordination^{2,3,4,6}. Infants and children are especially vulnerable to mercury exposure, and their developing nervous system is particularly sensitive to its effects^{1,2,3,4,5}.

Mercury can be found in various forms throughout the environment (air, water, soil, and biota). It is commonly found in combination with other elements. Inorganic mercury is formed when mercury combines with oxygen, chlorine, or sulphur. Organic mercury compounds (such as methylmercury) are formed when mercury combines with carbon and hydrogen, which may occur as a result of plant or animal metabolism^{1,6}. Chemical properties of methylmercury allow it to rapidly diffuse and tightly bind to proteins in the muscle tissue of fish. This leads to bioaccumulation in the fish, with the mercury level increasing with the age of the fish. Biomagnification along the food chain also leads to higher mercury levels in predatory fish (such

as tuna)⁷. Although inorganic mercury can bioaccumulate, it does so to a far lesser extent. In the majority of cases, analysis of food samples involves a measurement of the sum of all mercury (or total mercury) in the sample, regardless of the chemical form in which it is present. From a human health perspective, it is the amount of methylmercury, rather than total mercury that is of greatest interest, since methylmercury is much more readily absorbed into the human bloodstream. Several studies have measured the actual portion of total mercury that is present in fish as methylmercury. Although the levels can be variable, even among fish of the same species, the ratio of methylmercury to total mercury is usually high. As a result, for the purposes of health risk assessments, it is often assumed that 100% of the total mercury is in the methylated form⁴.

This survey aims to measure the levels and the proportion of methylmercury in seafood products. Fish and shellfish were the focus of this study as they are the primary source of dietary intake of mercury for humans⁴.

What we sampled

A variety of domestic and imported canned fish and shellfish (crustaceans and mollusks) were sampled between April 1, 2015 and March 31, 2016. 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, Ottawa), and
- 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.

Table 1. Distribution of samples based on origin

Product type	Number of domestic samples	Number of imported samples	Number of samples of unspecified ^a origin	Total number of samples
Fish	12	181	14	207
Shellfish	0	93	0	93
Crustaceans	0	31	0	31
Mollusks	0	62	0	62
Total	12	274	14	300

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 CFIA food testing laboratory. Generally, the results presented represent finished food products as sold and not as they would be consumed, whether the product sampled is considered an ingredient or requires preparation prior to consumption. Additionally, the packaging medium of fish products canned in water/broth/oil/sauce was mostly removed, so the fish portion could be assessed against the ML.

The maximum acceptable level of total mercury in retail fish (including canned tuna) is 0.5 ppm, with 6 exceptions (including fresh/frozen tuna) subject to 1.0 ppm standard⁶. The current standards for maximum levels of mercury in retail fish established by Health Canada assume that 100% of the total mercury levels are methylmercury⁴. No other standards have been established regarding mercury levels in seafood.

Results of the survey

A total of 300 domestic and imported canned fish, crustacean and mollusk products were tested for methylmercury and inorganic mercury in this targeted survey; 38% of samples had detected levels of methylmercury and 23% had detected levels of inorganic mercury, with 18% having detected concentrations of both types of analytes. Tables 2 and 3 below summarize methylmercury and mercury results by product types.

Table 2. Levels of methylmercury in fish and shellfish samples

Product type	Number of samples	Number of samples (%) with detected levels	Minimum (ppm)	Maximum (ppm)	Average ^b (ppm)
Fish	207	97 (47)	0.04	0.74	0.169
Shellfish	93	17 (18)	0.04	0.08	0.056
Mollusk	62	0	0	0	0
Crustacean	31	17 (55)	0.04	0.08	0.056
Total	300	114 (38)	0.04	0.74	0.152

Table notes

^b Only positive results were used to calculate average methylmercury levels.

Table 3. Levels of inorganic mercury in fish and shellfish samples

Product type	Number of samples	Number of samples (%) with detected levels	Minimum (ppm)	Maximum (ppm)	Average ^c (ppm)
Fish	207	55 (27)	0.03	0.19	0.071
Shellfish	93	14 (15)	0.03	0.06	0.044
Mollusk	62	10 (16)	0.03	0.06	0.037
Crustacean	31	4 (13)	0.04	0.06	0.050
Total	300	69 (23)	0.03	0.19	0.065

Table notes

^c Only positive results were used to calculate average inorganic mercury levels.

Only 2 samples of the 50 canned albacore tuna samples analyzed in this survey contained methylmercury concentrations (0.74 and 0.67 ppm) that were above Health Canada's ML for total mercury in retail fish of 0.5 ppm. In addition, when assuming that the total mercury content of each sample is equivalent to the sum of methylmercury and inorganic mercury concentrations, 2 additional samples of canned tuna, one 'light' and the other albacore, contained total mercury concentrations that were marginally greater than the ML (0.53 and 0.54 ppm, respectively). Health Canada has determined that these results were not expected to represent a health concern.

The portion of total mercury present in the samples as methylmercury was calculated for all samples that were positive for any form of mercury. The ratio of methylmercury to total mercury (assumed to be sum of methylmercury and inorganic mercury) was found to be on average 82% for fish and 56% for seafood. Although inconsistent sample size for each fish type did not allow full comparison, tuna which is known to be a predatory fish, was confirmed to on average have a higher methylmercury to total mercury ratio (87%, with a 62% to 100% range for 66 positive samples out of 80 samples).

What the survey results mean

The average, maximum and minimum methylmercury results in fish and seafood were compared to methylmercury and total mercury from previous survey years⁴ and scientific studies^{7,8,9,10,11} and were found to be generally comparable as shown in Table 4. Most samples with concentrations above average were tuna and mackerel samples for both methylmercury and inorganic mercury. The highest methylmercury levels were found in 2 albacore tuna samples at 0.74 and 0.67 ppm. Bioaccumulation of mercury, especially methylmercury, is common in predatory fish because of bioamplification. They accumulate the mercury present in their food source which itself has consumed methylmercury, leading to increased concentrations of that component higher in the food chain. Therefore, it was expected for predatory fish like tuna to have both higher total mercury concentrations and a higher proportion of methylmercury compared to forage fish species such as sardines. The levels observed for individual fish types

also often closely matched those reported in literature^{12,13}. The average levels reported in this survey are higher than those reported in comparable studies due to the difference in the limit of detection (LOD), leading to a different frequency of low levels recorded. As identified in a previous Canadian survey, canned fish (especially tuna) is expected to have lower mercury levels than fresh/frozen fish fillets⁸.

Shellfish generally contained lower levels of methylmercury and total mercury than fish. This was also observed in comparable scientific studies^{9,11,14}. The range of levels observed in this survey closely matched levels reported in scientific literature, also when methylmercury was compared to total mercury and a 56% ratio was considered. Methylmercury was not detected in mollusk samples in this survey, which is not unexpected as levels reported in literature are often lower than the LOD of the method used. For crustaceans, most of the samples that were positive for methylmercury were crab meat. Inorganic mercury was detected in other shellfish types however at very low levels of 0.03-0.06 ppm. Although the average levels of mercury in shellfish samples reported in the literature often vary due to differences like growth rate, body size and habitat characteristics¹¹, some studies also reported higher than the median level for crab meat⁹.

Health Canada has determined that the reported levels of methylmercury and inorganic mercury are safe and no product recalls were required.

Table 4. Minimum, maximum, and average concentration of methylmercury or total mercury (highlighted) across various studies

Product type	Study	Number of samples	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Fish (methyl mercury)	CFIA, 2015	207	0.04	0.74	0.169 ^d
Fish (methyl mercury)	Kuballa et al., 2011	503	<LOD ^e	0.567	0.049
Fish - Fresh or frozen tuna (total mercury)	Dabeka et al., 2004 ^g	13	0.02	2.12	0.93
Fish - Canned tuna (total mercury)	Dabeka et al., 2004 ^g	22	0.02	0.59	0.15
Fish (total mercury)	Basu et al., 2014	105	0.001	2.49	0.435
Fish (total mercury)	Olmedo et al., 2013	337	0.018	0.698	0.14 ^f
Shellfish (methyl mercury)	CFIA, 2015	93	0.04	0.08	0.056 ^d
Shellfish (methyl mercury)	Kuballa et al., 2011	83	<LOD ^e	0.084	0.021
Shellfish (total mercury)	Lena et al., 2018	15	0.070	1.197	0.331
Shellfish (total mercury)	Basu et al., 2014	21	0.003	0.138	0.023
Shellfish (total mercury)	Olmedo et al., 2013	148	0.003	0.145	0.003 ^f

Table notes

^d Only positive results were used to calculate average mercury levels.

^e Limit of detection (0.006 ppm).

^f Average based on median values.

^g Published in Health Canada's risk assessment. As assumed for the purpose of the health risk assessment total mercury is assumed to be 100% methylmercury.

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