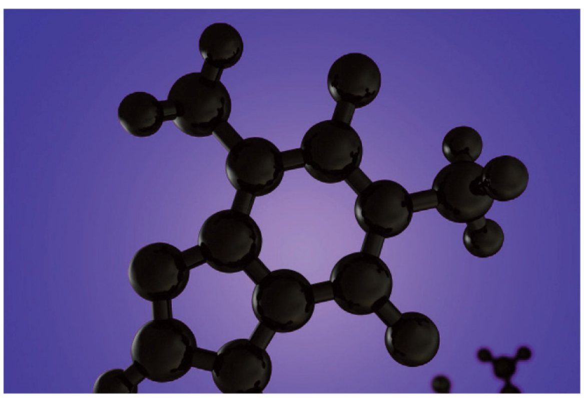
Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Chemistry



Mercury in Tea, Soft Drinks and Corn Syrup

TS-CHEM-10/11-13

Canada

Table of Contents

Executive Summary

The Food Safety Action Plan (FSAP) aims to modernize and enhance Canada's food safety system. As part of the FSAP enhanced surveillance initiative, targeted surveys are used to test various foods for specific hazards.

The main objectives of the 2010-11 Mercury Targeted Survey were to:

- Establish a baseline of information on mercury residues in specific commodities
- Continue the sampling and analysis of dried tea and compare with results obtained from the 2009-10 survey to assess year-to-year variability.
- Investigate the potential that products containing or manufactured using high fructose corn syrup could contain detectable levels of mercury

A total of 386 samples were collected from 11 cities across Canada and analysed for 19 metal residues, most notably mercury. Samples consisted of dried tea, soft drinks and corn syrups.

Overall, 53% of the samples tested did not contain any detectable residues of mercury. Of the remaining 47%, dried tea had the highest prevalence of detectable mercury (87% of dried tea samples contained detectable levels of mercury) and also exhibited the highest concentration of mercury observed in any of the samples tested (0.023 ppm). Soft drinks and corn syrup samples had a much lower frequency of detectable residues of mercury (only 6% and 10% respectively), and also had much lower maximum concentrations of mercury detected (0.011 ppm and 0.0002 ppm respectively). There are currently no established mercury guidelines or tolerances for the commodities tested in this survey.

When the results of the dried tea samples from this year and previous years are compared, it was found that the maximum and average values of mercury detected were similar; however the percentage of samples with detectable levels of mercury were much higher in the current year's survey.

From the results of this survey, it is apparent that the prevalence and levels of mercury detected in soft drinks and corn syrups is exceedingly low, indicating that mercury is not of concern in the products tested.

1 Introduction

1.1 Food Safety Action Plan

In 2007, the Canadian government launched a five-year initiative in response to a growing number of product recalls and concerns about food safety. This initiative, called the Food and Consumer Safety Action Plan (FCSAP), aims to modernize and strengthen the food safety regulatory system. The FCSAP initiative unites multiple partners in ensuring safe food for Canadians.

The CFIA's Food Safety Action Plan (FSAP) is one element of the government's broader FSCAP initiative. The goal of FSAP is to identify risks in the food supply, limit the possibility that these risks occur, improve import and domestic food controls and identify food importers and manufacturers. FSAP also looks to verify that the food industry is actively applying preventative measures, and that there is a rapid response when/if these measures fail.

Within FSAP, there are twelve main areas of activity, one of which is risk mapping and baseline surveillance. The main objective of this area is to better identify, assess, and prioritize potential food safety hazards through risk mapping, information gathering, and testing foods from the Canadian marketplace. Targeted surveys are one tool used to test for the presence and level of a particular hazard in specific foods. Targeted surveys are largely directed towards the 70% of domestic and imported foods that are regulated solely by the *Food and Drugs Act & Regulations,* and are generally referred to as non-federally registered commodities.

1.2 Targeted Surveys

Targeted surveys are pilot surveys used to gather information regarding the potential occurrence of chemical residues in defined commodities. The surveys are designed to answer specific questions therefore, unlike monitoring activities, testing of a particular chemical hazard is targeted to commodity types and/or geographical areas.

Due to the vast number of chemical hazards and food commodity combinations, it is not possible, nor should it be necessary, to use targeted surveys to identify and quantify all chemical hazards in foods To identify food-hazard combinations of greatest potential health risk, the CFIA uses a combination of scientific literature, media reports, and/or a risk-based model developed by the Food Safety Science Committee (FSSC).

The human health risks associated with exposure to mercury have been well documented. It has been shown that children are especially vulnerable to the effects of mercury, with the potential for delayed or stunted neurological development[1]. Based on reports finding detectable mercury levels in products containing high fructose corn syrup, and the unexpected prevalence of detected mercury in dried tea samples analyzed in a 2009-10

CFIA FSAP targeted survey, a survey devoted specifically to examining mercury levels in these commodities was timely.

1.3 Acts and Regulations

The *Canadian Food Inspection Agency Act* stipulates that the CFIA is responsible for enforcing restrictions on the production, sale, composition and content of foods and food products as outlined in the *Food and Drugs Act & Regulations* (FDAR).

Health Canada establishes the maximum levels (tolerances, standards) for contaminants in food and maximum residue limits for pesticide residues in food. Currently, there are two standards established for mercury in the edible portions of fish. There are no specific Canadian maximum levels for mercury tolerances established for any of the commodities tested in this survey.

Foods for which contaminant standards have not been established may still contain low levels of mercury. Standards have not been established in these foods because their consumption presents a low health risk to the general Canadian population. Despite the limited number of general standards for mercury in food, higher than average levels of mercury in specific foods may still be scrutinized by Health Canada. Health Canada assesses any findings of elevated levels of mercury in food on a case-by-case basis using the most current scientific data available. If levels of mercury in food are deemed to be unsafe, corrective actions (such as public recalls, product retention and/or the establishment of maximum levels) may be taken by the CFIA and Health Canada.

In the United States, a maximum allowable concentration of mercury in drinking water has been established at 0.002 ppm, and action levels of 1 ppm have been established for both aquatic products (fish, shellfish, crustaceans, other aquatic animals) and wheat (pink kernels only)[2]. The Guidelines for Canadian Drinking Water Quality stipulate a Maximum Acceptable Concentration (MAC) for mercury of 0.001 ppm.

Internationally, a number of maximum levels have been established by the Codex Alimentarius, an international organization that establishes global food standards based on the scientific advice from the Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO). Both mercury and methylmercury (a highly toxic and readily absorbed form of mercury) standards have been established for marine-based commodities, mineral water and food grade salt[3]. Australian/New Zealand food standards include specific limits for mercury in certain types of fish products[4]. Likewise, the European Union (EU) has established specific maximum limits for mercury in fish products and food supplements[5].

2 Survey Specific Information and Rationale

2.1 Mercury

Mercury is a metal that can be toxic to humans in very small doses. Although it can be found in its elemental form (Hg), it is more commonly found in combination with other elements. Inorganic mercury is formed when mercury combines with oxygen, chlorine or sulphur which naturally occurs in soils and rocks. Organic mercury compounds are formed when mercury combines with carbon and hydrogen, which may occur as the result of plant or animal metabolism.

Mercury can be found in various forms throughout the environment (air, water, soil and biota). Mercury contamination of the environment is often related to human activities, such as mining/smelting, burning of fossil fuels and other wastes, as well as the industrial production of chemicals. Once mercury is dispersed in the environment, it does not readily break down and may be transported over long distances. Once deposited in soils or water, it may be accumulated in plants, and be transferred to animals that ingest these plants, resulting in higher concentrations than are seen in the environment.

Mercury has commonly been used as a component of thermometers, scientific equipment, fluorescent lamps and dental amalgam material. It has also been used for the manufacture of industrial chemicals and in electrical applications; however, due to health and safety concerns many of these applications are being phased out.

The health effects of mercury depend on the form to which an individual has been exposed (elemental, inorganic or organic), the route of exposure (ingested, inhaled, absorbed through the skin), and the magnitude of the exposure[1]. Acute (short-term) exposure can take the form of respiratory distress, effects on the digestive and renal systems, as well as neurological effects (seizures, muscle twitches, personality changes, memory loss, etc.). Long-term exposures, either directly or pre-natally, have been linked to decreased cognitive function, delays achieving physical milestones, blindness, and lack of muscle coordination[6,7]. Infants and children are especially vulnerable to mercury exposure, and their developing nervous system is particularly sensitive to the effects of mercury.

2.2 Mercury in Tea

Tea plantations can remain in production for more than 50 years. Throughout this time, many applications of fertilizers and pesticides may occur, leading to an accumulation of metals and other chemicals in the soil. Additionally, many of the regions where tea is grown are also subject to increased atmospheric deposition of metals as a result of industrial activities and pollution.

Due to the physiology of the tea plant, it preferentially grows in acidic soils[8,9]. Over time, soils of a tea plantation become increasingly acidic. Generally, high acidity soil favours the dissociation of some metals from the soil, making them more available for uptake in the tea plant roots[8]. The quality of water used in irrigation also contributes to the quality of the soil and in turn the quality of the tea plant. Increased metal content in irrigation water may increase soil concentrations.

In 2009, an FSAP targeted survey examined the levels of pesticides and metals in dried tea samples. Mercury was detected in 32% of the dried tea samples collected, with levels ranging from below the limit of detection (LOD) (0.0007 ppm) to 0.030 ppm, with the maximum occurring in dried green tea leaves. Dried green tea leaves also exhibited the highest average mercury concentration (0.004 ppm).

Little is known about the source of the mercury accumulated by tea plants, the mechanism by which tea might accumulate mercury, or how mercury might be transferred to steeped tea from leaves containing measurable concentrations of mercury. Mercury has been used as a component of fungicides in the past; it may be present as a contaminant of both the water used to irrigate tea plantations, or as a product of atmospheric deposition onto soils or the tea plants themselves. Mercury may be directly absorbed through the leaves subjected to this atmospheric deposition, or may be transferred from the soil/groundwater, via roots. Research on the accumulation and distribution of other metals in tea plants has suggested that among various elements assimilated by the tea plant, metals can be differentially accumulated in different portions of the plant[10] and that the young leaves of a tea plant (the leaves most likely to be processed for tea) accumulate the lowest proportions of metals[11]. This same study suggests that the concentration of various metals in young shoots were linearly correlated with the extractable metal levels in the soil.

With respect to the proportions of metals leached from the dried leaves into the brewed tea, there have been a few studies that examined various metals [10, 12, 13, 14, 15, 16, 17, 18]. Due to the very different properties of the metals measured in these studies, the percentage transfer of metals also differed widely. Little mercury-specific information could be found regarding the levels of mercury detected in tea infusions. One study performed in 1983 found that mercury in tea leaves ranged from 4-32 ppb, which is very similar to the values found in the previous FSAP survey; and that transfer into the drinkable portion of brewed tea was quantified at up to 34%[18].

The current Mercury in Tea Survey looks to expand on the results from last year's survey, and provide more information on the prevalence and magnitude of mercury in dried tea leaves.

2.3 Mercury in Corn Syrups and Soft Drinks

One of the industrial uses of mercury has been in the production of caustic soda and other chlorine products. Chlor-alkali producers have used mercury cell technology to manufacture products such as hydrochloric acid, sodium hypochlorite, and caustic soda[19], which have applications as food additives or ingredients. The use of mercury-cell technology in the chlor-alkali industry is being phased out around the world due to the environmental concerns associated with its use[20]. However, these efforts are ongoing and there are still a number of plants using this technology around the globe[21, 22].

Although the use of these additives/ingredients is intended to be in the form of "food-grade" chemicals (i.e. having specific levels of purity so as to not represent a health hazard to consumers), there have been reports that products containing high fructose corn syrup (HFCS) have exhibited measurable levels of mercury[23,24]. This mercury may be present due to the use of non-food grade chlorine products during the manufacture of HFCS[25].

The following diagram shows the process by which HFCS is produced:

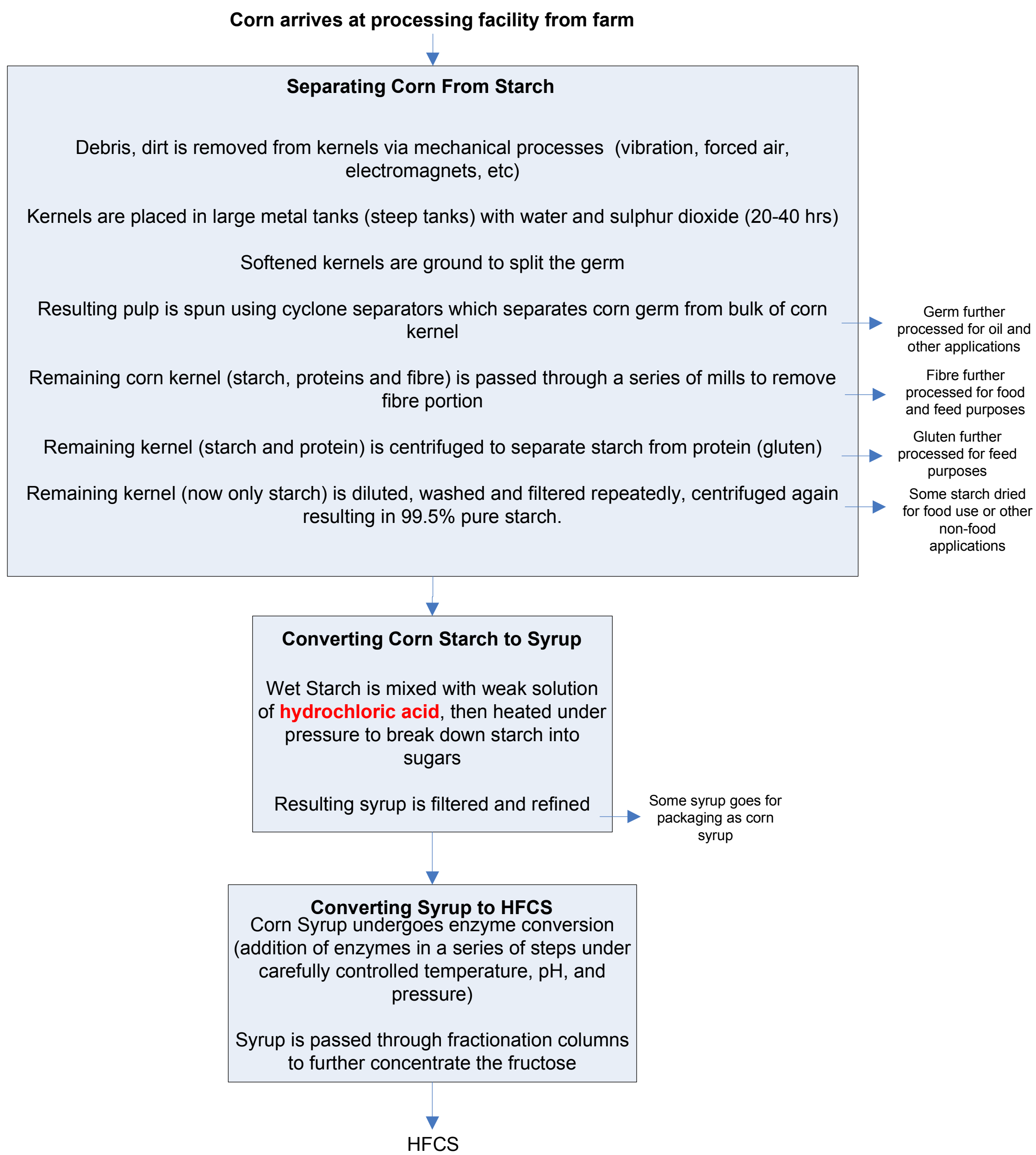


Figure 1. Process Diagram for the Production of High Fructose Corn Syrup.

As seen in the above diagram, there is a point in the HFCS process where chlor-alkali products are introduced (see hydrochloric acid in red). This survey looks to determine if products containing high proportions of HFCS (such as soft drinks), or originate from the same process that manufactures HFCS (as is the case with corn syrup), may contain measurable residues of mercury.

2.4 Rationale

Tea is a highly consumed beverage in Canada; in 2009, the per capita consumption of tea was 79.4 L/year[26]. There is little information available in the academic literature regarding mercury levels in tea. Therefore, it was thought timely to examine both the magnitude and prevalence of this metal in dried tea leaves.

Consumption of refined sugars (which includes HFCS) increased by 1.0 kg in 2008, reaching a per capita consumption of 23.1 kg refined sugar/year[26]. Given recent media reports of measurable levels of mercury being detected in HFCS products, and based on the prevalence of HFCS in Canadian foodstuffs, a targeted survey examining these products was undertaken.

From this survey, the CFIA will gain a better perspective on the baseline levels of mercury found in the commodity types tested herein (dried tea, corn syrups, and soft drinks), and this information may be used in future health risk assessments conducted on mercury exposure.

2.5 Sample Distribution

A total of 386 samples were collected for the 2010-11 Mercury Targeted Survey. Samples belonged to three different commodity categories: soft drinks, corn syrups and dried tea.

Samples originated from both domestic and imported sources. The samples were collected from retail locations in 11 different cities across Canada between October 2010 and March 2011.

2.6 Method Details

Tea samples were analyzed by an accredited, third-party laboratory. Third party laboratories are accredited to ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories* (or its equivalent by the Standards Council of Canada (SCC)).

Using an accredited method, all samples were analyzed using inductively coupled plasma mass spectrometry (ICP-MS) for the following 19 metals: aluminum, antimony, arsenic, beryllium, boron, cadmium, chromium, copper, iron, mercury, manganese, magnesium, molybdenum, nickel, lead, selenium, tin, titanium and zinc. Table 1 lists the limit of detection (LOD) for each metal.

Table 1. Detailed list of LODs used in the ICP-MS method for the determination of 19 metals		
ANALYTE	**Limit of Detection (LOD): Hydrated products**	**Limit of Detection (LOD): Dehydrated products**
Aluminum	0.1	0.5
Arsenic	0.005	0.025
Boron	0.05	0.25
Beryllium	0.02	0.1
Cadmium	0.002	0.01
Chromium	0.01	0.05
Copper	0.030	0.15
Iron	0.3	1.5
Magnesium	0.05	0.25
Manganese	0.02	0.1
Molybdenum	0.02	0.1
Nickel	0.01	0.05
Lead	0.002	0.01
Antimony	0.02	0.1
Selenium	0.02	0.1
Tin	0.02	0.1
Titanium	0.05	0.25
Zinc	0.1	0.5
Mercury	**0.0001/ 0.0005***	**0.0005**

* LOD sample for liquid samples/LOD for dry samples.

2.7 Limitations

A total of 386 samples were collected and analysed for the 2010-11 mercury targeted survey. In comparison to the number of HFCS-containing products and types of dried tea available to Canadian consumers, 386 samples represents a relatively small fraction of all products available. This data is intended to provide a snapshot of the targeted commodities, and is not meant to be representative of all the products available nationally. This survey does not examine long-term temporal trends, impact of product shelf life or cost of the commodity on the open market. It is important to note that, especially in the case of tea samples, products often contained the statement “processed in Country X”. Although this statement is true, it does not identify the true origins of the ingredients of the products (i.e. tea processed in Canada or England does not contain leaves grown in those countries). Therefore, no distinct comparison could be made regarding country of origin and the mercury levels in products associated with that country.

3 Results

Of the 386 samples collected and analyzed during the 2010-11 mercury targeted survey 143 were soft drinks, 50 were corn syrups and 193 consisted of dried tea samples. See

Figure 2 for a breakdown of each sample type, as well as the number of samples for which mercury was not detected.

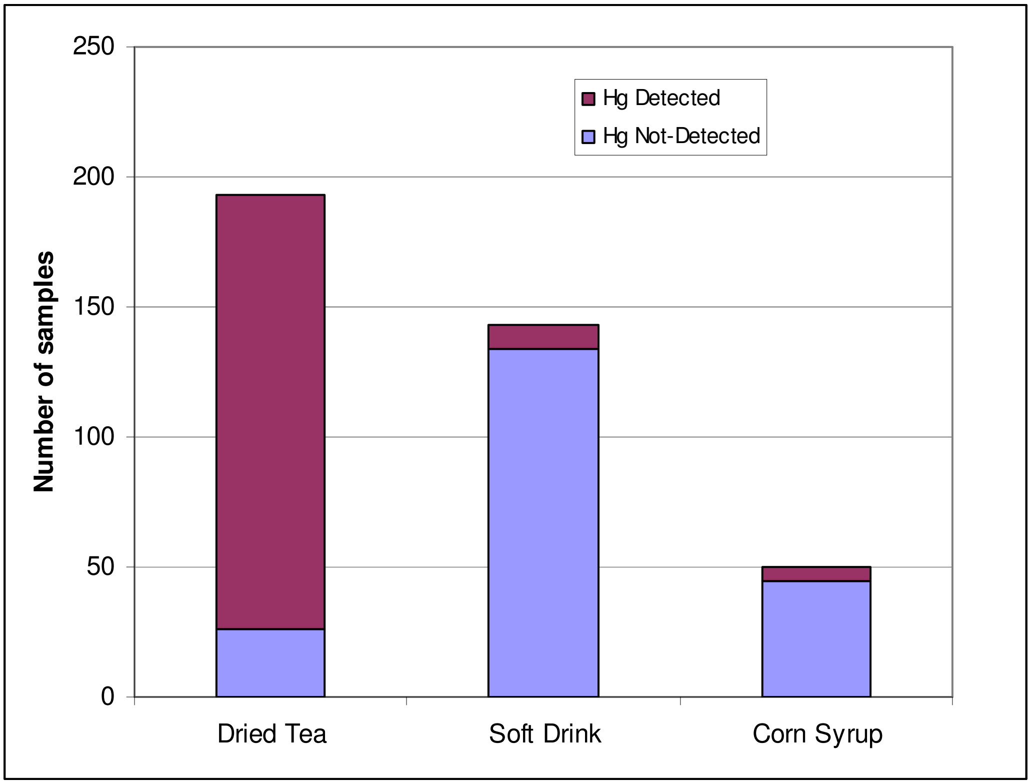


Figure 2. Distribution of samples by commodity type

Soft drinks and corn syrups had similar percentages of samples with no detectable levels of mercury (94% and 90%, respectively), whereas only 13% of dried tea samples had no detectable residues of mercury.

The maximum concentration of mercury observed in this survey (0.023 ppm) was found in a sample of dried black tea. This was higher than the maximum concentrations found in both drinks (0.011 ppm) and syrups (0.0002 ppm).

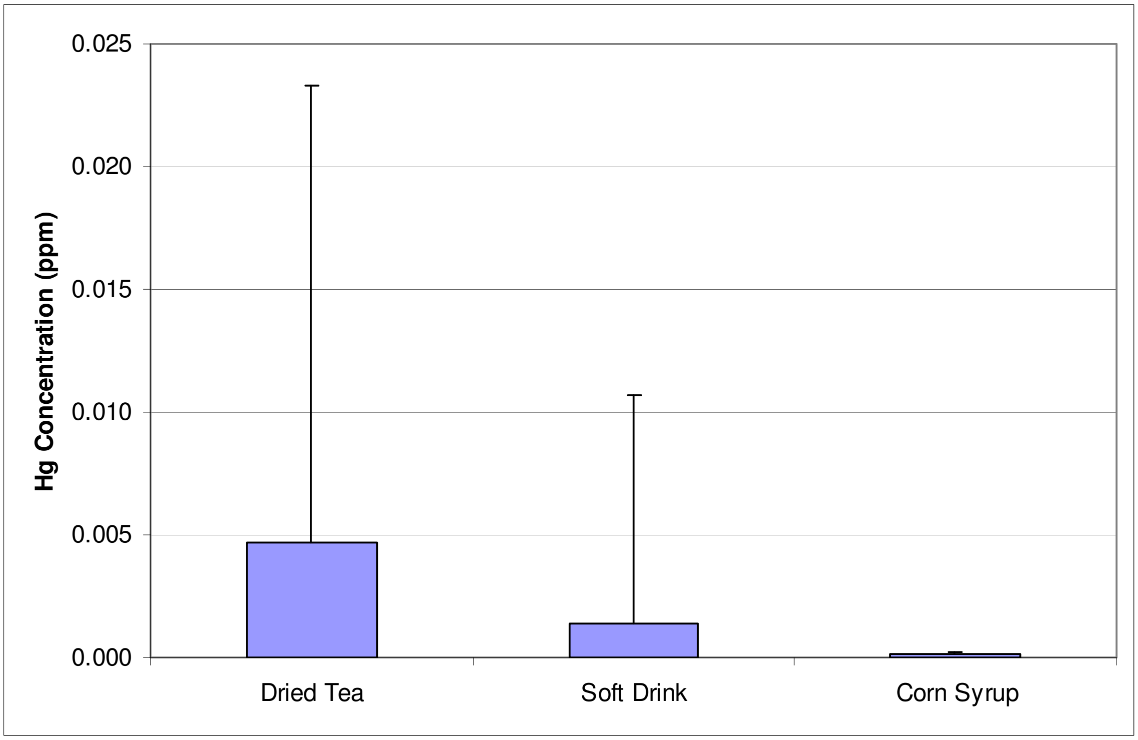


Figure 3. Average and maximum concentrations of mercury detected by product type (solid bars indicate average concentration of samples with detectable Hg levels, error bars indicate the maximum Hg value observed for each commodity)

3.1 Mercury in Tea

A total of 193 dried tea samples were collected for this survey. Samples consisted of a variety of black teas, green teas, herbal teas and other miscellaneous tea types. Of the dried tea samples tested, 86.5% contained detectable levels of mercury. The maximum mercury concentration amongst the tea types was 0.023 ppm in a sample of dried black tea. The average concentration of mercury in teas that had detectable levels of mercury was similar amongst the tea types sampled. See Table 2 and Figure 4 for a comparison of the average and maximum levels observed.

Table 2. Distribution of tea samples and Hg levels observed

Tea Type	Examples	N (detects)	Average (ppm)	Max (ppm)
Black tea	Orange pekoe, Ceylon, Earl Grey	51	0.0042	**0.0233**
Green tea	Japanese green tea, green tea with herbal ingredients	46	0.0047	0.0128
Herbal tea	Chamomile, mint, jasmine	47	**0.0053**	0.0153
Other tea	Unspecified- may include types found above	15	0.0044	0.0135
TOTAL		159	0.0047	0.0233

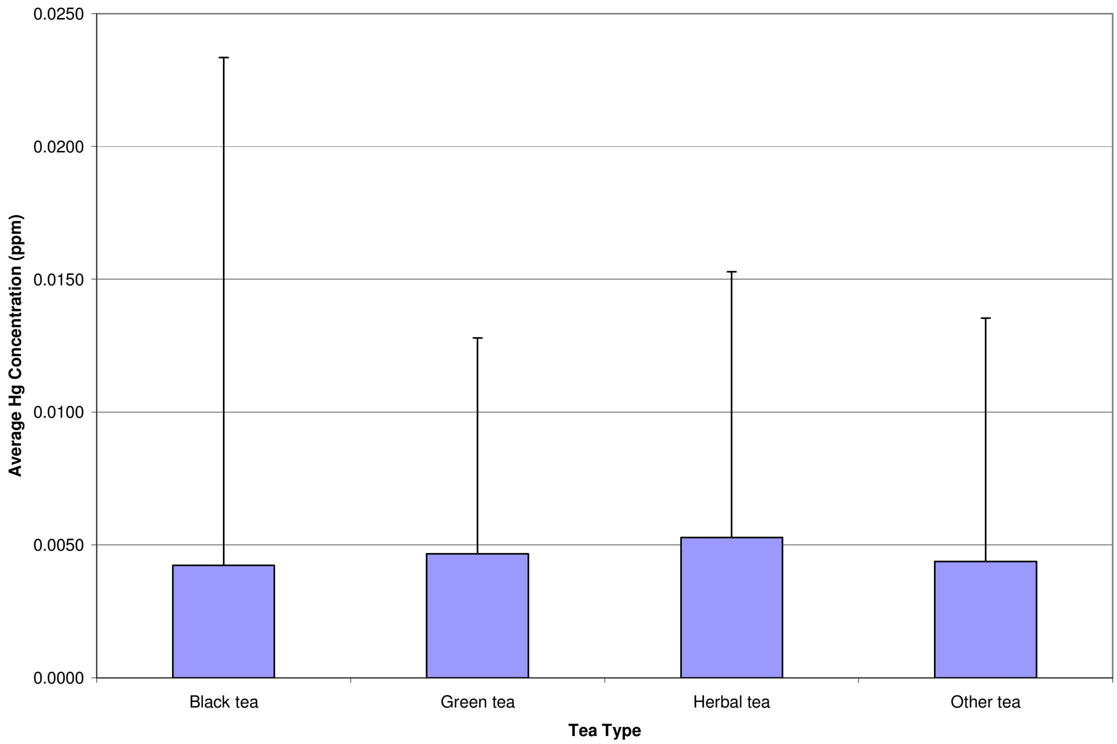


Figure 4. Average (bars) and maximum (lines) levels of Hg observed in dried tea types. (Averages were calculated using only those samples with detectable levels of Hg)

3.2 Mercury in Soft Drinks

A total of 143 samples of soft drinks were collected and analyzed for mercury as outlined in section 2.6. Samples consisted of cola drinks, citrus drinks (such as lime and orange-based sodas), ginger drinks (such as ginger ale and ginger beers), and other drinks (such as root beers and other various soft drinks). A total of 108 samples originated from Canada, with the remaining 35 originating from Ecuador, Italy, Jamaica, USA, the UK, or from unverifiable origins. Only nine of the drink samples analysed (6.3%) contained detectable levels of mercury. Levels of mercury detected in the nine positive drink samples ranged from 0.00012 to 0.0107 ppm. The average concentration based on those drink samples with detectable residues was 0.0014 ppm. All of the drink samples with detectable levels of mercury were of domestic origin. There did not appear to be any specific type of soft drink that had a greater prevalence of detectable mercury.

3.3 Mercury in Corn Syrup

A total of 50 samples of corn syrup (i.e. light corn syrup, golden corn syrup) were analyzed as per section 2.6. Fourteen samples originated from Canada, while 30 originated from the US (n=29) or the UK (n=1), and six samples were of unverifiable origin. A total of 45 corn syrup samples (90%) contained no detectable level of mercury. The maximum concentration of mercury detected was 0.00026 ppm. The average concentration of mercury in corn syrup samples found to have a detectable level was

0.00016 ppm. The maximum values observed for each country sampled was similar (Canada=0.00016 ppm, US=0.00012 ppm, UK=0.00026 ppm).

4 Discussion

As can be seen from the results above, the levels of mercury detected in the products tested were exceedingly low (in the low ppb to ppt range). The low prevalence of detectable mercury residues in soft drinks and corn syrup indicates that mercury is not a concern in these products.

In dried tea, the occurrence and levels of mercury were significantly higher than those observed in soft drinks and corn syrup. It is important to consider the nature of the commodities when comparing overall mercury levels observed. Tea is generally sold as a dried product. During the drying process, up to a 77% reduction of water content can occur[27]. Because metals are generally stable in the plant tissues during this drying process, any metal residue will be concentrated as the tea leaves undergo the drying procedure. Likewise, spices have been reported to contain similar concentrations of mercury (0.008 ppb) [28]. This would indicate that the levels of mercury in fresh plants are concentrated during the drying process, which would reduce spices and dried tea to a similar moisture content.

It should also be noted that this product was analysed for mercury "as it is sold", not "as it would be consumed". Based on information found in the academic literature, it has been estimated that between 19% and 34% of the mercury content in tea leaves would be transferred after the brewing of tea with boiling water[18]. Results from total diet studies performed in Canada indicate that fish is the most significant contributor of mercury to the total dietary intake for groups above 1 year[29]. Furthermore, beverages and other packaged foods (which are prepared for consumption prior to analysis) were shown to contribute very little to the total mercury dietary intake. The results of this survey support this assessment.

When the results of the current survey on dried tea are compared with the previous year's survey results, there is fairly good agreement. The maximum and average values detected are similar. When the datasets are normalized to account for differences in the detection limit from year-to-year the % of samples with detectable levels of mercury are in agreement.

Table 3. Comparison of dried tea survey data with previous year's findings

Survey Year	**# of samples**	**# of samples with Hg >0.005 ppm***	**Average +(ppm)**	**Max (ppm)**
2010-2011	193	64 (33%)	0.0047	0.0233
2009-2010	100	32 (32%)	0.0081	0.0303

*The LOD from the previous year's survey (0.005 ppm) was 10x higher than the current year (0.0005 ppm), in order to accurately compare the two datasets, the old LOD was applied to the current dataset.
+Average as calculated using the entire dataset. Not adjusted for differences in LODs

5 Conclusion

The 2010-11 Mercury Targeted Survey was completed in response to a finding from the 2009-10 survey which showed detectable levels of mercury in dried tea leaves, and also in order to elucidate the levels of this particular contaminant in food commodities that have not been investigated in detail previously, namely soft drinks and corn syrups. In total, 386 samples of dried tea, soft drinks and corn-based syrups were analysed for mercury. In all, 205 samples did not contain measurable residues of mercury. Dried tea samples had the highest proportion of samples with detectable mercury residues (86%) and had the highest overall mercury residue detected (0.023 ppm). Both soft drinks and corn syrups had relatively low rates of detectable mercury (6.3% and 10%, respectively), and the maximum levels observed (0.011 ppm for soft drinks and 0.00016 ppm for syrups) were much lower than those observed in dried tea.

6 References

[1] Health Canada, Healthy Living: Mercury and Human Health. [online] March 2009, Accessed August 2011. http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/merc-eng.php

[2] U.S. Food And Drug Administration: Guidance for Industry: Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. [online] August 2000, Accessed August 2011. http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/Chemical ContaminantsandPesticides/ucm077969.htm

[3] Codex Alimentarius: Codex General Standard for Contaminant and Toxins in Food and Feed (CODEX STAN 193-1995-Rev. 1-1997) [online] Accessed August 2011. https://apps.who.int/fsf/Codex/GENERALSTANDARDCONTAMINANTSANDTOXINSInFOODS.pdf

[4] Australia New Zealand Food Standard Code: Standard 1.4.1 Contaminants and Natural Toxicants-F2011C00542. [online] July 2011, Accessed August 2011. http://www.comlaw.gov.au/Details/F2011C00542

[5] European Commision Regulation No. 466/2001: Setting Maximum Levels for Certain Contaminants in Foodstuffs. [online] Accessed August 2011. http://www.safefoodnet.net/attachments/Consol_Reg466_2001.pdf

[6] US Environmental Protection Agency: Mercury-Health Effects [online] Accessed August 2011. http://www.epa.gov/mercury/effects.htm

[7] Canadian Center for Occupational Health and Safety: 2-Health Effects of Mercury. [online]Dec. 1998, Accessed August 2011. http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/mercury/health_mercury.html

---

[8] Zhang M., Fang, L. Tea Plantation-Induced Activation of Soil Heavy Metals. Communications in Soil Science and Plant Analysis (2007. 38:11, 1467-1478.

[9] Wong, M.H., Zhang, Z.Q. Wong, J.W.C. and Lan, C.Y. Trace metal contents (Al, Cu and Zn) of tea : tea and soil from two tea plantations, and tea products from different provinces of China. ï. (1998) 20:87-94.

[10] Natesan, S., Ranganathan, V. Content of various elements in different parts of the tea plant and in infusions of black tea from southern India. Journal of the Science of Food and Agriculture. (1990) 51:125-139.

[11] Shi, Y-Z. Shi,[†] Jian-yun Ruan, J.Y., Ma, L.F.,Han, W.Y. and Wang, F. Accumulation and distribution of arsenic and cadmium by tea plants. Journal of Zenjian University SCIENCE B. (2008) 9(3):265-270.

[12] Shen, F-M. and Chen, H-W. Element composition of tea leaves and tea infusions and its impact on health. Bulletin of Environmental Contaminants and Toxicology. (2008) 80:300-304.

[13] Yuan C, Gao E, He B, Jiang G. Arsenic species and leaching characters in tea (*Camellia sinensis*). Food and Chemical Toxicology. (2007) 45:2381-2389

[14] Zhou, C.Y., Wu, J. Chi, H. , Wong, M.K., Koh, L.L. and Yee,Y.C. The behaviour of leached aluminium in tea infusions. The Science of the Total Environment. (1996) 177:9-16

[15] Seenivasan, S., Manikandan, N. and Muraleedharan, N. Chromium contamination in black tea and its transfer into tea brew. Food Chemistry (2008) 106:1066-1069.

[16] Mehra, A., Baker, C.L. Leaching and bioavailability of aluminium, copper, and manganese from tea. Food Chemistry (2007) 100: 1456-1463.

[17] Karak, T., Bhgat, R. M. Trace elements in tea leaves, made tea and tea infusion: a review. Food Research International. (2010) 43(9):2234-2252

[18] Ahmad, S., Chaudhary, M. S., Mannan, A.and Qureshi, I. H. Determination of toxic elements in tea, leaves by instrumental neutron activation analysis. Journal of Radioanalytical Chemistry. (1983) 78(2):375-383

[19] Olin Chlor Alkali Products : Caustic Soda Production. [online] 2009. Accessed August, 2011. http://www.olinchloralkali.com/Library/Literature/OverviewOfProcess.aspx

[20] Pacyna, E.G., Pacyna, G.M., Steenhuisen, F., and Wilson, S. Global anthropogenic mercury emission inventory for 2000. Atmospheric Environment (2006) 40:4048-4063.

---

[21] Euro Chlor. Chlorine Online- Information Resource: How is Chlorine Made? [online] August 2011. Accessed August 22, 2011, http://www.eurochlor.org/makingchlorine

[22] Environment Canada. Compliance with Chlor-Alkali Mercury Regulations, 1986-1989:Status Report. [online] March 2010. Accessed August 2011. http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=E7E0E329-1&printerversion=true

[23] Fox, M. Studies find Mercury in Much US Corn Syrup (Reuters). [online] January 27, 2009. Accessed April, 2010. http://uk.reuters.com/article/idUKTRE50Q5IA20090127

[24] Institute for Agriculture and Trade Policy. Press Release: Much High Fructose Corn Syrup Contaminated with Mercury, New Study Finds. January 2009.

[25] Dufault R., LeBlanc, B., Schnoll, R., Cornett, C., Schweitzer, L. Wallinga, D., Hightower, J., Patrick, L. and Lukiw, W.J. . Mercury from Chlor-alkali Plants : Measured Concentrations in Food Product Sugar. Environmental Health (2009) 8:2.

[26] Statistics Canada. Food Available for Consumption in Canada – 2008. [online] Accessed August 2011. http://www.statcan.gc.ca/ads-annonces/23f0001x/hl-fs-eng.htm

[27] Roberts, E. A. H., The chemistry of tea manufacture. Journal of the Science of Food and Agriculture, (1958) 9: 381–390.

[28]Muñoz, O. Bastias, J.M., Araya, M., Morales, A., Orellana, C., Rebolledo, R., Velez, D. Estimation of the dietary intake of cadmium, lead, mercury, and arsenic by the population of Santiago (Chile) using a Total Diet Study, Food and Chemical Toxicology(2005) 43:11 - 1647-1655, Accessed August, 2011 http://www.sciencedirect.com/science/article/pii/S0278691505001511

[29] Dabeka, R. W. et al. Survey of Total Mercury in Total Diet Food Composites and an Estimation of the Dietary Intake of Mercury by Adults and children from Two Canadian Cities, 1998-2000. (2003) Food Additives and Contaminants. 20:7, 629-638.