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

FOOD SAFETY ACTION PLAN

REPORT

2011-2013
TARGETED SURVEYS - CHEMISTRY

Cadmium in Selected Foods

RDIMS 5514915
Data tables 2011-2012 RDIMS 5477303
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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 examine various foods for specific hazards.

The main objectives of the 2011-2013 FSAP cadmium targeted survey were to provide baseline data regarding the presence and levels of cadmium in a defined set of food commodities, and to compare these levels to the previous FSAP and other Canadian surveys and to data reported by other countries, where feasible.

Cadmium is a toxic metal occurring in food as a result of contamination of soil and water from natural sources and human activities. The kidneys, which accumulate cadmium, are considered the primary target organ for cadmium toxicity following chronic dietary exposure. Cadmium has been classified as a human carcinogen by the International Agency for Research on Cancer based on workers exposed occupationally through inhalation. Cadmium readily accumulates in many organisms, notably shellfish, while lower concentrations are found in vegetables and in cereals. In the non-smoking general population, the diet, mainly through the consumption of cereals and vegetables, accounts for approximately 90% of exposure.

For the 2011-2013 FSAP Cadmium survey, a total of 1805 samples were collected from retail stores in 11 Canadian cities. The products were categorized into groups: 813 grain-based foods, 613 vegetable/nut-based foods, and 379 assorted foods. All samples were collected between April 2011 and January 2013.

Overall, 57% of grain-based foods, 72% of vegetable/nut based-foods, and 72% of assorted foods tested positive for cadmium. The cadmium levels detected ranged from 0.002 parts per million (ppm) to 6.401 ppm. The highest average cadmium levels were detected in seaweed products (1.751 ppm) and dried mushrooms (0.682 ppm), and the lowest average levels were detected in pulses (0.014 ppm).

In general, the prevalence of cadmium and the range of observed cadmium levels were comparable between the current and previous FSAP surveys, other Canadian surveys, and data reported by other countries for similar products.

All the data generated were shared with Health Canada for use in performing human health risk assessments. Health Canada determined that the levels of cadmium detected in foods in this survey were not expected to pose a health risk. No product recalls were warranted given the lack of human health concern.

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 Canada's safety system for food, health, and consumer products. The FCSAP initiative unites multiple government partners in ensuring safe food for Canadians.

The Canadian Food Inspection Agency's (CFIA's) Food Safety Action Plan (FSAP) is one element of the government's broader FCSAP 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 preventive measures, and that there is a rapid response when/if these measures fail.

Within FSAP, there are 12 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 of 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.

Within the current regulatory framework, some commodities (such as meat products) traded internationally and interprovincially are regulated by specific Acts. These are referred to as federally registered commodities. Under the current regulatory framework, the non-federally registered commodities encompass 70% of domestic and imported foods that are regulated solely under the *Food and Drugs Act* and the *Food and Drug Regulations*. Targeted surveys are primarily directed towards non-federally registered commodities.

1.2 Targeted Surveys

Targeted surveys are used to gather information regarding the possible occurrence of chemical residues, contaminants, and/or natural toxins in defined food 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, a group of federal, provincial, and territorial subject matter experts in the area of food safety.

The cadmium levels observed in foods for the current survey were compared to the previous 2010-2011 FSAP survey on cadmium in rice and rice products, Children's Food Project (CFP) data, Health Canada's Total Diet Study, and relevant data from the U.S. Food and Drug Association (FDA) and the European Food Safety Authority (EFSA).

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* and *Regulations*.

Health Canada establishes the health-based maximum levels for chemical residues, contaminants, and natural toxins in food sold in Canada. Certain maximum levels for chemical contaminants in food appear in the Canadian *Food and Drug Regulations*, where they are referred to as tolerances. There are also a number of maximum levels that do not appear in the regulations and are referred to as standards. However, all foods sold in Canada must comply with the provisions in Section 4(1)(a) of the *Food and Drug Act*, which prohibits the sale of a food that contains a poisonous or harmful substance.

Currently, no maximum level, tolerance, or standard has been established by Health Canada for cadmium levels in food and therefore, compliance with Canadian regulations was not evaluated in this survey. However, the Codex Alimentarius Commission[1], Food Standards of Australia New Zealand (FSANZ)[2], and the European Food Safety Authority (EFSA)[3] have established maximum levels (MLs) for cadmium in several commodities relevant to this survey (see Table 1).

Table 1. Codex Alimentarius, EU, and FSANZ Maximum levels of Cadmium (ppm) in relevant commodities

Food Product	Maximum Level (ppm)		
	CODEX[1]	EU[3]	FSANZ[2]
Pulses	0.1	-	-
Rice	0.4	0.2	0.1
Potatoes	0.1	0.1	0.1
Wheat	0.2	0.2	0.1
Seaweed Products	-	3.0	-
Fungi (including mushrooms)	-	0.2, 1.0*	-
Chocolate	-	-	0.5
Peanuts	-	-	0.5

*Maximum levels for fungi depend on species

In the absence of tolerances or standards, elevated levels of cadmium in foods may be assessed by Health Canada on a case-by-case basis using the most current scientific data available. If Health Canada's Bureau of Chemical Safety identifies a potential safety concern, the CFIA may conduct follow-up actions. Follow-up actions are initiated in a manner that reflects the magnitude of the health concern. Actions may include further analysis, notification to the producer or importer, follow-up inspections, additional directed sampling, and recall of products.

2 Survey Details

2.1 Cadmium

Cadmium (Cd) is a relatively rare heavy metal occurring naturally in the environment and as a pollutant from industrial and agricultural sources[3,4,5,6]. Several industrial activities such as the manufacturing of pigments, plastics, textiles and rechargeable batteries involve the use of cadmium[7]. Although some Cd-containing products can be recycled, the improper disposal and incineration of Cd-containing products leads to environmental pollution in water and soils[3,5,6]. From the environment, cadmium readily accumulates in many organisms, notably shellfish while lower concentrations are found in vegetables and in cereals[5]. In the non-smoking general population, the diet, mainly through the consumption of cereals and vegetables, accounts for approximately 90% of exposure (EFSA, 2009)[8].

Cadmium is not known to fulfill a biological role in the human body and has been classified as a human carcinogen by the International Agency for Research on Cancer based on workers exposed occupationally through inhalation[9]. While cadmium absorption from dietary food is low, it accumulates over time in the body, particularly in the kidneys, lungs, and liver[6,10,11]. The kidneys are considered the primary target organ for cadmium toxicity following chronic dietary exposure. Its accumulation in kidneys can lead to renal dysfunction and potentially renal failure and bone demineralisation[6].

2.2 Rationale

The objectives of this survey were to compare to, and expand upon, previous CFIA survey data of cadmium in rice and rice products by examining cadmium levels in other products not covered under the National Chemical Residue Monitoring Program (NCRMP) or the Children's Food Project (CFP).

A large portion of the dietary cadmium exposure comes from plant-based sources, such as grain products (e.g., rice, wheat, cereal), potatoes, nuts, and pulses[3]. Plant-based commodities most susceptible to cadmium accumulation are rice, potatoes, and vegetables[3,12]. Rice is particularly susceptible to cadmium contamination due to its distinctive cultivation in flooded fields[13]. In Canada, rice available for consumption reached 7.1 kg per person in 2009[14]. In addition to rice grain, vegetarians and individuals with gluten or lactose intolerance often use plant-based products (e.g., soy milk, rice milk, rice flour) as a substitute for gluten-containing or dairy-containing products, further increasing their exposure to dietary Cd. Therefore, a variety of grain and grain-based products, potato products, nuts, and pulses were analyzed for Cd in this survey.

In addition to vegetable- and grain-based foods, an EFSA scientific opinion paper indicated that commodities such as seaweed and chocolate contained some of the highest levels of Cd[3]. Therefore, this survey sampled a variety of seaweed products and chocolates available in Canadian retail stores.

The current targeted survey complements both the Health Canada Total Diet Studies (TDS), as well as other CFIA monitoring activities, such as the CFP and the NCRMP. This survey also adds to baseline data established in the previous CFIA FSAP targeted survey[15] on cadmium in rice and rice products by sampling a wider variety of rice-based foods.

All survey data was shared with Health Canada for use in conducting human health risk assessments of dietary exposure to cadmium.

2.3 Sample Distribution

The 2011-2013 FSAP survey on cadmium included 521 domestic products, 1243 imported products, and 41 products of unspecified origin. In general, an unspecified origin refers to those samples for which the country of origin could not be determined from the product label or sample information. It is important to note that the products sampled often contained the statement “processed in Country X”, “imported for Company A in Country Y” or “manufactured for Company B in Country Z”, and though the labelling meets the intent of the regulatory standard, it does not specify the true origin of the product ingredients. Only those products labelled with a clear statement of “Product of”, “Prepared in”, “Made in”, “Processed in”, and “Manufactured by” were considered as being from a specific country of origin. The samples originated in at least 34 countries, including Canada, with approximately 59% of the samples originating in either Canada or the United States.

2.4 Analytical Methods

Samples were analyzed by an ISO 17025 accredited laboratory under contract with the Government of Canada. Samples were tested as sold, meaning that the product was not prepared as per the package instructions (if applicable). The laboratory method used microwave digestion and inductively coupled plasma mass spectroscopy for analyte detection. The limit of detection (LOD) for cadmium was 0.002 ppm and the limit of quantitation (LOQ) for cadmium was 0.007 ppm.

2.5 Limitations

This targeted survey was designed to provide a snapshot of the levels of cadmium in selected foods available to Canadian consumers, and highlight commodities that warrant further investigation. In comparison to the total number of such products available to Canadian consumers, a sample size of 1805 is considered small. Therefore, care must be taken when interpreting and extrapolating these results. Regional differences, impact of product shelf-life, packaging and storage conditions, or cost of the commodity on the open market were not examined in this survey.

3 Results and Discussion

3.1 Overview of Survey Results

Samples analysed in the current survey were separated into three groups of products: assorted foods, vegetable/nut-based foods, and grain-based foods. Of the 1805 samples tested for cadmium, 1179 samples (65%) had detectable levels of cadmium. Figure 1 illustrates the number of samples with a detectable level of cadmium as a function of product group (assorted foods, vegetable/nut-based foods, and grain-based foods) and product type (e.g., chocolate, dried mushrooms). Pulses had the lowest occurrence of cadmium, with only 28% testing positive, whereas 100% of seaweed products and dried mushroom products tested positive for cadmium.

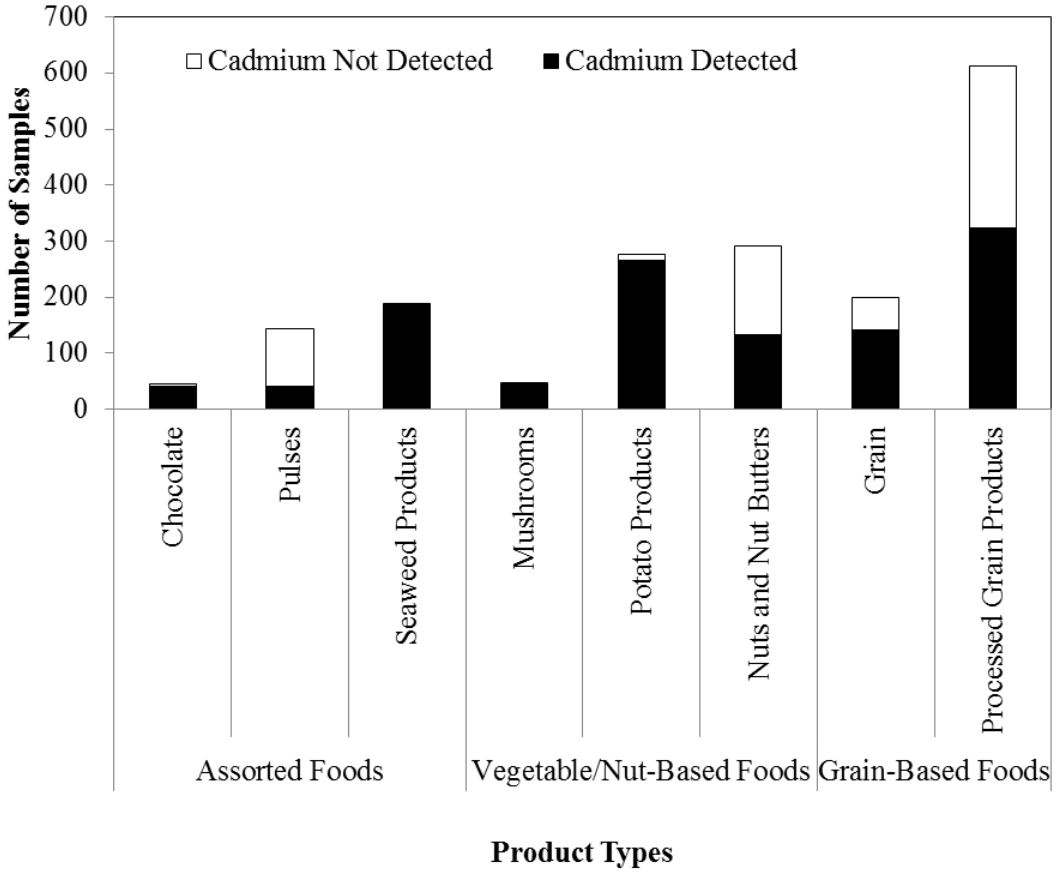


Figure 1. Number of samples by product type (arranged in order of increasing number of samples per product group)

Table 2 summarizes the minimum, maximum, and average levels of cadmium by product type. The measured levels of cadmium ranged from 0.002 ppm to 6.401 ppm. It should be noted that the average cadmium levels discussed below were calculated using only those

samples for which cadmium was detected (i.e., average of the positive results only). The average cadmium level by product type ranged from 0.014 ppm in pulses to 1.751 ppm in seaweed products. Many of the products selected for sampling were anticipated to contain cadmium; therefore, the positive rates (percentage of samples with detectable levels) were expected to be high.

Table 2. Minimum, maximum, and average cadmium levels detected in food samples (in order of decreasing maximum cadmium level per category)

Product Type	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Assorted Foods					
Seaweed Products	189	189 (100)	0.025	6.401	1.751
Chocolate	46	42 (91)	0.007	0.311	0.103
Pulses	144	41 (28)	0.004	0.040	0.014
Total (Assorted Foods)	**379**	**272 (72)**	**0.004**	**6.401**	**1.234**
Vegetable/Nut-Based Foods					
Dried Mushrooms	47	46 (98)	0.012	2.483	0.682
Potato Products	276	265 (96)	0.005	0.326	0.055
Nuts/Nut Butters	290	131 (45)	0.004	0.231	0.050
Total (Vegetable/Nut-Based Foods)	**613**	**442 (72)**	**0.004**	**2.483**	**0.119**
Grain Based-Foods					
Processed Grain Products	613	324 (53)	0.002	0.296	0.038
Grain	200	141 (71)	0.004	0.074	0.017
Total (Grain-Based Foods)	**813**	**465 (57)**	**0.002**	**0.296**	**0.031**
Overall	**1805**	**1179 (65)**	**0.002**	**6.401**	**0.342**

Health Canada's Bureau of Chemical Safety determined that the levels of cadmium detected in all foods analyzed in this survey were unlikely to pose a human health concern. No product recalls were warranted given the lack of a health concern.

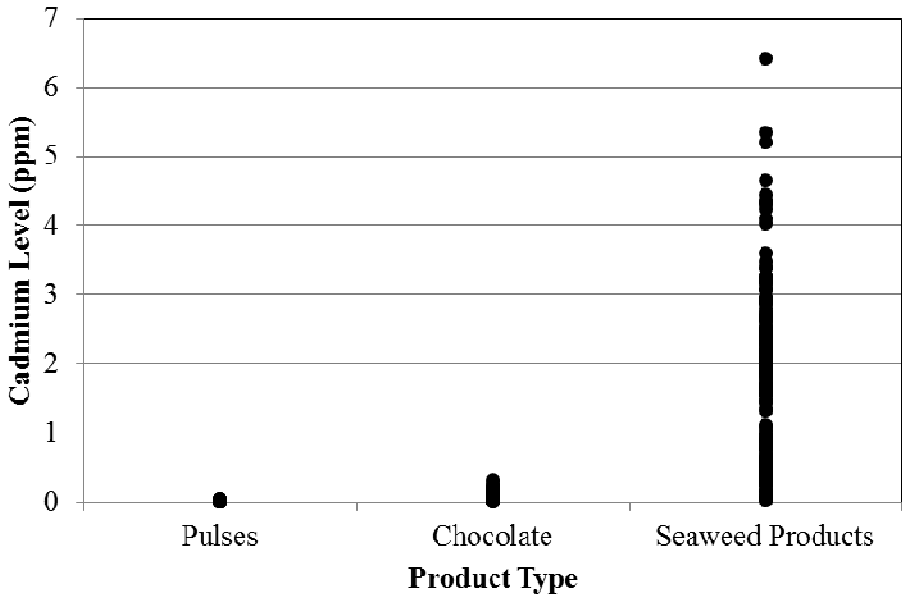
3.2 Survey Results by Product Type

More detailed results by product type are presented and discussed in the following sections. Where possible, the results of the survey were compared with the cadmium levels reported in the previous FSAP survey[15], previous CFIA Children's Food Project (CFP) surveys[16,17], with Health Canada's (HC) Total Diet Study (TDS)[18], with a recent U.S. Food and Drug Administration (FDA) survey on cadmium levels in specific foods[19], and a European Food Safety Authority (EFSA) report on cadmium in food[3]. It should be noted that the average results for the FDA surveys were calculated (by CFIA staff) as the mean of the positives based on the individual reported results. Also, the EFSA report contains data collected from 18 EU Member States, Iceland, Australia, and several commercial organisations over a 4-year span from 2003 to 2007. The analysis method, LOD, and LOQ vary by region and by year, therefore care must be taken when comparing the average cadmium levels. Finally, Health Canada's available TDS data for cadmium spans from 1993 to 2007 across 9 Canadian cities with numerous composite food samples tested. The HC data is reported as a range of average cadmium levels, therefore comparison to this data is described within the text (i.e., not tabulated).

3.2.1 Assorted Foods

The assorted foods category included 46 chocolate samples, 144 pulses (e.g., lentils, chickpeas, dried beans), and 189 seaweed products. All 189 samples of seaweed products tested positive for cadmium, 91% (42 samples) of chocolates tested positive, and only 28% (41 samples) of pulses tested positive for cadmium.

The distribution of detected cadmium levels in assorted foods is shown in Figure 2 as a function of product type (only positive values are shown). The highest levels of cadmium were detected in seaweed products, whereas pulses and chocolate had relatively low cadmium levels.



Note: Only values above the limit of detection are displayed.

Figure 2. Cadmium levels in assorted foods by product type (in order of increasing maximum cadmium level)

Pulses

Pulses consisted of 144 samples of dried beans, dried peas, chickpeas, and lentils. Overall, pulses had low positive rates for cadmium, with only 28 samples (41%) testing positive. The average cadmium level detected was 0.014 ppm with minimum and maximum levels of 0.004 ppm and 0.040 ppm respectively (see Table 3).

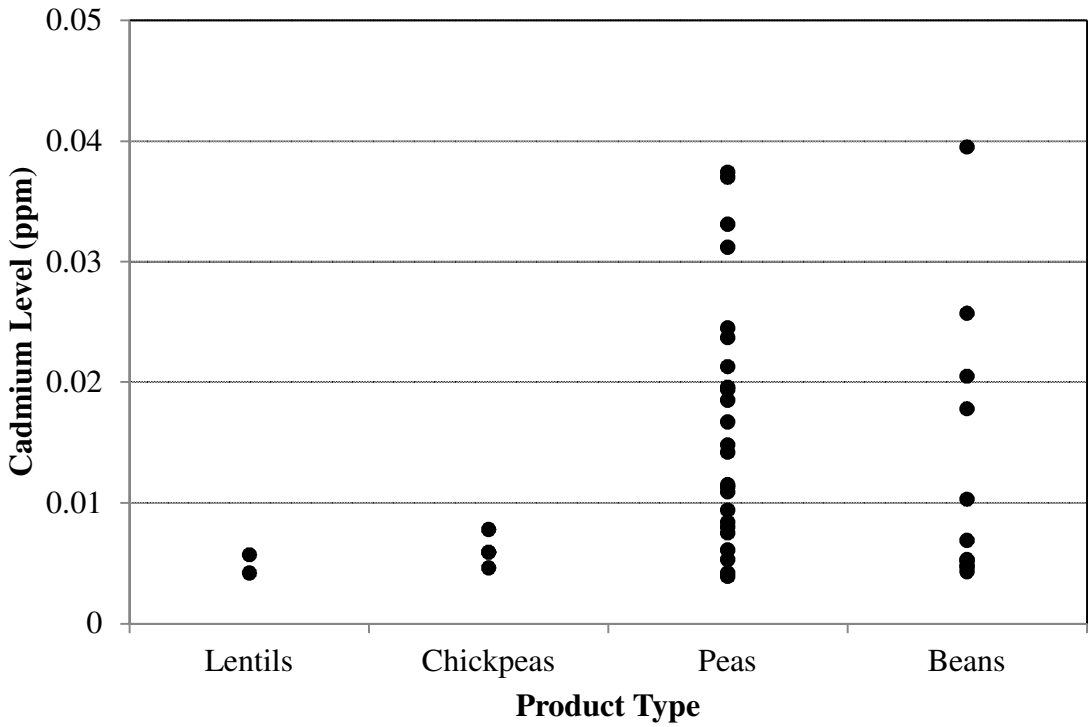
Table 3. Summary of FSAP survey and EFSA data on cadmium levels in pulses

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Pulses						
FSAP	2011-2013	144	41 (28)	0.004	0.040	0.014
EFSA[3]	2009*	1322	925 (70)	< LOD	0.114	0.008

*The EFSA survey included butterbeans, peas, chickpeas, lentils, soybeans

Figure 3 shows the cadmium levels detected in pulses by product type. Lentils and chickpeas had low positive rates and low average cadmium levels. Dried beans and dried peas had very similar average cadmium levels (0.013 ppm and 0.017 ppm respectively) despite disparity in positive rates. The higher Cd concentrations in these commodities,

relative to the hydrated chickpeas and lentils that were also analysed, may be due to the fact that all bean and pea samples included in this survey were dried.



Note: Only values above the limit of detection are displayed.

Figure 3. Cadmium levels in pulses by product type (in order of increasing maximum cadmium level)

In comparison to the EFSA data on cadmium levels in pulses, the current FSAP data has a higher average but a lower maximum value. It should be noted that product-specific details from the EFSA survey are not available (i.e., fresh versus dried pulses). Also, the EFSA reports LODs as a range, due to data being collected from various sources. The EFSA's median LOD for pulses was 0.001 ppm, potentially accounting for the lower detection rate and higher average observed for the current survey data.

Chocolate

A total of 46 samples of chocolate were tested for cadmium, including 13 milk chocolates, 20 dark chocolates, and 13 other chocolates. Other chocolates included samples where the cocoa concentration was unknown and milk/dark was unspecified. Chocolates had high positive rates (91% tested positive) with an overall average cadmium level of 0.103 ppm. The cadmium levels detected ranged from 0.007 ppm in milk chocolate to 0.311 ppm in other chocolates (see Figure 4). Table 4 summarizes the

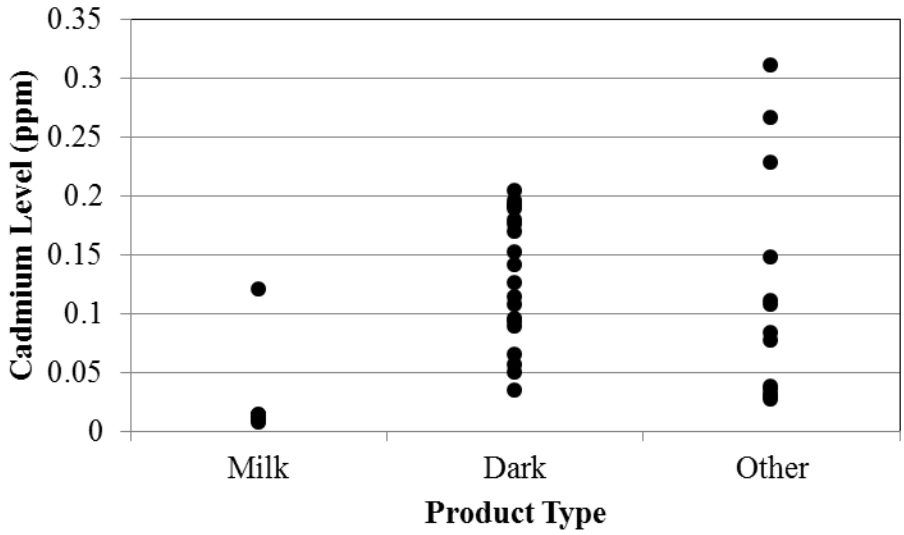
current FSAP, CFP, FDA and EFSA data on cadmium levels in chocolate. Note that detection rates and minimum/maximum levels for the EFSA data are unavailable.

Table 4. Summary of FSAP survey, CFP, and FDA/EFSA data on cadmium levels in chocolate

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Milk						
FSAP	2011-2013	13	9 (70)	0.007	0.121	0.024
FDA[19]	2006-2008	12	12 (100)	0.018	0.040	0.028
EFSA[3]	2009	122	NA	NA	NA	0.025
Dark						
FSAP	2011-2013	20	20 (100)	0.035	0.204	0.131
EFSA[3]	2009	19	NA	NA	NA	0.164
Other						
FSAP	2011-2013	13	13(100)	0.027	0.311	0.115
CFP[16,17]	2009-2011	18	17 (94)	0.006	0.435	0.080

*FDA study sampled only milk chocolate bars

Figure 4 shows the detected cadmium levels in chocolates by product type. Milk chocolates had the lowest positive rate (70%) and the lowest average cadmium level (0.024 ppm). Health Canada tested composites of milk chocolate during their Total Diet Study. Average cadmium levels ranged from 0.009 ppm to 0.023 ppm. Despite disparity in maximum values and detection levels, the average cadmium levels in milk chocolate agree well with data from the HC TDS, FDA, and EFSA. All 20 dark chocolates tested positive for cadmium, with an average level of 0.131 ppm, slightly lower than the EFSA reported average.



Note: Only values above the limit of detection are displayed.

Figure 4. Cadmium levels in chocolate by product type (in order of increasing maximum cadmium level)

Other chocolates included the same forms (e.g., chocolate chips, baking chocolate) however; the samples were not labelled milk or dark. All 13 other chocolates tested positive for cadmium, with an average of 0.080 ppm. This average is higher than the CFP average. Note that the CFP survey did not specify chocolate type, therefore the inclusion of a variety of chocolates, specifically milk chocolate, is expected to give a lower average cadmium level.

Seaweed Products

A total of 189 seaweed products were tested for cadmium, consisting of dried/roasted seaweed, seaweed sushi paper, and dulse. All samples (100%) tested positive for cadmium, with an average cadmium level of 1.751 ppm. The cadmium levels in seaweed products were highly variable, ranging from 0.025 ppm to 6.401 ppm (see Table 5). There is a lack of scientific data on cadmium levels in seaweed products, therefore comparison is limited; however, an EFSA study also reported that seaweed products contained some of the highest cadmium levels of the food products surveyed. The EFSA range of LODs for seaweed products had a median of approximately 0.005 ppm and an upper LOD of approximately 0.180 ppm, potentially accounting for the disparity in detection rates between the current FSAP and the EFSA data sets.

Table 5. Summary of FSAP survey and EFSA data on cadmium levels in seaweed products

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Seaweed Products						
FSAP	2011-2013	189	189 (100)	0.025	6.401	1.751
EFSA[3]	2009	1547	959 (62)	< LOD	3.000	0.077

3.2.2 Vegetable/Nut-Based Foods

Vegetable/nut-based foods included 47 samples of dried mushrooms, 276 potato products (e.g., chips, canned/dehydrated/flaked potato products, frozen products), and 290 nuts and nut butters. Mushrooms and potato products had high positive rates for cadmium (98% and 96% respectively), whereas only 45% of nuts and nut butters tested positive.

Dried Mushrooms

A total of 47 dried mushrooms were sampled, consisting of a variety of types. Of the 47 tested, 46 samples (98%) tested positive for cadmium, with an average cadmium level of 0.682 ppm. The minimum and maximum cadmium levels detected were 0.012 ppm and 2.483 ppm, respectively (see Table 6).

When comparing the cadmium levels in mushrooms, it is important to note whether the samples were fresh or dried. Note that the current FSAP survey investigated only dried mushrooms. Health Canada's TDS results from the 1993 to 2007 sampling periods included a number of mushroom samples with averages ranging from 0.003 ppm to 0.018 ppm. The mushroom composite from the HC TDS data consists of fresh and cooked mushrooms in a 1:1 ratio, resulting in lower average cadmium levels detected relative to the current FSAP data for dried mushrooms.

The EFSA collected a large amount of data regarding various mushrooms, both fresh and dried. The maximum cadmium level detected in the current FSAP survey is lower than the EFSA data but with a higher average. The EFSA's median LOD for mushrooms was 0.001 ppm. The combination of a lower LOD and the inclusion of fresh mushroom samples may explain the disparity in average detected cadmium levels.

Table 6. Summary of FSAP survey and EFSA data on cadmium levels in mushrooms

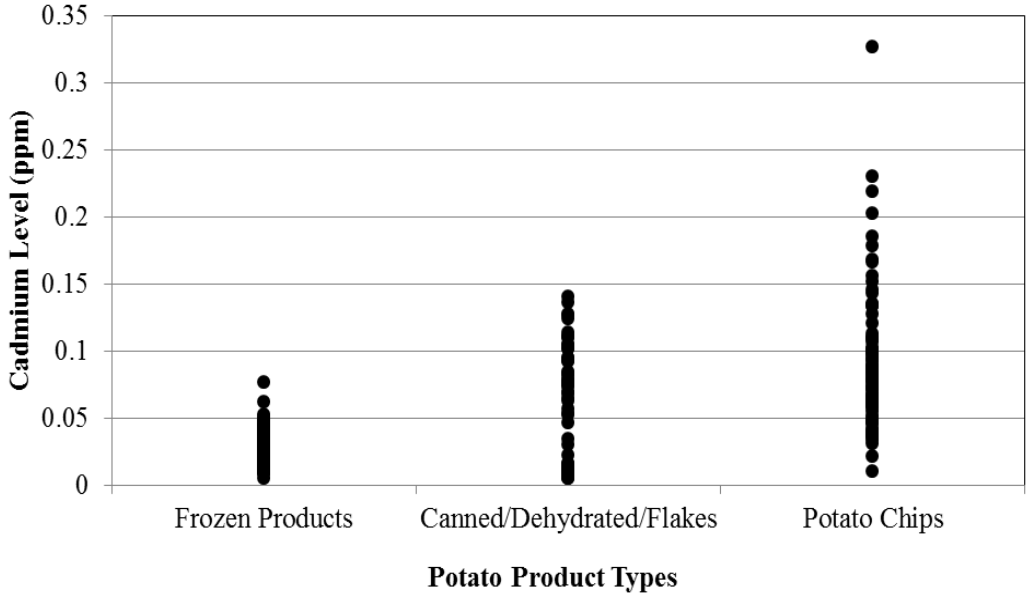
Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Mushrooms						
FSAP	2011-2013	47	46 (98)	0.012	2.483	0.682
EFSA[3]	2009*	2017	1734 (86)	< LOD	2.709	0.209

*EFSA sampled a variety of fresh and dried mushrooms

Potato Products

Potato products were further separated into three categories: canned/dehydrated/flakes (e.g., instant potato products, canned whole potatoes), potato chips, and frozen potato products (e.g., frozen hash browns, French fries). A total of 83 canned/dehydrated/flaked potato products, 90 potato chips, and 103 frozen products were sampled. Potato chips had the highest occurrence, with 100% of the samples testing positive for cadmium.

Figure 5 shows the detected cadmium levels in potato products as a function of product type. Potato chips had the highest average cadmium level (0.052 ppm), followed by canned/dehydrated/flakes (0.090 ppm), and frozen products had the lowest (0.027 ppm).



Note: Only values above the limit of detection are displayed.

Figure 5. Cadmium levels in potato products by product type (in order of increasing maximum cadmium level)

Table 7 summarizes the FSAP, CFP, and US FDA survey data on cadmium levels in potato products. A limited number of potato chip samples were included in the 2009-2010 CFIA CFP survey and the FDA's 2006-2008 total diet study. The average and maximum cadmium levels in chips for the current FSAP survey are higher than both the CFP and FDA levels reported.

HC's TDS also investigated cadmium levels in potatoes (peeled and boiled), potato chips, and French fries. Average cadmium concentrations in potatoes ranged from 0.017 ppm to 0.048 ppm. In potato chip composite samples, the average cadmium levels ranged from 0.040 ppm to 0.102 ppm. Average cadmium levels in French fries ranged from 0.029 ppm to 0.064 ppm. Note that the HC samples were ready to eat (cooked) French fries and boiled potatoes. Despite differences in sample preparation, the current averages for cadmium levels in frozen potato products agree well with the HC cooked French fry data.

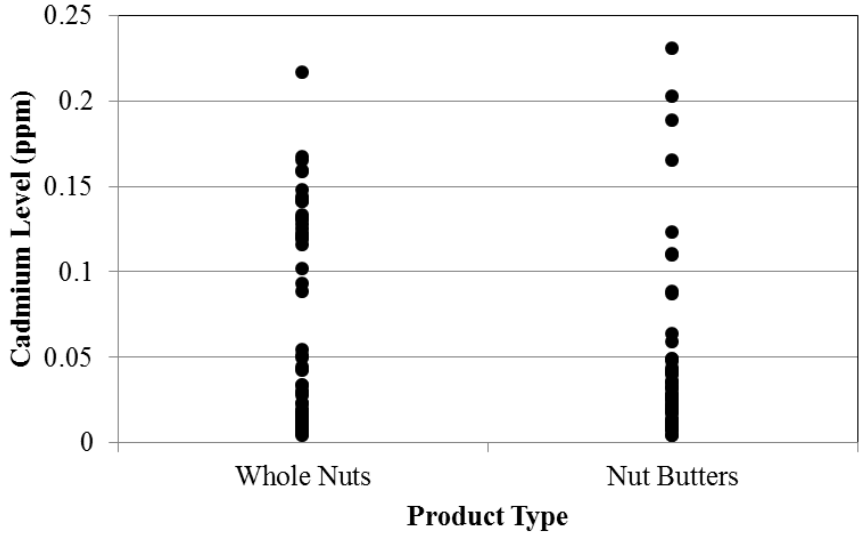
Table 7. Summary of FSAP survey, CFP, and EFSA data on cadmium levels in potato products

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Canned/Dehydrated/Flakes						
FSAP	2011-2013	83	73 (88)	0.007	0.126	0.052
Potato Chips						
FSAP	2011-2013	90	90 (100)	0.040	0.326	0.090
CFP[16,17]	2009-2011	14	8 (57)	0.005	0.069	0.027
FDA[19]	2006-2008	12	12 (100)	0.044	0.094	0.057
Frozen Products						
FSAP	2011-2013	103	102 (99)	0.009	0.076	0.027

Whole Nuts/Nut Butters

A total of 160 whole nuts and 130 nut butters were tested for cadmium. This included raw, in-shell, and roasted varieties of nuts. The types of nuts/nut butters included tree nuts (e.g., cashews, almonds, hazelnuts) and ground nuts (e.g., peanuts). Soy and seed butters were not included in this survey. Nuts and nut butters had low positive rates for cadmium, with only 38% of whole nuts and 55% of nut butters testing positive.

The detected cadmium levels in whole nuts and nut butters are shown in Figure 6. Whole nuts had a higher average cadmium level (0.066 ppm) than nut butters (0.037 ppm), despite nut butters having the greater maximum detected level (0.231 ppm).



Note: Only values above the limit of detection are displayed.

Figure 6. Cadmium levels in nuts/nut butters by product type (in order of increasing maximum cadmium level)

Table 8 outlines the current FSAP and FDA/EFSA data for cadmium in nuts/nut butters. In comparison to the FDA study, the current FSAP data for both whole nuts and nut butters show higher maximum levels of cadmium but very consistent averages. Note that the FDA study sampled only peanuts and peanut butter. Compared to the EFSA survey, the current study has a higher average cadmium level in whole nuts but a much lower maximum detected level. The EFSA's median LOD for nuts was 0.001 ppm, potentially accounting for the lower detection rate and higher average observed for the current survey data.

Table 8. Summary of FSAP survey and FDA/EFSA data on cadmium levels in nuts/nut butters

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Whole Nuts						
FSAP	2011-2013	160	60 (38)	0.004	0.216	0.066
FDA[19]	2006-2008*	12	12 (100)	0.023	0.084	0.054
EFSA[3]	2009	1418	964 (68)	< LOD	0.410	0.043
Nut Butters						
FSAP	2011-2013	130	71 (55)	0.004	0.231	0.037
FDA[19]	2006-2008*	12	11 (92)	< LOD	0.059	0.037

*Note that the FDA study included only peanuts and peanut butter.

Tree nuts had considerably lower levels of cadmium than peanuts, with no cashew samples testing positive. Peanuts had the highest levels of cadmium of the nut types sampled, with average cadmium levels of 0.122 ppm in peanuts and 0.056 ppm in peanut butter. HC's TDS also investigated cadmium levels in nuts (de-shelled peanuts and walnuts in a 1:1 ratio) and peanut butter. The nut composite from the TDS study had average cadmium levels ranging from 0.023 ppm to 0.115 ppm and 0.029 ppm to 0.105 ppm for peanut butter. The average cadmium levels in whole nuts and nut butters from the current FSAP study agree well with the HC TDS data.

3.2.3 Grain-Based Foods

The grain-based foods category included both whole grains and processed grain products. The grain category included 44 oat, 48 barley, and 108 rice samples. Processed grain products included 32 oat products, 48 other grain products (e.g., barley, quinoa, and millet products), 122 wheat products, 128 corn products, and 283 rice products. Processed grain products included various forms of each grain (e.g., flour, bran), as well as beverages (e.g., rice milk) and chips (e.g., rice chips, corn chips).

Figure 7 shows the number of samples by product type for grains and processed grain products. Grains had consistent positive rates for oats (68%), barley (71%), and rice (71%). The positive rates in processed grain products were highly variable; only 5% of corn products tested positive for cadmium whereas 98% of wheat products tested positive.

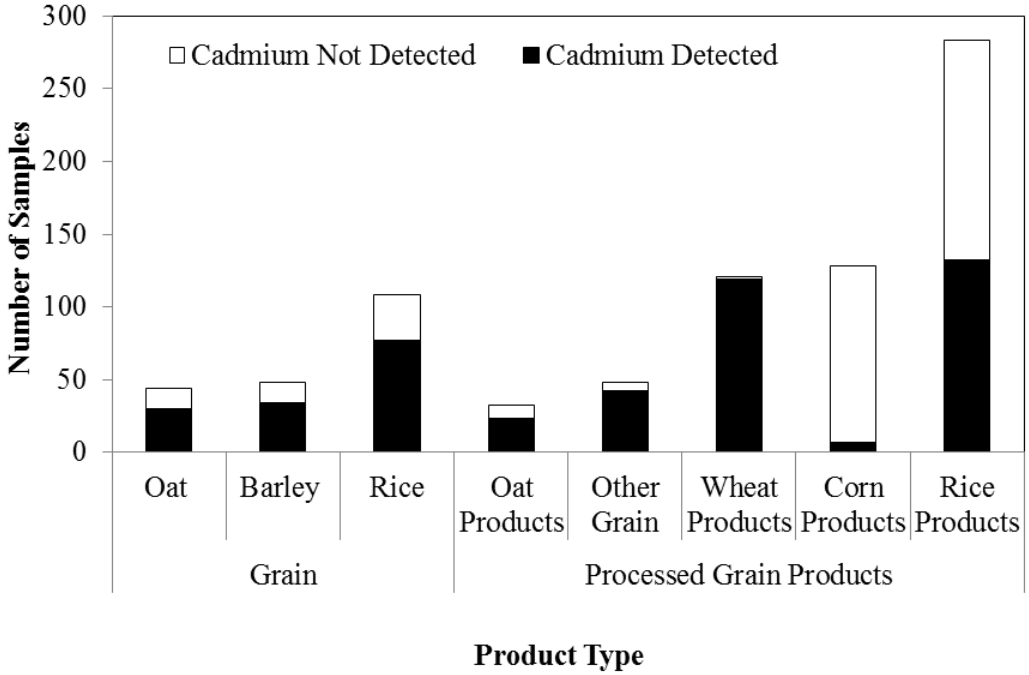
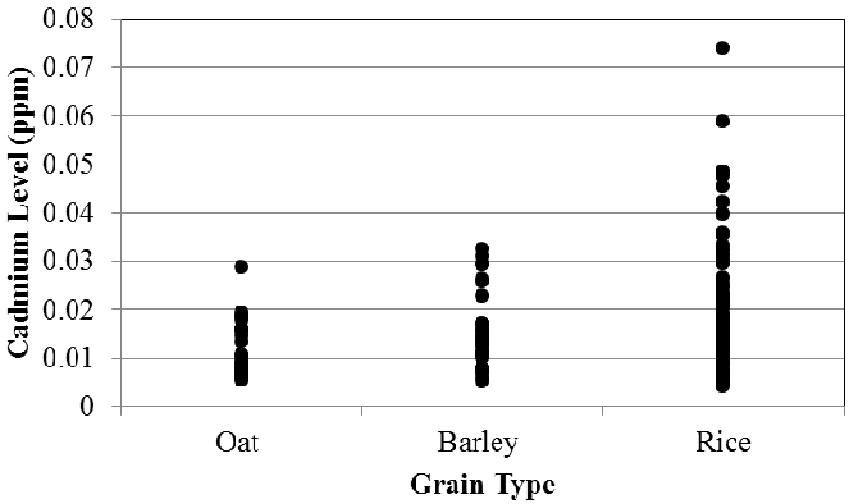


Figure 7. Number of samples by product type (arranged in order of increasing number of samples)

Grains

The grain category included 44 oat, 48 barley, and 108 rice samples. Grains had consistent positive rates for cadmium, with 68% of oats and 71% of both rice and barley samples testing positive. Figure 8 shows the cadmium levels in grains as a function of grain type. The maximum and average cadmium levels for oats and barley were very similar, whereas rice grains had the highest average cadmium levels at 0.019 ppm. Cadmium levels in rice were variable, ranging from minimum of 0.004 ppm to a maximum of 0.074 ppm.



Note: Only values above the limit of detection are displayed.

Figure 8. Cadmium levels by grain type (in order of increasing maximum cadmium level)

There is a lack of scientific data on cadmium levels in specific grains other than rice, therefore comparison of the survey data for oats and barley is limited. For the current FSAP survey, the positive rates, maximum, and average cadmium levels detected in oats and barley are very similar.

Cadmium levels in rice have been reported in previous FSAP and CFP surveys, as well as by the EFSA (see Table 9). For comparison purposes, the CFP LOD was 0.002 ppm and the range of LODs reported by the EFSA had a median of 0.001 ppm. The maximum cadmium level detected in the current survey is higher than the previous FSAP survey; however, the average is very similar. Health Canada's TDS results from the 1993 to 2007 sampling periods included a number of rice samples with averages ranging from 0.004 ppm to 0.014 ppm. Direct comparison to this data is difficult because the HC samples were prepared as they would be for consumption. In general, the average cadmium levels in rice grains are very consistent across all surveys, despite disparity in detection rates, maximum levels, and sample preparation.

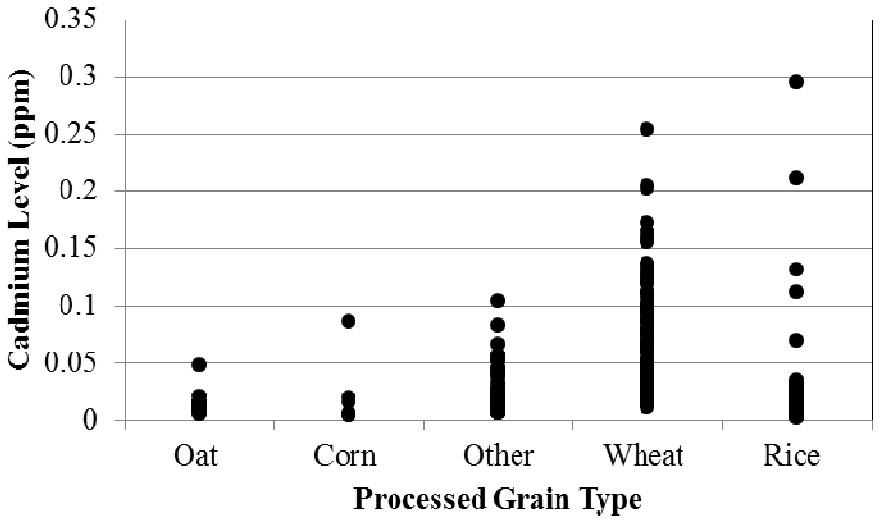
Table 9. Summary of FSAP survey and CFP/EFSA data on cadmium levels in grains

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Oat						
FSAP	2011-2013	44	30 (68)	0.006	0.029	0.012
Barley						
FSAP	2011-2013	48	34 (71)	0.005	0.033	0.015
Rice						
FSAP	2011-2013	108	77 (71)	0.004	0.074	0.019
	2010-2011	56	42 (75)	0.005	0.051	0.020
CFP[16,17]	2009-2011	16	7 (44)	0.005	0.042	0.014
EFSA[3]	2009	1000	880 (88)	<LOD	0.134	0.025

Processed Grain Products

Processed grain products included 32 oat products, 48 other grain products, 122 wheat products, 128 corn products, and 283 rice products. Oat products included oat bran, oat flour, and oat cereal. Other grain products included quinoa flour, barley flour, buckwheat flour, and millet flour. Wheat products included wheat-based flour, bran, germ, pasta, and couscous. Corn products included corn chips, corn bread, cornmeal/grits, and corn starch. Rice products included rice milk, rice pudding, rice crackers, rice chips, and rice cereal.

The cadmium levels detected in processed grain products are shown in Figure 9 as a function of grain type. Processed rice products had the highest maximum cadmium level (0.296 ppm) and oat products had the lowest (0.047 ppm). Wheat products had a higher average cadmium level (0.068 ppm) than other processed grain products. The highest cadmium concentrations for wheat products were found in wheat germ and wheat bran, and the highest cadmium concentrations for rice products were found in rice chips/sticks and rice noodles.



Note: Only values above the limit of detection are displayed.

Figure 9. Cadmium levels by processed grain products by grain type (in order of increasing maximum cadmium level)

Table 10 summarizes the FSAP survey and CFP/FDA/EFSA data on cadmium levels in processed grain products. Oat products had the lowest average cadmium level (0.013 ppm) of all the processed grain product types. Other grain products (e.g., barley, millet, quinoa) had maximum and average cadmium levels of 0.104 ppm and 0.027 ppm respectively. Wheat products had the highest average cadmium level of the grain products (0.068 ppm).

Corn products had very low positive rates, with only 5% of samples testing positive for cadmium. The maximum and average values for the current survey are higher than the FDA study; however, the FDA survey had a much higher positive rate. Note that the FDA sampled only corn bread, corn grits, and corn chips, whereas the current study sampled these products in addition to corn flour and corn starch.

Processed rice products included rice beverages (e.g., rice milk), puddings, rice chips/crackers, cereals, and rice noodles/papers. The current survey data for cadmium levels in rice products agrees well with the previous FSAP survey data. The CFP maximum level is lower than the FSAP surveys; however, the average is quite comparable.

Table 10. Summary of FSAP survey and CFP/FDA/EFSA data on cadmium levels in processed grain products

Study Author	Year	Number of Samples	Number (%) of Samples with Detectable Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Oat Products						
FSAP	2011-2013	32	23 (72)	0.005	0.047	0.014
Corn Products						
FSAP	2011-2013	128	7 (5)	0.004	0.086	0.020
FDA[19]	2006-2008	36	22 (61)	0.003	0.017	0.007
Other Grain Products						
FSAP	2011-2013	48	42 (88)	0.007	0.104	0.027
Wheat Products						
FSAP	2011-2013	122	120 (98)	0.011	0.254	0.069
Rice Products						
FSAP15	2011-2013	283	132 (42)	0.002	0.296	0.018
	2010-2011	224	84 (38)	0.003	0.265	0.028
CFP[16,17]	2009-2011	29	19 (66)	0.003	0.047	0.022

4 Conclusions

A total of 1805 samples were tested for cadmium. Of these samples, 65% (1179) had detectable levels of cadmium. More specifically, 57% of grain-based foods, 72% of vegetable/nut-based foods, and 72% of assorted foods tested positive for cadmium. The cadmium levels detected ranged from 0.002 ppm to 6.401ppm. The highest average cadmium levels were detected in seaweed products (1.751 ppm) and dried mushrooms (0.682 ppm), with the lowest average levels detected in pulses (0.014 ppm).

For similar products, the current CFIA FSAP survey positive rates and range of cadmium levels are comparable to the previous FSAP survey, the CFP data, Health Canada's Total Diet Study, as well as data published by the US FDA and EFSA.

Currently, no maximum level, tolerance, or standard has been established by Health Canada's Bureau of Chemical Safety for cadmium levels in food and therefore, compliance with a numerical standard was not evaluated in this survey. All the data generated were shared with Health Canada's Bureau of Chemical Safety for use in

performing human health risk assessments. Health Canada determined that the levels of cadmium detected in foods in this survey were unlikely to pose a human health concern. There were no product recalls associated with this survey.

5 References

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