



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Total Arsenic and Arsenic Speciation in Alcoholic Beverages, Fish, Shellfish and Crustaceans - April 1, 2018 to March 31, 2019

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.

Arsenic is a naturally occurring element that can be found in the Earth's crust. It is expected to be present at very low levels in food as a result of natural accumulation from the environment¹. Arsenic can exist in both organic and inorganic forms in food; the inorganic forms are widely considered to be much more toxic to humans. The amount and forms of arsenic found in foods is dependent on a number of factors such as food type, growing conditions, and processing techniques. Chronic exposure to inorganic arsenic may lead to a variety of detrimental health effects in humans, including affecting the gastrointestinal tract, kidneys, liver, lungs and skin as well as contributing to the risk of certain cancers^{2,3,4}.

The CFIA's regular monitoring activities examine the levels of total arsenic in various commodities but have not examined speciated arsenic to a great extent. As such, there is a need for surveillance data on the presence and levels of total arsenic as well as the various forms of arsenic, specifically the levels of inorganic arsenic, in Canadian retail products.

A total of 402 samples of grape-based alcoholic beverages, domestic fish and domestic shellfish and crustaceans were collected from retail locations in 6 cities across Canada and tested for arsenic. As expected, most (98.8%) of the survey samples contained traces of arsenic while inorganic arsenic was detected in 78.6% of products tested. When considering the levels of only the inorganic species (noted to be much more toxic to humans than other forms of arsenic), fish had the lowest average levels, whereas shellfish and crustaceans contained the highest average concentrations of inorganic arsenic. Inorganic arsenic was detected in all wine and shellfish and crustaceans samples tested.

The levels of arsenic detected in ready-to-serve beverage samples (alcoholic beverages) met the existing tolerances of 100 parts per billion (ppb). There are no regulations in Canada for metal levels in the other products tested. Health Canada (HC) determined that none of the samples analyzed for arsenic in this survey posed a concern to human health.

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

Arsenic is a naturally occurring element that can be found in the Earth's crust. Arsenic may be released into the air, water and/or soil through natural erosion/leaching or through man-made activities. The primary routes of human exposure to arsenic are through drinking water and food. The presence of arsenic in food is expected as a result of natural accumulation from the environment¹.

Arsenic can exist in both organic and inorganic forms in food; the inorganic forms are widely considered to be much more toxic to humans. The ratio of inorganic to organic arsenic species can vary widely depending on the source of contamination and the commodities in which it is present. While inorganic arsenic is the predominant species in drinking water, organic arsenic species are the main forms found in aquatic organisms (such as seaweed, fish, shellfish and crustaceans). Chronic exposure to inorganic arsenic may lead to a variety of detrimental health effects in humans, including affecting the gastrointestinal tract, kidneys, liver, lungs and skin as well as contributing to the risk of certain cancers^{2,3,4}.

The CFIA's regular monitoring activities examine the levels of total arsenic in various commodities but have not examined speciated arsenic. As such, there is a need for surveillance data on the presence and levels of total arsenic as well as the various forms of arsenic, specifically levels of inorganic arsenic, in Canadian retail products.

What did we sample

A variety of domestic and imported grape-based alcoholic beverages, domestic fish and domestic shellfish and crustaceans samples were sampled between April 1, 2018 and March 31, 2019. 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 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. Domestic products may indicate that they are manufactured or processed in Canada with domestic and/or imported ingredients. 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
Alcoholic beverages	62	167	21	250
Fish	92	0	0	92
Shellfish and crustaceans	60	0	0	60
Grand total	214	167	21	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 a CFIA laboratory which is ISO/IEC 17025 accredited for food testing. The results are based on the food products as sold and not necessarily as they would be consumed.

Contaminants and other adulterating substances in foods have regulatory maximum levels. In 2014 Health Canada established regulatory tolerances for arsenic in a variety of ready-to-serve beverages⁵. Compliance is assessed against the established tolerances available when the survey was carried out. In the absence of a specific maximum level, the levels of arsenic may be assessed by Health Canada on a case-by-case basis using the most current scientific data available.

What were the survey results

A total of 402 samples domestic and imported grape-based alcoholic beverages, and domestic fish and shellfish and crustaceans samples were analysed for arsenic and 6 arsenic species. Most (98.8%) of the survey samples contained traces of arsenic. Inorganic arsenic was detected in 78.6% of products tested.

When considering the levels of only the inorganic species (noted to be much more toxic to humans than other forms of arsenic), fish had the lowest average levels, whereas shellfish and crustaceans contained the highest average concentrations of inorganic arsenic. Inorganic arsenic was detected in all wine, shellfish and crustaceans samples tested. The proportions of inorganic arsenic varied across the commodity types tested in this survey, with wines containing the highest proportions of inorganic arsenic. The levels of arsenic detected in ready-to-serve beverage samples (alcoholic beverages) met the existing tolerances.

Table 2. Detected levels of arsenic in selected foods

Product type	Number of samples	Samples with detectable total (inorganic) Arsenic	Average^b total Arsenic (ppb)	Average^b inorganic Arsenic (ppb)
Alcoholic beverages	250	245 (192)	3.31	3.12
Wine	155	155 (155)	4.16	3.19
Other	95	90 (37)	1.85	2.79
Fish	92	92 (56)	1027	1.31
Shellfish and crustaceans	60	60 (60)	5832	34.28
Grand total	402	397 (308)	1121	8.86

^b Average values were calculated using only results for samples with quantifiable metal levels

Figure 1. Distribution of arsenic levels in alcoholic beverages

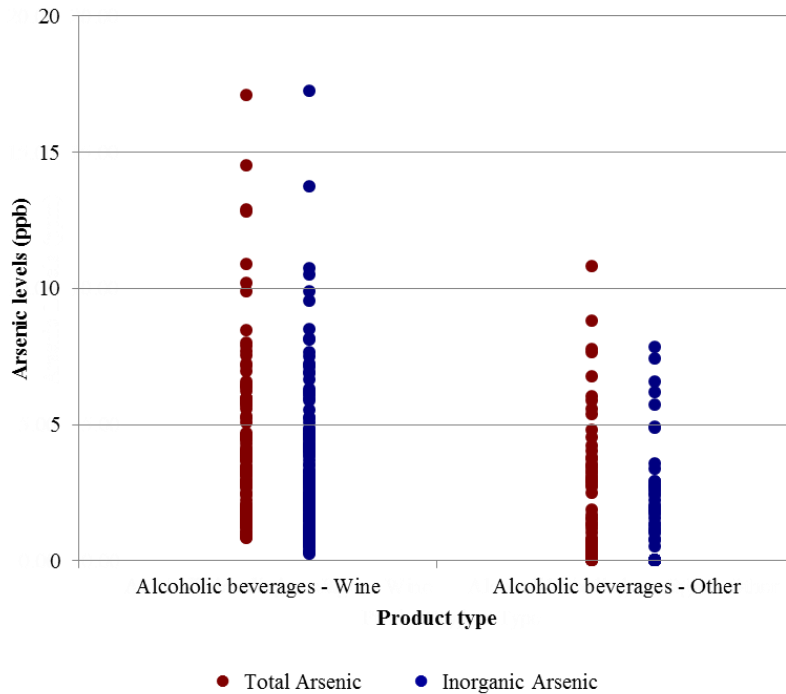
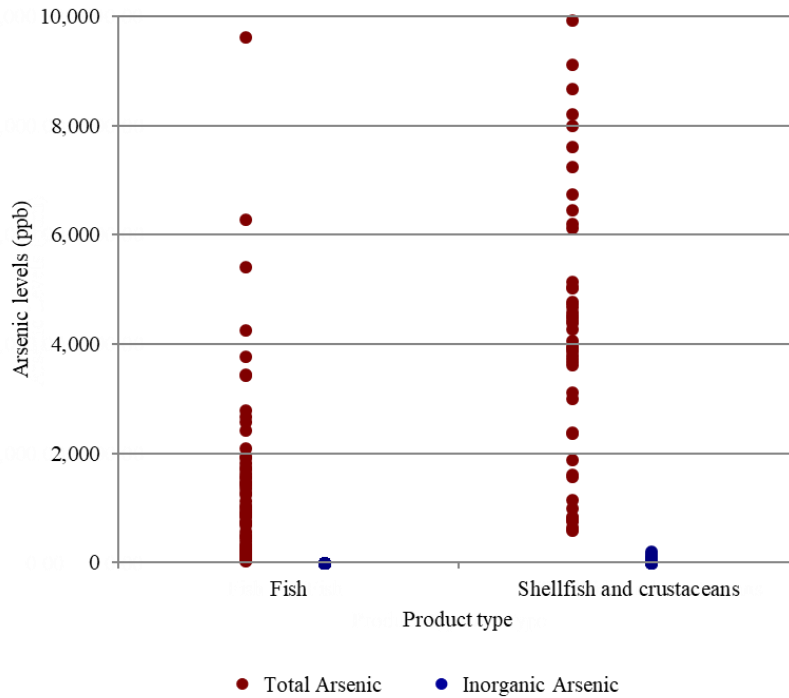


Figure 1 shows the ranges of total arsenic and inorganic arsenic concentrations in wine and other (vermouth, distilled spirits (cognac, brandy, sherry)) alcoholic beverages. Distilled spirits had the lowest inorganic arsenic levels.

Arsenic concentration detected in fish, shellfish and crustaceans samples tested are displayed in Figure 2. The ranges of total arsenic concentrations are wider than the range of inorganic arsenic levels detected in these commodities. These differences reinforce that the majority of arsenic species in aquatic products are organic in nature.

Figure 2. Distribution of arsenic levels in fish and shellfish and crustaceans



What do the survey results mean

The detection rates and the levels of arsenic reported in this targeted survey were comparable to those previously found in similar product types^{6,7}. The levels recorded for total and inorganic arsenic in alcoholic beverages tested in this survey closely matched those found in products tested in 2017 to 2018⁶. Some differences observed may be due to the specific type of product tested.

Of note is the disparity between the average concentrations of total arsenic in aquatic products (Table 3), as only 2 organic arsenic species were considered in the calculation of total arsenic in previous survey years⁷. Despite the large difference between the reported average total arsenic levels, the range of inorganic arsenic concentrations detected in these products from different survey years are in good agreement.

Table 3. Arsenic testing results from various survey years

Product type	Survey year	Number of samples	Samples with detectable total (inorganic) Arsenic	Average ^b total Arsenic (ppb)	Average ^b inorganic Arsenic (ppb)
Alcoholic beverages - Wine	2018 to 2019	155	155 (155)	4.16	3.19
Alcoholic beverages - Wine	2017 to 2018	76	76 (75)	4.89	3.53
Alcoholic beverages - Other	2018 to 2019	95	90 (37)	1.85	2.79
Alcoholic beverages - Other	2017 to 2018	142	96 (48)	1.66	2.27
Fish	2018 to 2019	92	92 (56)	1027	1.31
Shellfish and crustaceans	2018 to 2019	60	60 (60)	5832	34.28
Seaweed	2011 to 2013	145	145 (145)	271 ^c	37.19

^b Average values were calculated using only results for samples with quantifiable metal levels

^c A sum of 4 arsenic species; includes only 2 of the 4 possible organic arsenic species (DMA and MMA)

All survey results were forwarded to Health Canada for health risk assessment and were determined to pose no concern to human health.

References

1. [Dietary exposure to inorganic arsenic in the European population.](#) (PDF). (2014). The EFSA Journal, 12(10): 3597, pp.1-68.
2. [Monograph on the evaluation of carcinogenic risks to humans: Arsenic and arsenic compounds.](#) (PDF). (2012). International Agency for Research on Cancer.
3. [Fact sheet: Arsenic.](#) (2018). World Health Organization.
4. [Arsenic.](#) (2008). Canada. Health Canada.
5. [List of contaminants and other adulterating substances in foods.](#) (2018). Canada. Health Canada.
6. 2017-2018 Pesticides and Metals in Selected Foods. [unpublished results]. Canada. Canadian Food Inspection Agency.
7. [2011-2013 Arsenic Speciation in Selected Foods.](#) (2018). Canada. Canadian Food Inspection Agency.

Appendix A

Figure 1

Distribution of arsenic levels in alcoholic beverages

Product type: Alcoholic beverages - Wine (Concentration of total Arsenic [ppb])

- 17.1
- 14.5
- 13.2
- 12.9
- 12.8
- 10.9
- 10.2
- 9.89
- 9.88
- 9.41
- 8.61
- 8.46
- 8.41
- 8.35
- 8
- 7.92
- 7.89
- 7.68
- 7.53
- 7.24
- 7.16
- 6.97
- 6.68
- 6.57
- 6.48
- 6.42
- 6.39
- 6.38
- 6.36
- 6.23
- 6.13
- 5.96
- 5.94
- 5.84
- 5.78

- 5.75
- 5.69
- 5.56
- 5.32
- 5.3
- 5.22
- 5.21
- 5.08
- 4.92
- 4.77
- 4.67
- 4.62
- 4.61
- 4.6
- 4.54
- 4.5
- 4.45
- 4.43
- 4.31
- 4.24
- 4.23
- 4.14
- 4.05
- 4.04
- 4.03
- 3.97
- 3.92
- 3.91
- 3.87
- 3.8
- 3.78
- 3.73
- 3.72
- 3.68
- 3.66
- 3.55
- 3.48
- 3.42
- 3.41
- 3.38

- 3.36
- 3.35
- 3.33
- 3.27
- 3.24
- 3.21
- 3.2
- 3.18
- 3.17
- 3.12
- 3.11
- 2.93
- 2.91
- 2.9
- 2.89
- 2.86
- 2.83
- 2.79
- 2.75
- 2.74
- 2.71
- 2.69
- 2.5
- 2.43
- 2.42
- 2.2
- 2.05
- 2.03
- 2.01
- 2
- 1.98
- 1.96
- 1.9
- 1.88
- 1.86
- 1.81
- 1.78
- 1.77
- 1.76
- 1.73

- 1.66
- 1.65
- 1.63
- 1.61
- 1.58
- 1.53
- 1.47
- 1.45
- 1.44
- 1.43
- 1.39
- 1.36
- 1.33
- 1.3
- 1.29
- 1.25
- 1.24
- 1.23
- 1.16
- 1.06
- 0.99
- 0.89
- 0.88
- 0.85
- 0.84
- 0.71
- 0.68

Product type: Alcoholic beverages - Other (Concentration of total Arsenic [ppb])

- 10.8
- 8.82
- 7.78
- 7.66
- 6.77
- 6.03
- 5.89
- 5.58
- 5.37
- 4.79
- 4.51

- 4.21
- 4.03
- 3.8
- 3.72
- 3.52
- 3.5
- 3.4
- 3.31
- 3.23
- 3.08
- 3.04
- 2.99
- 2.96
- 2.95
- 2.88
- 2.85
- 2.75
- 2.72
- 2.49
- 1.87
- 1.68
- 1.55
- 1.5
- 1.38
- 1.34
- 1.28
- 1.18
- 1.02
- 0.81
- 0.75
- 0.73
- 0.72
- 0.68
- 0.64
- 0.62
- 0.6
- 0.51
- 0.5
- 0.46
- 0.44

- 0.43
- 0.4
- 0.39
- 0.38
- 0.37
- 0.36
- 0.34
- 0.31
- 0.3
- 0.29
- 0.28
- 0.26
- 0.25
- 0.24
- 0.23
- 0.22
- 0.21
- 0.2
- 0.19
- 0.18
- 0.16
- 0.15
- 0.13
- 0.12
- 0

Product type: Alcoholic beverages - Wine (Concentration of inorganic Arsenic [ppb])0

- 17.26
- 13.73
- 10.72
- 10.5
- 9.89
- 9.53
- 8.51
- 8.13
- 8.11
- 7.63
- 7.49
- 7.24
- 7.2

- 7.09
- 6.92
- 6.86
- 6.63
- 6.3
- 6.23
- 6.15
- 6.07
- 5.96
- 5.88
- 5.54
- 5.27
- 5.23
- 5.07
- 4.84
- 4.83
- 4.74
- 4.67
- 4.64
- 4.62
- 4.58
- 4.48
- 4.45
- 4.43
- 4.31
- 4.27
- 4.26
- 4.22
- 4.21
- 4.18
- 4.18
- 4.13
- 4.03
- 4.01
- 3.99
- 3.85
- 3.82
- 3.69
- 3.51
- 3.5

- 3.31
- 3.29
- 3.27
- 3.21
- 3.11
- 3.09
- 3.07
- 3.01
- 2.96
- 2.92
- 2.89
- 2.87
- 2.86
- 2.85
- 2.83
- 2.74
- 2.68
- 2.67
- 2.58
- 2.49
- 2.46
- 2.41
- 2.4
- 2.37
- 2.36
- 2.29
- 2.28
- 2.27
- 2.24
- 2.2
- 2.19
- 2.17
- 2.13
- 2.1
- 2.02
- 1.97
- 1.94
- 1.93
- 1.86
- 1.84

- 1.82
- 1.73
- 1.67
- 1.65
- 1.62
- 1.61
- 1.59
- 1.57
- 1.53
- 1.52
- 1.43
- 1.33
- 1.24
- 1.2
- 1.18
- 1.16
- 1.14
- 1.13
- 1.11
- 1.09
- 1.08
- 1.06
- 1.05
- 1.03
- 1.02
- 1
- 0.99
- 0.92
- 0.9
- 0.88
- 0.82
- 0.79
- 0.78
- 0.76
- 0.74
- 0.73
- 0.72
- 0.71
- 0.68
- 0.66

- 0.56
- 0.55
- 0.53
- 0.51
- 0.35
- 0.33
- 0.27
- 0.25

Product type: Alcoholic beverages - Other (Concentration of inorganic Arsenic [ppb])

- 7.84
- 7.43
- 6.55
- 6.19
- 5.72
- 4.9
- 4.88
- 3.56
- 3.35
- 2.92
- 2.9
- 2.8
- 2.77
- 2.76
- 2.69
- 2.64
- 2.56
- 2.46
- 2.4
- 2.23
- 2.01
- 1.97
- 1.93
- 1.86
- 1.81
- 1.78
- 1.71
- 1.54
- 1.37
- 1.29

- 1.19
- 1.08
- 1.07
- 1.03
- 0.79
- 0.75
- 0.53
- 0

Figure 2

Distribution of arsenic levels in fish and shellfish and crustaceans

Product type: Fish (Concentration of total Arsenic [ppb])

- 9620
- 6270
- 5420
- 4250
- 3780
- 3440
- 3430
- 2790
- 2680
- 2580
- 2430
- 2090
- 1950
- 1920
- 1820
- 1750
- 1710
- 1640
- 1570
- 1550
- 1490
- 1470
- 1450
- 1420
- 1370
- 1280
- 1250
- 1130

- 1030
- 983
- 932
- 901
- 895
- 881
- 859
- 851
- 754
- 740
- 722
- 699
- 579
- 497
- 492
- 465
- 411
- 331
- 316
- 310
- 284
- 276
- 261
- 259
- 242
- 240
- 234
- 221
- 212
- 208
- 206
- 203
- 197
- 183
- 175
- 173
- 148
- 145
- 120
- 118

- 115
- 113
- 106
- 90.2
- 83.2
- 78.9
- 75.4
- 75.1
- 73.7
- 72
- 68.7
- 66.9
- 66.8
- 64.2
- 60.4
- 59.5
- 57.5
- 56.9
- 53.7
- 44.9

Product type: Shellfish and crustaceans (Concentration of total Arsenic [ppb])

- 19090
- 17670
- 16360
- 14960
- 14470
- 12700
- 11770
- 11500
- 11390
- 11000
- 10100
- 9930
- 9120
- 8670
- 8200
- 8000
- 7600
- 7240

- 6750
- 6450
- 6200
- 6130
- 5150
- 5040
- 5020
- 4780
- 4730
- 4680
- 4580
- 4530
- 4480
- 4430
- 4400
- 4270
- 4060
- 3950
- 3940
- 3900
- 3880
- 3800
- 3740
- 3670
- 3620
- 3120
- 3000
- 2380
- 2360
- 1880
- 1610
- 1570
- 1160
- 998
- 855
- 827
- 782
- 781
- 773
- 658

- 615
- 603

Product type: Fish (Concentration of inorganic Arsenic [ppb])

- 2.12
- 1.98
- 1.93
- 1.87
- 1.86
- 1.79
- 1.69
- 1.64
- 1.59
- 1.57
- 1.55
- 1.49
- 1.48
- 1.47
- 1.45
- 1.44
- 1.41
- 1.39
- 1.38
- 1.35
- 1.32
- 1.31
- 1.29
- 1.25
- 1.24
- 1.23
- 1.22
- 1.21
- 1.2
- 1.19
- 1.16
- 1.15
- 1.12
- 1.1
- 1.05
- 1.03

- 1.02
- 1.01
- 0.98
- 0.9
- 0.89
- 0.88
- 0.87
- 0.86
- 0.68
- 0

Product type: Shellfish and crustaceans (Concentration of inorganic Arsenic [ppb])

- 219.5
- 166.9
- 131.7
- 101.5
- 96.8
- 77.3
- 76.04
- 73
- 72.8
- 62.9
- 61.53
- 59.7
- 54.9
- 43.2
- 37
- 35.7
- 35.61
- 35.3
- 31
- 28.88
- 28.67
- 23.42
- 23.4
- 22.5
- 20.54
- 19.9
- 19.5
- 19.2

- 19
- 18.1
- 17.5
- 16.6
- 15.9
- 15.1
- 14.3
- 14.2
- 13.8
- 13.7
- 13.5
- 12.7
- 11.7
- 11.2
- 10.8
- 10.7
- 10
- 9.94
- 9.85
- 9.41
- 8.66
- 7.33
- 6.11
- 5.84
- 4.81
- 2.35
- 1.87