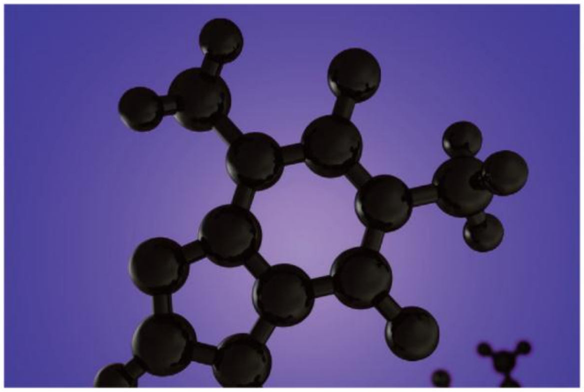
Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Chemistry



Cadmium in Rice and Rice-based Products

TS-CHEM-10/11

Canada

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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 test various foods for specific hazards.

The main objective of this survey was to generate baseline surveillance data on the level of cadmium in rice and rice-based products available on the Canadian retail market.

Cadmium is a toxic metal occurring naturally in the environment and as a pollutant from industrial and agricultural sources. Since cadmium is not known to fulfill a biological role in the human body, there is growing concern about its effect on humans. Cadmium has been classified as a human carcinogen by the International Agency for Research on Cancer[1,2]. Cadmium is relatively easily taken up by plants, making food intake the primary source for human cadmium exposure[1,3].

The 2010-2011 FSAP Cadmium Survey targeted domestic and imported rice and rice-based products. A total of 280 samples were collected from grocery and specialty stores in 11 Canadian cities between October 2010 and March 2011. The samples collected included 56 rice grain samples and 224 rice-based products.

Of the 280 samples analyzed for cadmium, 154 (55%) did not contain a detectable level of cadmium. The remaining 126 samples contained detectable cadmium levels ranging from 0.0054 to 0.0505 parts per million (ppm) in rice grains and 0.0026 to 0.2646 ppm in rice-based products. Currently, no maximum level, tolerance, or standard has been established by Health Canada for cadmium levels in food so compliance to a numerical standard could not be assessed. It is important to note that the cadmium levels observed in the current survey were well below the Codex Alimentarius Commission's established maximum level of 0.4 ppm of cadmium in rice[4].

All the data generated were shared with Health Canada for use in performing human health risk assessments. The levels of cadmium found in the various rice products tested in this survey were not expected to pose an unacceptable health risk. Appropriate follow-up actions were initiated that reflected the magnitude of the 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 the food safety regulatory system. The FCSAP initiative unites multiple partners in ensuring safe food for Canadians.

The Canadian Food Inspection Agency's (CFIA) Food Safety Action Plan (FSAP) is one element of the government's broader FCSAP initiative. The goal of the 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.

Within the 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 analysis of foods in 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 under the *Food and Drugs Act* and *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 food commodities. The surveys are designed to answer specific questions. Therefore, unlike monitoring activities, testing for 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 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), a group of federal, provincial and territorial subject matter experts in the area of food safety.

The CFIA regularly monitors metal analytes, including cadmium, in a variety of processed products under the National Chemical Residue Monitoring Program (NCRMP) and the Children's Food Project. Targeted surveys focus mainly on products not monitored under these two programs. The purpose of this targeted survey was to establish baseline data on the level of cadmium in rice and rice-based products available on the Canadian retail market. The scope of this survey is complementary to the NCRMP and Children's Food Project (CFP) monitoring of processed products in that it includes additional commodities (i.e., rice grains) not routinely monitored for metals. The cadmium levels observed in rice and rice-based products sampled in this survey were compared with previous CFP[12,13] data and relevant data from Health Canada's Total Diet Study (TDS)[18].

1.3 Acts and Regulations

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

Health Canada establishes the health-based maximum levels for chemical residues and contaminants 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. Tolerances are established as a risk management tool, and generally only for foods that significantly contribute to the total dietary exposure. There are also a number of maximum levels that do not appear in the regulations and are referred to as standards. Currently, no maximum level, tolerance, or standard has been established by Health Canada for cadmium levels in food so compliance to a numerical standard could not be assessed.

Internationally, the Codex Alimentarius Commission of the Food and Agriculture Organization/World Health Organization (FAO/WHO) has established a maximum level of 0.4 parts per million (ppm) of cadmium in rice[4].

Elevated levels of cadmium in specific foods may be assessed by Health Canada on a case-by-case basis using the most current scientific data available. Follow-up actions are initiated in a manner that reflects the magnitude of the health concern. Actions may include further analysis, notification of the producer or importer, follow-up inspections, additional directed sampling, and recall of products.

2 Survey Details

2.1 Cadmium

Cadmium is a toxic metal occurring naturally in the environment and as a pollutant from industrial and agricultural sources[1,3-5]. Cadmium is widely used in pigments, corrosion-resistant plating on steel, as a stabilizer in plastics, and in the fabrication of rechargeable batteries[5,6]. Although some cadmium-containing products can be recycled, a large share of the cadmium pollution is caused by dumping and incinerating cadmium-containing waste[5]. Cadmium can be present in water and soils[3,4]. Soils may become contaminated with cadmium by the use of phosphate fertilizers or sewage sludge[7]. Cadmium is relatively easily taken up by plants, making food intake the primary source for human cadmium exposure[1,3-7].

Cadmium is not known to fulfill a biological role in the human body[3] and has been classified as a human carcinogen by the International Agency for Research on Cancer[2]. In humans, cadmium is virtually absent at birth but once absorbed, it accumulates over time in the body, particularly in the kidneys, lungs, and liver[1,5-7]. While its absorption from dietary food is low, cadmium interference with basic cellular functions is long-lasting[3]. Its accumulation in kidneys can lead to renal damage and bone demineralisation[5]. Studies have demonstrated an association of cadmium and renal cancer in humans[5].

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has identified rice, wheat, root vegetables, leafy vegetables, tuber vegetables, other vegetables and molluscs[3] as commodity groups that contribute significantly to the total dietary intake of cadmium.

2.2 Rationale

The main objective of this survey was to generate baseline surveillance data on the level of cadmium in rice and rice-based products available on the Canadian retail market.

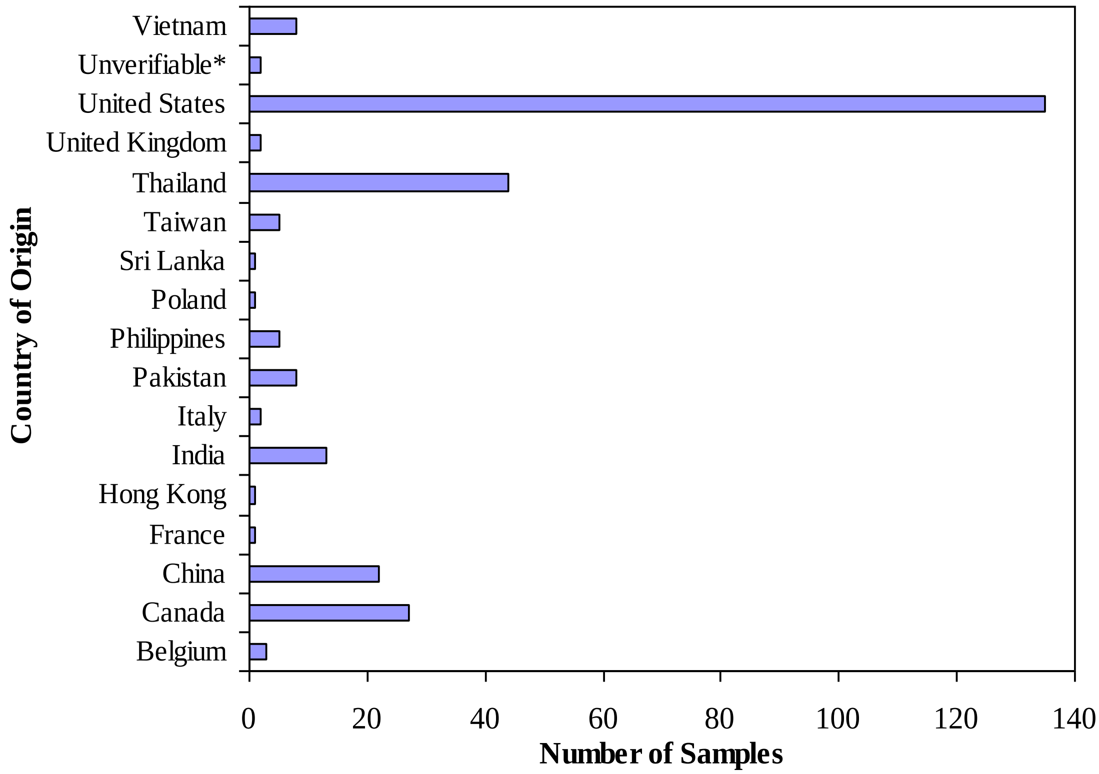
Plant-based commodities most susceptible to cadmium accumulation are rice, potatoes and vegetables[3,8]. Rice is particularly susceptible to cadmium contamination due to its distinctive cultivation in flooded fields[10]. Over 90% of the world's rice is produced in the Asia-Pacific region[9], where water contamination by cadmium has been noted repeatedly[10]. In Canada, rice available for consumption reached 7.1 kg per person in 2009[11]. Rice products like crackers or milk, which are popular substitutes for individuals with gluten or lactose intolerances, are also subject to cadmium contamination. Rice and rice-based products were therefore targeted in this survey.

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

2.3 Sample Distribution

The 2010-2011 Cadmium Survey targeted domestic and imported rice and rice-based products. A total of 280 samples were collected from grocery and specialty stores in 11 Canadian cities between October 2010 and March 2011.

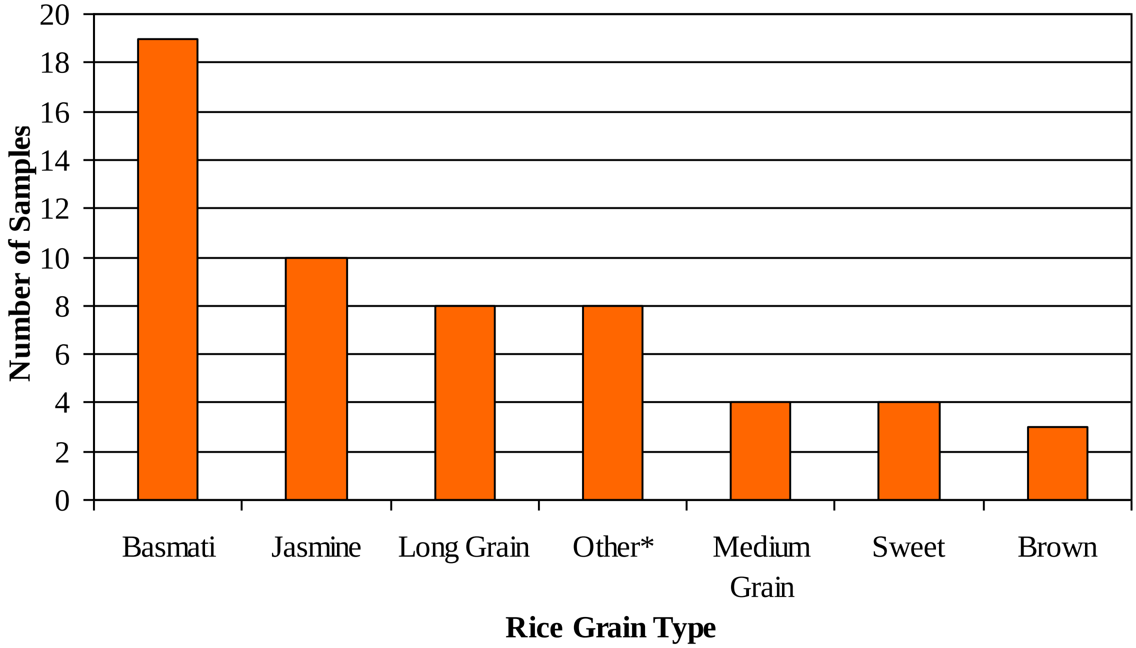
The 280 samples collected included 27 domestic products, 251 imported products and 2 products of unverifiable origin. Rice is not grown in Canada, so rice products listed as domestic were manufactured or processed in Canada using imported ingredients. It is important to note that the products sampled often contained the statement “processed in Country X”, “imported for Company A in Country Y” or “manufactured for Company B in Country Z”. Although the labelling is accurate, it does not unambiguously identify the true origin of the product ingredients. Only those products labelled with a clear statement of “Product of Country A” were considered as being from a specific country of origin. The distribution of samples collected in this survey with respect to the country of origin (as recorded by the sampler or indicated on the label) is depicted in Figure 1.



*Unverifiable refers to those samples for which the country of origin could not be determined from the label or sample information.

Figure 1. Distribution of rice and rice-based product samples by country of origin

The 280 samples collected included 56 rice grain samples and 224 rice-based products. The 56 rice grain samples were further categorized into 7 rice grain types, which included 19 basmati, 3 brown, 10 jasmine, 8 white long grain, 4 white medium grain, 4 sweet and 8 classified as other (sushi rice, pressed thin rice, red and black rice). The distribution of rice grain samples by rice grain type is shown in Figure 2.



* Other category included sushi rice, pressed thin rice, red and black rice.

Figure 2. Distribution of rice grain samples by grain type (arranged by decreasing number of samples)

The 224 rice-based products included: 64 non-refrigerated rice milks, 31 rice noodles, 29 rice-based breakfast cereals, 28 rice crackers, 26 rice flours (white and brown rice flours, rice bran flours), 15 rice cakes, 12 rice puddings, 8 rice papers, 8 rice crisps and 3 rice dessert mixes (cake, cookie). The distribution of rice-based products collected in this survey with respect to the product type is depicted in Figure 3.

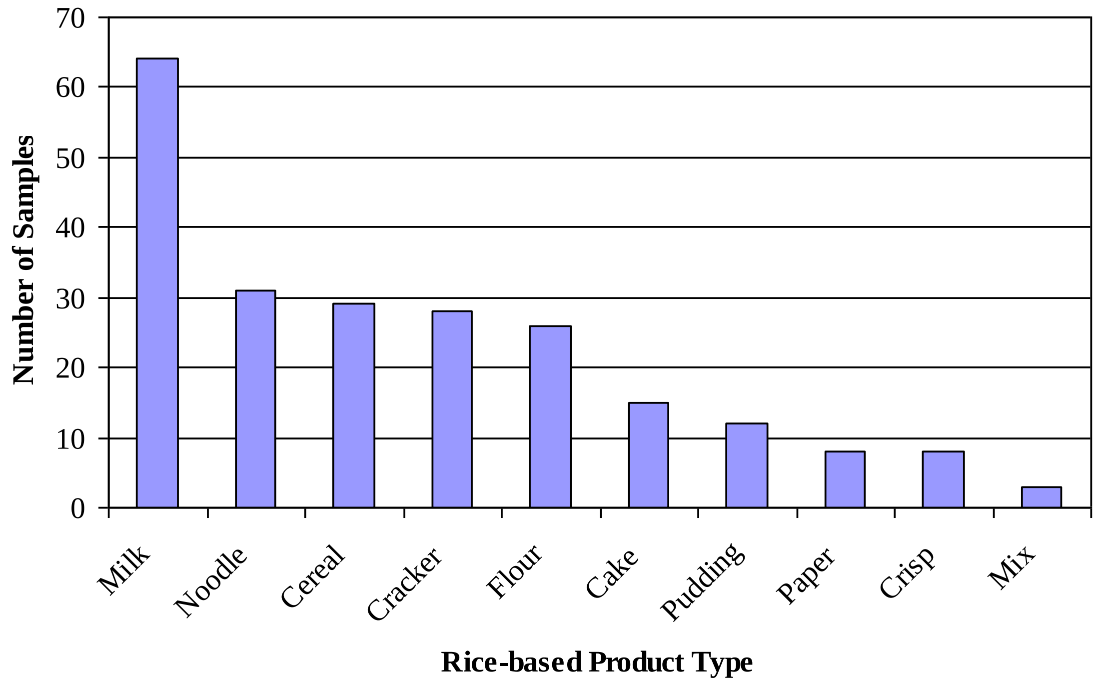


Figure 3. Distribution of rice-based samples by product type (arranged by decreasing number of samples)

2.4 Method Details

Samples were analyzed by a laboratory under contract with the Government of Canada. The laboratory is 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).

Samples were tested as sold, meaning that the product was not prepared as per the package instructions (if applicable). The laboratory used microwave digestion and inductively coupled plasma mass spectroscopy to analyze and confirm metal residues in the samples. While the focus of this survey was cadmium, the method also analyzed for 19 other metals. 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

The current targeted survey was designed to provide a snapshot of the levels of cadmium in rice and rice-based products available for sale in Canada and had the potential to highlight commodities that warrant further investigation. The limited sample sizes analyzed represent a small fraction of the products available to Canadian consumers. 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. Country of origin was assigned for all but two samples (designated “Unverifiable” in Figure 1) based on information provided by the sampler or indicated on the label.

3 Results and Discussion

The levels of cadmium detected in samples in this survey are presented and discussed in the following sections. The results of the 19 other metals tested in this survey will not be presented or discussed.

3.1 Overview of Cadmium Results

The 2010-2011 FSAP Cadmium Survey consisted of testing 280 samples obtained at the retail level. Commodities collected included 56 rice grain samples and 224 rice-based products of both domestic and imported origin. One hundred and fifty six (55%) samples did not have a detectable level of cadmium, while the remaining 126 samples contained cadmium ranging from 0.0054 to 0.0505 ppm in rice grain samples (Table 1) and 0.0026 to 0.2646 ppm in rice-based products (Table 2). Currently, no maximum level, tolerance, or standard has been established by Health Canada for cadmium levels in food so compliance to a numerical standard could not be assessed. It is important to note that the cadmium levels observed in the current survey were well below the Codex Alimentarius Commission’s established maximum level of 0.4 ppm of cadmium in rice[4]. Results by product type are presented in the following sections, with comparison to results obtained under the CFP (2009 to 2011)[12,13] and Health Canada’s TDS[18] where feasible.

3.2 Rice Grains

Of the 56 rice grain samples collected, 14 did not have a detectable level of cadmium. The remaining 42 had cadmium levels ranging from 0.0054 to 0.0505 ppm. The minimum, maximum and average levels of cadmium in the rice grain samples tested in this survey are presented in Table 1. Cadmium was not detected in any of the medium grain rice samples analyzed. On average, the lowest levels of cadmium were detected in jasmine rice and the highest cadmium levels were detected in brown rice. The observed cadmium levels in these rice samples may be due to the fact that rice plants absorb and accumulate cadmium present in polluted soils and distribute it uniformly throughout the entire rice grain[10,14]. The rice milling process (i.e., removal of husk and bran layers to produce an edible rice grain) does not significantly reduce the cadmium levels in the grain[14,15]. It is important to note that, as previously stated (Section 2.4), rice grain samples were tested as sold and other studies[16,17] have reported a slight decrease in cadmium content due to the cooking process.

Table 1. Minimum, maximum, and average levels of cadmium in rice grain samples in order of decreasing average levels

Rice Grain Type	Number of Samples	Number of Samples with Detectable Levels	Percentage of Samples with Detected Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Brown	3	3	100.0	0.0145	0.0505	0.0334
Sweet	4	3	75.0	0.0054	0.0385	0.0261
Basmati	19	17	89.5	0.0091	0.0324	0.0208
Other*	8	6	75.0	0.0061	0.0373	0.0198
Long Grain	8	6	75.0	0.0102	0.0310	0.0181
Jasmine	10	7	70.0	0.0083	0.0222	0.0138
Medium	4	0	0.0	-	-	-

Note: Minimum, maximum and average values were calculated using only results for samples with detectable levels of cadmium
*Other category included sushi rice, pressed thin rice, red and black rice.

When comparing only sample results with detectable levels of cadmium, a majority of the samples in the current survey had higher levels of cadmium than the limited number (16) of rice grain samples analyzed under the CFP (2009 to 2011)[12,13]. Rice samples analyzed under the CFP had detectable cadmium levels ranging from 0.001 ppm (brown rice) to 0.0422 ppm (long grain instant rice). The analytical methods used to test CFP samples were different from that used in the current survey, and the limits of detection for cadmium ranged from 0.0009 to 0.002 ppm.

Health Canada's TDS results from the 1993-2007 sampling periods[18] included a number of rice samples with average cadmium concentrations ranging from 0.0049 to 0.0140 ppm. TDS results cannot be easily compared to the current survey data as samples were prepared as they "would be consumed" in the average household kitchen[19] and there is limited information on rice grain type specifics. As previously discussed, studies[16,17] have reported a slight decrease in cadmium levels in prepared rice grains due to the cooking process.

It is important to note that the cadmium levels observed in the current survey for rice grains were well below the Codex's established maximum level of 0.4 ppm of cadmium in rice[4]. The levels of cadmium found in the rice grain samples tested in this survey were not expected to pose an unacceptable health risk. Appropriate follow-up actions were initiated that reflected the magnitude of the health concern.

3.3 Rice-based Products

Of the 224 rice-based samples analyzed, 140 did not have a detectable level of cadmium. The remaining 84 had cadmium levels ranging from 0.0026 to 0.2646 ppm. The minimum, maximum and average levels of cadmium in the rice-based products analyzed in this survey are presented in Table 2. Cadmium was not detected in any of the rice pudding samples analyzed. On average, the lowest levels of cadmium were detected in rice milk and the highest cadmium levels were detected in rice noodles.

Table 2. Minimum, maximum, and average levels of cadmium in rice-based product samples in order of decreasing average levels

Rice-Based Product Type	Number of Samples	Number of Samples with Detectable Levels	Percentage of Samples with Detected Levels	Minimum (ppm)	Maximum (ppm)	Average (ppm)
Noodles	31	26	83.9%	0.0112	0.2646	0.0491
Dessert Mixes	3	3	100.0%	0.0157	0.0626	0.0323
Cereal	29	10	34.5%	0.0087	0.0514	0.0240
Cake	15	10	66.7%	0.0069	0.0567	0.0190
Cracker	28	10	35.7%	0.0056	0.0621	0.0179
Flour	26	15	57.7%	0.0044	0.0343	0.0166
Paper	8	2	25.0%	0.0077	0.0229	0.0153
Crisps	8	5	62.5%	0.0046	0.0108	0.0073
Milk	64	3	4.7%	0.0026	0.0127	0.0060
Pudding	12	0	0.0%	-	-	-

Note: Minimum, maximum and average values were calculated using only results for samples with detectable levels of cadmium

When comparing only sample results with detectable levels of cadmium, a majority of the samples in the current survey had higher levels of cadmium than most of the rice-based samples (56) analyzed under the CFP (2009 to 2011)[12,13]. Rice-based samples analyzed under the CFP had detectable cadmium levels ranging from 0.0029 ppm (rice cake) to 0.0469 ppm (puffed rice snack). As previously stated, the analytical methods used to test

CFP samples were different from that used in the current survey, and the limits of detection for cadmium ranged from 0.0009 to 0.002 ppm.

Health Canada's TDS results from the 1993-2007 sampling periods[18] included a number of cereal samples (wheat, rice and bran) with average cadmium concentrations ranging from 0.0119 to 0.0614 ppm. Cadmium levels observed in the TDS cannot be easily compared to the current survey data given that TDS samples, as previously discussed, were prepared as they "would be consumed" and the TDS cereal samples consisted of both rice and other cereal types (wheat and bran) combined, and were not solely rice-based as in the current survey.

It is important to note that the cadmium levels observed in rice-based products in the current survey were well below the Codex's established maximum level of 0.4 ppm of cadmium in rice[4]. The levels of cadmium found in the rice-based products tested in this survey were not expected to pose an unacceptable health risk. Appropriate follow-up actions were initiated that reflected the magnitude of the health concern.

4 Conclusions

The 2010-2011 FSAP Cadmium Survey generated baseline surveillance data on the levels of cadmium in rice and rice-based products available on the Canadian retail market. Samples collected included 56 rice grain samples and 224 rice-based products of both domestic and imported origin. One hundred and fifty six (55%) samples did not have detectable levels of cadmium, while the remaining 126 samples contained cadmium levels ranging from 0.0054 to 0.0505 ppm in rice grain samples and 0.0026 to 0.2646 ppm in rice-based products. Cadmium was not detected in any of the medium rice grain and rice pudding samples analyzed in the survey. Compliance with a numerical standard was not evaluated in this survey as no maximum level, tolerance, or standard has been established by Health Canada for cadmium levels in food. It is important to note that the cadmium levels observed in the current survey were well below the Codex's established maximum level of 0.4 ppm of cadmium in rice[4].

All data generated were shared with Health Canada for use in performing human health risk assessments. The levels of cadmium found in the various rice products tested in this survey were not expected to pose an unacceptable health risk. Appropriate follow-up actions were initiated that reflected the magnitude of the health concern.

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